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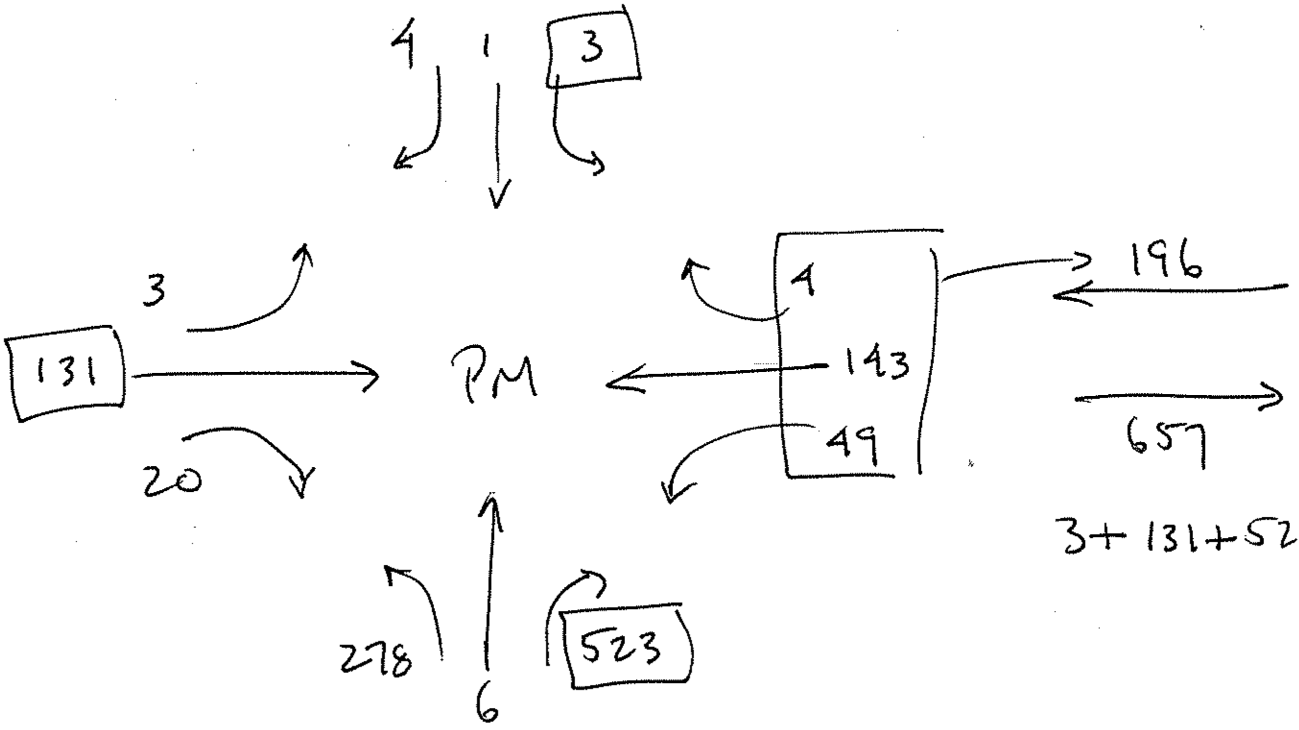
TABLE 2 (Augmented)

COMPARISON OF TRAFFIC VOLUMES REPORTED BY CME FOR THE BELLEAYRE RESORT WITH COUNTS TAKEN FOR THE CATSKILL CENTER ON SAT. FEB. 15, 2003

COUNTY RD. 49A AT ROUTE 28 (Entrance to Bellearye Ski Resort)

	AM PEAK HOUR			PM PEAK HOUR		
	EIS 2000	Feb. 15 03 Ct.	% Diff.	EIS 2000	Feb. 15 03 Ct.	% Diff.
WB Rt. 28						
Left	270	355	31%	38	49	29%
Through	87	77	-11%	138	143	4%
Right	1	0		2	4	
EB Rt. 28						
Left	2	0		8	3	
Through	50	59	18%	113	131	16%
Right	85	99	16%	28	20	-29%
NB CR 49A						
Left	13	32	146%	243	278	14%
Through	1	1		4	6	
Right	27	27	0%	391	523	34%
SB CR 49A						
Left	1	1		5	3	
Through	7	1	-86%	0	1	
Right	0	0		3	4	
TOTALS	544	652	20%	973	1165	20%

COMMUNITY CONSULTING SERVICES (Revised 6/10/03)



3+131+523 = 657

ROUTE 28 EAST OF 49A, DEIS, 2/15/03
SATURDAY ESTIMATED TEMPORAL DISTRIBUTION

	EB	WB	TOTAL	EB	WB
12-1 am	63	36	99	1.7%	1.0%
1-2	29	29	58	0.8%	0.8%
2-3	25	17	42	0.7%	0.5%
3-4	20	14	34	0.6%	0.4%
4-5	27	14	42	0.8%	0.4%
5-6	27	28	55	0.8%	0.8%
6-7	53	72	125	1.5%	2.0%
7-8	65	216	281	1.8%	6.0%
8-9	73	364	437	2.0%	10.1%
9-10	119	401	519	3.3%	11.1%
10-11	133	299	432	3.7%	8.3%
11-12	140	284	425	3.9%	7.9%
12-1 pm	173	266	439	4.8%	7.4%
1-2	248	227	475	6.9%	6.3%
2-3	299	194	493	8.3%	5.4%
3-4	355	171	526	9.9%	4.8%
4-5	657	196	853	18.3%	5.5%
5-6	223	184	407	6.2%	5.1%
6-7	198	137	335	5.5%	3.8%
7-8	166	119	284	4.6%	3.3%
8-9	155	104	259	4.3%	2.9%
9-10	122	94	216	3.4%	2.6%
10-11	116	79	195	3.2%	2.2%
11-12 pm	114	54	168	3.2%	1.5%
	3,600	3,600	7,200	100.0%	100.0%

Community Consulting Services (Revised 6/10/03)

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CPC Ex 44

COMMUNITY
CONSULTING
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IMPACT OF BELLEAYRE RESORT ON TRAVEL IN ROUTE 28 CORRIDOR

Brian Ketcham
Community Consulting Services
June 14, 2004

On a typical weekend ski day, the added traffic due to the proposed Belleayre Resort will increase travel time by at least 3,000 vehicle hours for all motorists and their passengers in the Route 28 corridor between Interstate 87 and the project sites on either side of the Belleayre Mountain Ski Area. Although the ski season was selected as the focus of the traffic analysis in the DEIS, traffic impacts may be much greater at other times of the year.

The entire traffic analysis reported in the Belleayre Resort DEIS is based on the unsupported, and probably inaccurate, supposition that traffic volumes in the winter on Route 28 are approximately double those during the summer. The selection of winter travel conditions to represent the worst case is contrary to both observation and data with which consultants must have been familiar. New York State Department of Transportation (NYSDOT) guidance for seasonal adjustment factors for recreational rural roads like Route 28 shows summer traffic is approximately double winter volumes.[1] The DEIS reports a survey by Crossroads in which 53% of businesses in the area reported the summer as their busiest season. Nevertheless, the DEIS traffic analysis postulates, without any data, that compared to June (implying that represents average conditions), traffic in January is 80% to 150% higher than for summer conditions.[2]

Based on this pivotal premise, the DEIS traffic analysis is limited to the peak skier arrival and departure hours. Professional experience should have alerted the consultant team that prepared the DEIS that this fundamental assumption is also at odds with their own work for NYSDOT, which found that, even for an area that bills itself as the "Winter Sports Capital of the World" and is the top ranked eastern ski area by readers of Ski Magazine, Lake Placid, NY, that "Typically peak summer volumes are 33 to 132 percent higher than volumes at other times a year." [3]

The degree to which the foundation of the DEIS is at variance with statewide travel patterns should have demanded detailed analysis, whereas there is none at all in the DEIS. Our estimate, therefore, is illustrative and developed by applying professional judgment to data assembled from several authoritative sources to compensate for the lack of data in the DEIS. However, it suggests that our estimated increased travel time most likely applies to many days of the year and that actual peak days may be much higher when not only background traffic is likely higher than assumed in the DEIS, but there are many more dispersed activities that likely attract many more off-site trips in the corridor.

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[1] Ketcham, B., Community Consulting Services. Memorandum re Route 28 Seasonal Traffic Changes and the Belleayre Resort, June 14, 2004, attached.

[2] Belleayre Resort at Catskill Park DEIS, (Appendix 25, p. 3)

[3] Creighton Manning Engineering, LLP, the LA Group, Konheim & Ketcham, The Hudson Group, LLC, A Mobility Plan for the Lake Placid Area, NYSDOT, 1998.

Among the standard elements that the Appendix 25 traffic analysis for the Belleayre Resort fails to report, without which any analysis is speculative, are:

- hourly traffic volumes by direction for at least three weekdays and two weekend days by season (especially needed if peak period effects are to be accounted for)
- vehicle occupancy for all periods by all vehicle types
- vehicle classification (type of vehicle by time of day)
- trip generation for each Resort component by trip purposes by hour and by season based on documentation (the average of counts at three representative facilities of each component)
- origin and destination of trips (with supporting documentation)
- NYSDOT average annual daily traffic volumes (AADT) for the Route 28 corridor by segment
- Travel speeds by vehicle type by road sector by time of day

In the absence of measured data in the DEIS, future travel speeds are calculated as described below for average daily traffic. Since an analysis of corridor travel delay for a "worst-case" day was not performed for the DEIS, our first step was to characterize baseline travel speeds based on 2002 traffic volume data for Route 28 reported by NYSDOT (Table 1). The data, AADTs (Annual Average Daily Travel) for 18 roadway sections on Route 28 between I-87 and Route 30 show an eightfold decrease from Route 209 to County Road 47, the point closest to the project sites. The data, AADT volumes, are, as the name implies, the average of all traffic along Route 28 (the 24 hour total in both directions) over a year. NYSDOT also reports seasonal travel variations, but as explained above their data shows quite the reverse characteristics for roads like Route 28, with summer traffic more that double what occurs in the winter (Factor Group 60, see attached tables). The DEIS traffic analysis ignores the published AADTs and guidance on seasonal adjustment factors, and asserts that traffic in January is 80% to 150% higher than for summer conditions. Based on this pivotal premise, the DEIS traffic analysis is devoted to the peak hours of skier arrival and departure, without any attention to non-ski trips or the arrival and departure of Resort visitors, which, for time-share guests is reported to occur on Saturdays, greatly adding to the volume and complexity of vehicle trips. In fact, the DEIS misleadingly asserts (again without support) that 80% of the post-arrival trips during ski season will be by shuttle bus, when it must mean 80% of ski-area destination trips (itself, optimistic given the time penalties of shuttle routes). Even so, no mention is made of travel for any other purpose, such as buying gas, the highest off-site expenditure after restaurants.

Travel speeds were estimated based on observed conditions along Route 28 reflecting posted speeds for current conditions (2003). Speeds decline as volumes increase; the standard State DOT relationship between speed and volume is expressed as Speed = $3600/(A+B*VC^4)$, where A and B are factors reflecting the posted speeds and a factor reflecting roadway type. VC is the ratio of the traffic volume to the capacity of a road section. Note, this differs from the calculation of volume to capacity of an intersection which accounts for conditions in each approach lane. For the Route 28 corridor, which is fairly uniform west of Route 209, it has been assumed that changes in VC are proportional to traffic volumes.

The daily impact of traffic along the 43 miles of Route 28 between I-87 and Route 30 for the increase in travel in 2014 associated with both the Ski Area and the Belleayre Resort is also shown in Table 1, assuming a 60% increase in skier days, a 2% per year (compounded) growth in background traffic and the 6,300 Resort trips presented at the May 27th hearing.

Assuming an average of two people per vehicle (averaged over Resort and Ski-Center generated vehicles along with general background traffic, another missing factor in the DEIS) a total of approximately 100,000 travelers daily will be delayed to varying degrees depending on location and time of day. We conclude that at least 6,000 person hours of added travel time will be wasted each peak period day and, likely, on other days as well as a consequence of the proposed Resort project. These impacts are believed to be conservatively low, even for the ski season.

The potential significance of the impact of added Resort traffic on travel delay suggests that a thoroughly documented (incorporating the data listed above) corridor analysis should be incorporated into the DEIS to provide the kind of information to enable the lead and involved agencies and the public to make the informed decision that is central to the SEQRA process. The incorrect basis of the traffic and parking analysis may necessitate a complete revision of the DEIS for a different peak season.

5,000 - 8,000 @ Bell.
60 % increase

TABLE 1

ROUTE 28 CORRIDOR ANALYSIS, VEHICLE HOURS OF DELAY ON PEAK SKI DAYS DUE TO THE OPERATION OF THE BELLEAYRE RESORT, 85% OCCUPIED

From	To	Distance Miles	AADT (2-way) Est. 2002	Est. 2014 +2%/yr	Estimated Belleayre Ski Area Growth	Percent Increase	TOTALS	Estimated Belleayre Resort Traffic	Percent Increase	TOTALS
I-87	Rt. 209	0.39	24190	30,679	1000	4%	31,679	2000	6%	33,679
Rt. 209	Rt. 28A Stony Hollow	2.49	19661	24,935	1000	5%	25,935	2000	8%	27,935
Rt. 28A Stony Hollow	CR 52 Zena Rd	2.04	15160	19,227	1000	7%	20,227	2000	10%	22,227
CR 52 Zena Rd	Rt. 375 W. Hurley	0.98	15488	19,643	1000	6%	20,643	2000	10%	22,643
Rt. 375 W. Hurley	Reservoir Rd. & Winchell Corn	6.17	8800	11,161	1000	11%	12,161	2000	16%	14,161
Reservoir Rd. & Winchell Corn	Rt. 28A Boiceville	4.21	7079	8,978	1000	14%	9,978	2300	23%	12,278
Rt. 28A Boiceville	Rt. 212 Mt. Tremper	2.61	5807	7,365	1100	19%	8,465	2500	30%	10,965
Rt. 212 Mt. Tremper	Rt. 214 Phoenicia	3.69	7414	9,403	1200	16%	10,603	2500	24%	13,103
Rt. 214 Phoenicia	Rt. 42 Shandaken	5.06	4371	5,543	1300	30%	6,843	2800	41%	9,643
Rt. 42 Shandaken	Big Indian RD CR 47	3.14	2965	3,760	1350	46%	5,110	3000	59%	8,110
Big Indian RD CR 47	Delaware CO Line	4.13	2704	3,429	1350	50%	4,779	5000	105%	9,779
Ulster CO Line	Old Rt. 28	1.25	3239	4,108	200	6%	4,308	5000	116%	9,308
Old Rt. 28	CR 38	5.5	3284	4,165	200	5%	4,365	800	18%	5,165
CR 38	Start 30 OLAP	1.41	5544	7,031	200	4%	7,231	700	10%	7,931
	TOTALS	43.17								

From	To	Estimated Average Speed (MPH) Exist. Cond.	VC Ratio Exist. Cond.	2014 w/Ski Area Expansion		Effects of Belleayre Resort, 2014			
				VC Ratio Future w/ Bell. Resort	Estimated Average Speed (MPH) w/ Bell. Resort	VC Ratio Future w/ Bell. Resort	Estimated Average Speed (MPH) w/ Bell. Resort	Speed Reduction Percent	Travel Time Lost (Veh. Hrs.) Per Day
I-87	Rt. 209	42	0.49	0.64	37	0.68	35	5%	17
Rt. 209	Rt. 28A Stony Hollow	43	0.44	0.58	39	0.62	38	4%	75
Rt. 28A Stony Hollow	CR 52 Zena Rd	44	0.37	0.49	42	0.54	41	3%	33
CR 52 Zena Rd	Rt. 375 W. Hurley	44	0.37	0.49	42	0.54	41	3%	16
Rt. 375 W. Hurley	Reservoir Rd. & Winchell Corn	53	0.39	0.54	49	0.63	46	7%	143
Reservoir Rd. & Winchell Corn	Rt. 28A Boiceville	48	0.58	0.82	35	1.00	24	31%	659
Rt. 28A Boiceville	Rt. 212 Mt. Tremper	53	0.39	0.57	48	0.74	40	17%	121
Rt. 212 Mt. Tremper	Rt. 214 Phoenicia	53	0.39	0.56	49	0.70	42	13%	162
Rt. 214 Phoenicia	Rt. 42 Shandaken	54	0.30	0.47	51	0.67	44	14%	160
Rt. 42 Shandaken	Big Indian RD CR 47	54	0.30	0.52	50	0.83	35	30%	222
Big Indian RD CR 47	Delaware CO Line	54	0.30	0.53	50	1.09	20	60%	1207
Ulster CO Line	Old Rt. 28	54	0.30	0.40	53	0.87	32	39%	140
Old Rt. 28	CR 38	54	0.30	0.40	53	0.48	51	3%	16
CR 38	Start 30 OLAP	54	0.30	0.39	53	0.43	52	1%	3
						VEHICLE HOURS OF DELAY PER WEEKEND DAY			2963

V/C

Community Consulting Services, June 13, 2004

Travel time lost assuming 2 people per car at $10 per hour per person as the value of time. PER DAY $ 59,269

**COMMUNITY
CONSULTING
SERVICES INC.**

June 14, 2004

MEMORANDUM

RE: ROUTE 28 SEASONAL TRAFFIC CHANGES AND THE BELLEAYRE RESORT

FROM: BRIAN KETCHAM, P.E.

This is to document my findings regarding seasonal variations in traffic volumes from data presented on the New York State Department of Transportation WEB site. Attached are tables from the DOT web site. They show three group types: 30 is for highways carrying heavy commuter traffic; 60 is for roads exhibiting heavy seasonal traffic patterns; and 40 is for conditions between these two extremes. I spoke with engineers at the Region 8 office of State DOT who reported that Route 28 is considered a group type 60, exhibiting very high seasonal variations. As the attached tables reveal, summer traffic for all three conditions are higher than for winter; moreover, for road groups 40, summer exhibits a doubling of traffic volume.

This is of concern in reference to the Belleayre Resort traffic analysis in that that analysis reports just the opposite characteristics, winter traffic as much as double summer volumes. There is nothing in the Belleayre Resort DEIS to support this assertion. Because the Belleayre Resort traffic analysis is based on the premise that winter ski season traffic is much greater than summer traffic, that it deemed it was not necessary to study summer conditions. The NYSDOT data suggests this may not be the case. Because this matter is so pivotal to the adequacy of the Belleayre Resort traffic analysis, a very substantial presentation of traffic data must be made to justify the basis for the traffic analysis that has been presented.

The Belleayre Resort must provide, at a minimum, 24-hour traffic counts for three of the four seasons under consideration: A minimum of two weeks of continuous ATR (automatic traffic recorder) counts must be provided during February, August and October. It is my experience that travel in the spring time (the Catskill mud season) is of little consequence.

To repeat, this data is essential if the assertion for Route 28, which is so hugely different from NYSDOT experience, be verified. And, if these characteristics cannot be verified, then the Belleayre Resort traffic analysis must be rethought.

WORK WEEK (WEEK DAY) SEASONAL ADJUSTMENT FACTORS FOR 2003 TRAFFIC COUNT PROCESSING

(Based on 2000 - 2002 Continuous Count Site Data)

FACTOR GROUP	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
31	0.967	1.004	1.018	1.034	1.056	1.088	1.100	1.113	1.062	1.059	1.006	0.992
30	0.908	0.958	0.972	0.999	1.030	1.059	1.046	1.063	1.017	1.027	0.978	0.939
29	0.850	0.913	0.926	0.963	1.005	1.030	0.992	1.013	0.972	0.996	0.950	0.886
STD (+/-)	0.058	0.046	0.046	0.036	0.025	0.029	0.054	0.050	0.045	0.031	0.028	0.053
41	0.907	0.937	0.940	1.011	1.096	1.164	1.323	1.308	1.122	1.070	1.011	0.940
40	0.827	0.868	0.881	0.955	1.046	1.095	1.210	1.221	1.064	1.019	0.945	0.875
39	0.747	0.800	0.821	0.899	0.998	1.026	1.096	1.134	1.006	0.968	0.879	0.811
STD (+/-)	0.080	0.068	0.059	0.056	0.049	0.069	0.114	0.087	0.058	0.051	0.066	0.065
61	0.762	0.803	0.845	0.873	1.082	1.257	1.945	1.846	1.218	1.002	0.846	0.767
60	0.660	0.718	0.737	0.777	1.011	1.175	1.729	1.667	1.103	0.921	0.777	0.714
59	0.558	0.632	0.629	0.680	0.940	1.093	1.513	1.488	0.989	0.839	0.707	0.661
STD (+/-)	0.102	0.085	0.108	0.097	0.071	0.082	0.216	0.179	0.114	0.081	0.070	0.053

Seasonal adjustment factors convert average daily traffic (ADT) to annual average daily traffic (AADT). The ADT is divided by the seasonal factor to obtain the AADT value.

The work week seasonal factors are developed from NYSDOT continuous counter data collected for a three year period. The continuous counter sites are grouped into three major factor groups (FG). Factor Group 30 is characteristic of highways carrying heavy commuter traffic. Factor Group 60 is characterized by heavy seasonal traffic patterns. Factor Group 40 highways lie between these two extremes. Minor Factor Groups surround each of the major groups. The factor values associated with these minor groups are + and - one standard deviation (Std. Dev.) of the major groups's value.

Monthly average daily traffic values (MADT) based on week day data are developed for each month in each factor group. The factor values are computed by dividing the week day MADT by the annual average daily traffic (AADT) within each factor group. This factoring procedure does accountfor week end traffic. Other daily (7 day) and weekend seasonal adjustment factors are available from the Highway Data Services Bureau by request.

The work week factor is specifically applicable to traffic count data collected between 6:00 a.m. Mondays through 12:00 noon Fridays. The available hourly data is averaged for each of the twenty four hours in a day. The sum of these 24 'averaged' hours constitutes the ADT value. At a minimum, two hours of data in each hour must be available for averaging.

Highway Data Services Bureau
Revised on April 30, 2003

OTHER (WEEK END) SEASONAL ADJUSTMENT FACTORS FOR 2004 TRAFFIC COUNT PROCESSING

(Based on 2001 - 2003 CONTINUOUS COUNT SITE DATA)

FACTOR GROUP	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
31	0.951	0.972	1.013	1.040	1.101	1.098	1.081	1.091	1.065	1.076	1.019	1.006
30	0.901	0.925	0.974	1.005	1.072	1.055	1.027	1.044	1.026	1.038	0.982	0.946
29	0.851	0.878	0.935	0.970	1.043	1.012	0.973	0.997	0.987	1.000	0.945	0.886
STD	0.050	0.047	0.039	0.035	0.029	0.043	0.054	0.047	0.039	0.038	0.037	0.060
41	0.915	0.922	0.941	1.040	1.140	1.179	1.307	1.303	1.125	1.119	1.020	1.000
40	0.800	0.830	0.875	0.962	1.071	1.103	1.187	1.201	1.063	1.057	0.942	0.898
39	0.685	0.738	0.809	0.884	1.002	1.027	1.067	1.099	1.001	0.995	0.864	0.796
STD	0.115	0.092	0.066	0.078	0.069	0.076	0.120	0.102	0.062	0.062	0.078	0.102
61	0.742	0.776	0.823	0.943	1.140	1.336	1.778	1.722	1.201	1.128	0.926	0.809
60	0.651	0.697	0.737	0.828	1.059	1.216	1.577	1.534	1.118	1.024	0.801	0.726
59	0.560	0.618	0.651	0.713	0.978	1.096	1.376	1.346	1.035	0.920	0.676	0.643
STD	0.091	0.079	0.086	0.115	0.081	0.120	0.201	0.188	0.083	0.104	0.125	0.083

Highway Data Services Bureau
March 2004

WORK WEEK (WEEK DAY) SEASONAL ADJUSTMENT FACTORS FOR 2004 TRAFFIC COUNT PROCESSING

(Based on 2001 - 2003 CONTINUOUS COUNT SITE DATA)

FACTOR GROUP	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
31	0.967	0.994	1.009	1.031	1.057	1.095	1.109	1.115	1.060	1.062	1.007	0.991
30	0.913	0.939	0.964	0.995	1.031	1.062	1.059	1.064	1.016	1.029	0.977	0.943
29	0.859	0.884	0.919	0.959	1.005	1.029	1.009	1.013	0.972	0.996	0.947	0.895
STD	0.054	0.055	0.045	0.036	0.026	0.033	0.050	0.051	0.044	0.033	0.030	0.048
41	0.920	0.931	0.933	1.003	1.092	1.160	1.316	1.302	1.109	1.073	1.017	0.950
40	0.833	0.857	0.876	0.950	1.043	1.101	1.210	1.216	1.058	1.022	0.945	0.884
39	0.746	0.783	0.819	0.897	0.994	1.042	1.104	1.130	1.007	0.971	0.873	0.818
STD	0.087	0.074	0.057	0.053	0.049	0.059	0.106	0.086	0.051	0.051	0.072	0.066
61	0.778	0.801	0.848	0.884	1.082	1.270	1.904	1.860	1.195	0.997	0.851	0.781
60	0.677	0.722	0.735	0.774	1.010	1.190	1.706	1.670	1.087	0.922	0.778	0.729
59	0.576	0.643	0.622	0.664	0.938	1.110	1.508	1.480	0.979	0.847	0.705	0.677
STD	0.101	0.079	0.113	0.110	0.072	0.080	0.198	0.190	0.108	0.075	0.073	0.052

Highway Data Services Bureau
March 2004

DAILY (7 DAY) SEASONAL ADJUSTMENT FACTORS FOR 2004 TRAFFIC COUNT PROCESSING

(Based on 2001 - 2003 CONTINUOUS COUNT SITE DATA)

FACTOR GROUP	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
31	0.941	0.968	0.991	1.035	1.067	1.090	1.100	1.107	1.057	1.076	1.007	0.998
30	0.903	0.926	0.955	1.003	1.046	1.060	1.054	1.057	1.021	1.041	0.978	0.949
29	0.865	0.884	0.919	0.971	1.025	1.030	1.008	1.007	0.985	1.006	0.949	0.900
STD	0.038	0.042	0.036	0.032	0.021	0.030	0.046	0.050	0.036	0.035	0.029	0.049
41	0.922	0.930	0.934	1.008	1.108	1.169	1.324	1.326	1.106	1.086	1.005	0.947
40	0.824	0.850	0.877	0.946	1.051	1.105	1.212	1.226	1.059	1.032	0.932	0.881
39	0.726	0.770	0.820	0.884	0.994	1.041	1.100	1.126	1.012	0.978	0.859	0.815
STD	0.098	0.080	0.057	0.062	0.057	0.064	0.112	0.100	0.047	0.054	0.073	0.066
61	0.741	0.770	0.804	0.905	1.117	1.322	1.827	1.821	1.212	1.068	0.869	0.783
60	0.653	0.699	0.719	0.791	1.042	1.224	1.625	1.597	1.118	0.980	0.781	0.722
59	0.565	0.628	0.634	0.677	0.987	1.126	1.423	1.373	1.024	0.892	0.693	0.661
STD	0.088	0.071	0.085	0.114	0.075	0.098	0.202	0.224	0.094	0.088	0.088	0.061

Highway Data Services Bureau
March 2004

45

DOT Does not have enough information. From seasonal adjustment factor

CPC Ex 45

ESTIMATE OF AVERAGE DAILY TRAVEL, 2014, BY MONTH
ROUTE 28 NEAR BIG INDIAN (total, both directions)

(Assuming heavy seasonal traffic patterns)

MONTH	SEA (1)	ADT (3)	Compared to Feb/March
January	0.852	DOT Act. 3,204	5%
February	0.804	3,023	0%
March	0.812	3,053	0%
April	0.886	2900 3,331 ~~2995~~	10%
May	1.038	3,903	28%
June	1.032	3,880	28%
July	1.382	5,196	71%
August	1.408	5,294	74%
September	1.062	3,993	31%
October	0.973	3,658	20%
November	0.884	3,324	9%
December	0.837	2600 3,147 4,400 wk end	4%
AADT (2)	3760		

(1) SEA = Seasonal Adjustment Factor, NYSDOT, Factor Group 60
(2) AADT = Annual Average Daily Traffic, Route 28 between Rt. 42 Shandaken and Big Indian CR 47, Est. for 2014
(3) ADT = Average Daily Traffic
Community Consulting Services (June 17, 2004)

All estimated

ESTIMATE OF AVERAGE DAILY TRAVEL, 2014, BY MONTH ROUTE 28 NEAR BIG INDIAN (total, both directions)

(Assuming combined commuting traffic and heavy seasonal traffic patterns)

MONTH	SEA (1)	ADT (3)	Compared to Feb/March
January	0.827	3,110	-5%
February	0.868	3,264	-1%
March	0.881	3,313	1%
April	0.955	3,591	9%
May	1.046	3,933	20%
June	1.095	4,117	25%
July	1.21	4,550	38%
August	1.221	4,591	40%
September	1.064	4,001	22%
October	1.019	3,831	17%
November	0.946	3,557	8%
December	0.875	3,290	0%
AADT (2)	3760		

(1) SEA = Seasonal Adjustment Factor, NYSDOT,
Factor Group 40
(2) AADT = Annual Average Daily Traffic, Route 28
between Rt. 42 Shandaken and Big Indian CR 47, Est. for 2014
(3) ADT = Average Daily Traffic
Community Consulting Services (June 17, 2004)

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TABLE 6

WORK WEEK (WEEK DAY) SEASONAL ADJUSTMENT FACTORS FOR 2003 TRAFFIC COUNT PROCESSING

(Based on 2000 - 2002 Continuous Count Site Data)

FACTOR GROUP	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
31	0.967	1.004	1.018	1.034	1.056	1.088	1.100	1.113	1.062	1.059	1.006	0.992
30	0.908	0.958	0.972	0.999	1.030	1.059	1.046	1.063	1.017	1.027	0.978	0.939
29	0.850	0.913	0.926	0.963	1.005	1.030	0.992	1.013	0.972	0.996	0.950	0.886
STD (+/-)	0.058	0.046	0.046	0.036	0.025	0.029	0.054	0.050	0.045	0.031	0.028	0.053
41	0.907	0.937	0.940	1.011	1.095	1.164	1.323	1.308	1.122	1.070	1.011	0.940
40	0.827	0.868	0.881	0.955	1.046	1.095	1.210	1.221	1.064	1.019	0.945	0.875
39	0.747	0.800	0.821	0.899	0.998	1.026	1.096	1.134	1.006	0.968	0.879	0.811
STD (+/-)	0.080	0.068	0.059	0.056	0.049	0.069	0.114	0.087	0.058	0.051	0.066	0.065
61	1.316	1.016	1.030	1.115	1.134	1.311	1.940	1.874	1.225	1.133	1.153	1.045
60	0.852	0.804	0.812	0.886	1.038	1.032	1.382	1.408	1.062	0.973	0.884	0.837
59	0.368	0.591	0.594	0.657	0.942	0.754	0.824	0.941	0.899	0.813	0.615	0.630
STD (+/-)	0.464	0.212	0.218	0.229	0.096	0.278	0.558	0.467	0.163	0.160	0.269	0.208

Seasonal adjustment factors convert average daily traffic (ADT) to annual average daily traffic (AADT). The ADT is divided by the seasonal factor to obtain the AADT value.

AADT x FACT. = ADT

The work week seasonal factors are developed from NYSDOT continuous counter data collected for a three year period. The continuous counter sites are grouped into three major factor groups (FG). Factor Group 30 is characteristic of highways carrying heavy commuter traffic. Factor Group 60 is characterized by heavy seasonal traffic patterns. Factor Group 40 highways lie between these two extremes. Minor Factor Groups surround each of the major groups. The factor values associated with these minor groups are + and - one standard deviation (Std. Dev.) of the major groups's value.

Monthly average daily traffic values (MADT) based on week day data are developed for each month in each factor group. The factor values are computed by dividing the week day MADT by the annual average daily traffic (AADT) within each factor group. This factoring procedure does accountfor week end traffic. Other daily (7 day) and weekend seasonal adjustment factors are available from the Highway Data Services Bureau by request.

The work week factor is specifically applicable to traffic count data collected between 6:00 a.m. Mondays through 12:00 noon Fridays. The available hourly data is averaged for each of the twenty four hours in a day. The sum of these 24 'averaged' hours constitutes the ADT value. At a minimum, two hours of data in each hour must be available for averaging.

Highway Data Services Bureau
April 2003

STATION: **860230**

New York State Department of Transportation
Traffic Count Hourly Report

ROUTE/RD #: NY 28
DIRECTION: Southbound
STATE DIR CODE: 2
DATE OF COUNT: 04/28/2003
NOTES: Week 18-Sb

ROAD NAME: Rte 28
FACTOR GROUP: 40
WK OF YR: 18

FROM: RT 212 MT TREMPER
REC. SERIAL #: 0458
PLACEMENT: Rte 28
@ REF MARKER: 28 86012222
COUNT TYPE: AXLE PAIRS
ADDL DATA:

TO: RT 214 PHOENICIA
FUNC. CLASS: 06
NHS: yes
JURIS: Other
COUNT TAKEN BY: JSV

COUNTY: Ulster
TOWN: SHANDAKEN
BIN:
RR CROSSING:
HPMS SAMPLE:

		AM												PM													
DATE	DAY	12 TO 1	1 TO 2	2 TO 3	3 TO 4	4 TO 5	5 TO 6	6 TO 7	7 TO 8	8 TO 9	9 TO 10	10 TO 11	11 TO 12	12 TO 1	1 TO 2	2 TO 3	3 TO 4	4 TO 5	5 TO 6	6 TO 7	7 TO 8	8 TO 9	9 TO 10	10 TO 11	11 TO 12	DAILY TOTAL	DAILY HIGH COUNT	DAILY HIGH HOUR
28	M												163	178	161	197	195	234	170	129	104	65	52	32	24			
29	T	11	8	5	8	19	62	143	262	242	223	194	179	166	192	159	180	196	156	136	95	63	60	27	12	2798	262	7
30	W	15	5	4	13	14	54	157	266	252	218	195	184	170	152	206	199	212	151	130	80	64	55	38	20	2854	266	7
1	T	10	17	17	9	18	47	140	268	232	219	226	200	175	175	187	196	217	168	146	90	68	63	35	24	2947	268	7
2	F	14	8	5	18	9	50	141	259	212	238																	

AVERAGE WEEKDAY HOURS (Axle Factored, Mon 6AM to Fri Noon)

																								ADT
12	10	8	12	14	51	139	253	225	215	197	179	165	163	160	184	206	155	130	88	62	56	32	19	2755

				AVERAGE WEEKDAY			
DAYS Counted	HOURS Counted	WEEKDAYS Counted	WEEKDAY Hours	High Hour	% of day	Axle Adj. Factor	Seasonal/Weekday Adjustment Factor
5	95	5	95	284	9%	0.960	0.955

ESTIMATED (one way)

AADT
2885

New York State Department of Transportation

PGM. VERSION 3.5 / 4.0

RC/STATION 860230

COVERAGE AND SPECIAL COUNT HOURLY REPORT

ST. TOURING RTE : 28 ROAD NAME : ROUTE 28 MILEPOINT 0122346 NHS 9 COUNTY : ULSTER
SECTION FROM : RT 212 MT TREMPER TO : RT 214 PHOENICIA TOWN : SHANDAKEN
FEDERAL DIR. 1 FACTOR GRP 40 FUNCTIONAL CLASS 06 HPMS NUMBER: BIN NUMBER:

COUNT DATE : 12/04/00 WEEK OF YR 50 RECORDER PLACEMENT: ROUTE 28 REFERENCE MKR: 28 86012222
RECORDER SERIAL #: 120

NOTES: DIRECTION 1 NB TUBE COUNT ADDITIONAL DATA:

DY MO	D W	D R	12 TO 1	1 TO 2	2 TO 3	3 TO 4	4 TO 5	5 TO 6	6 TO 7 AM	7 TO 8	8 TO 9	9 TO 10	10 TO 11	11 TO 12	12 TO 1	1 TO 2	2 TO 3	3 TO 4	4 TO 5	5 TO 6	6 TO 7 PM	7 TO 8	8 TO 9	9 TO 10	10 TO 11	11 TO 12	DAY TOTAL	HI COUNT	HI HOUR
4	1	1											122	126	152	160	211	204	270	274	195	118	76	80	30	44			
5	2	1	31	11	9	3	12	18	53	124	150	140	113	176	148	170	196	202	265	224	204	100	93	88	65	28	2623	265	17
6	3	1	29	11	12	0	18	18	46	110	144	137	116	146	146	152	178	232	276	256	160	122	126	94	57	36	2622	276	17
7	4	1	27	10	8	2	10	16	48	122	154	124																	

AVERAGE WEEKDAY HOUR (MON 6AM THRU FRI 12 NOON)

																								ADT
29	11	10	2	13	17	49	119	149	134	117	149	149	161	195	213	270	251	186	113	98	87	51	36	2609

AXLE - FACTORED (VEHICLES) AVG WEEKDAY HOUR (FACTOR USED = 0.973)

																								ADT
28	11	10	2	13	17	48	116	145	130	114	145	145	157	190	207	263	244	181	110	95	85	50	35	2541

HRS COUNTED	DAYS COUNTED	AVG HI HR	% AVG DAY	FACTORED HI HOUR	% FACTORED DAY	SEASONAL FACTOR
72	4	270	10.3%	263	10.4%	0.947

SEASONALLY FACTORED
ESTIMATED AADT
1-WAY COUNT
2683

ST. TOURING RTE 28 ON ROUTE 28 FROM RT 212 MT TREMPER TO RT 214 PHOENICIA
STATION: 860230 COUNT DATE: 12/04/00 ST. DIR: 1 RECORDER PLACEMENT: ROUTE 28

New York State Department of Transportation

PGM. VERSION 3.5 / 4.0

RC/STATION **860230**

COVERAGE AND SPECIAL COUNT HOURLY REPORT

ST. TOURING RTE : **28** ROAD NAME : **ROUTE 28** MILEPOINT **0122346** NHS **9** COUNTY : **ULSTER**
SECTION FROM : **RT 212 MT TREMPER** TO : **RT 214 PHOENICIA** TOWN : **SHANDAKEN**
FEDERAL DIR. **5** FACTOR GRP **40** FUNCTIONAL CLASS **06** HPMS NUMBER: BIN NUMBER:

COUNT DATE : **12/04/00** WEEK OF YR **50** RECORDER PLACEMENT: **ROUTE 28** REFERENCE MKR: **28 86012222**
RECORDER SERIAL #: **120**
NOTES: **DIRECTION 2 SB** **TUBE COUNT** ADDITIONAL DATA:

DY MO	D W	D R	12 TO 1	1 TO 2	2 TO 3	3 TO 4	4 TO 5	5 TO 6	6 TO 7	7 TO 8	8 TO 9	9 TO 10	10 TO 11	11 TO 12	12 TO 1	1 TO 2	2 TO 3	3 TO 4	4 TO 5	5 TO 6	6 TO 7	7 TO 8	8 TO 9	9 TO 10	10 TO 11	11 TO 12	DAY TOTAL	HI COUNT	HI HOUR
								AM												PM									
4	1	2											309	265	343	350	378	382	434	404	280	174	120	131	14	38			
5	2	2	28	16	22	14	32	90	176	330	370	328	276	286	308	306	322	340	401	306	198	116	72	67	47	31	4482	401	17
6	3	2	16	12	10	8	22	80	150	306	304	262	244	258	256	280	312	379	358	292	186	90	90	70	35	18	4038	379	16
7	4	2	10	5	10	6	22	73	164	319	272	278																	

AVERAGE WEEKDAY HOUR (MON 6AM THRU FRI 12 NOON) ADT

																								ADT
18	11	14	9	25	81	163	318	315	289	276	270	302	312	337	367	398	334	221	127	94	89	32	29	4431

AXLE - FACTORED (VEHICLES) AVG WEEKDAY HOUR (FACTOR USED =0.973) ADT

																								ADT
18	11	14	9	24	79	159	309	306	281	269	263	294	304	328	357	387	325	215	124	91	87	31	28	4313

HRS COUNTED	DAYS COUNTED	AVG HI HR	% AVG DAY	FACTORED HI HOUR	% FACTORED DAY	SEASONAL FACTOR
72	4	398	9.0%	387	9.0%	0.947

SEASONALLY FACTORED
ESTIMATED AADT
1-WAY COUNT
4554

ST. TOURING RTE **28** ON **ROUTE 28** FROM **RT 212 MT TREMPER** TO **RT 214 PHOENICIA**
STATION: **860230** COUNT DATE: **12/04/00** ST. DIR: **2** RECORDER PLACEMENT: **ROUTE 28**

STATE OF NEW YORK
DEPARTMENT OF TRANSPORTATION
ELEANOR ROOSEVELT STATE OFFICE BUILDING
4 BURNETT BOULEVARD
POUGHKEEPSIE, N.Y. 12603-2594

ROBERT A. DENNISION, P.E.
REGIONAL DIRECTOR

JOSEPH H. BOARDMAN
COMMISSIONER

FAX FROM PLANNING & PROGRAM MANAGEMENT

FAX #: (845) 431-7923

Date: 6/17/04

Message To: Brian Ketcham.

Message From: Akhtar Sharif.

Number of Pages: 12 (including cover)

Comments: If you have any questions. I can be reached at. (845)-431-5793.

IF THERE IS A PROBLEM WITH THIS TRANSMISSION PLEASE CALL (845) 431-5723

New York State Department of Transportation

PGM. VERSION 3.5 / 4.0

RC/STATION 930021

COVERAGE AND SPECIAL COUNT HOURLY REPORT

ST. TOURING RTE : 28 ROAD NAME : RTE 28 MILEPOINT 0210125 NHS 9 COUNTY : DELAWARE
SECTION FROM : ULSTER CO LINE TO : OLD RT 28 TOWN : MIDDLETOWN
FEDERAL DIR. 3 FACTOR GRP 40 FUNCTIONAL CLASS 06 HPMS NUMBER: BIN NUMBER:

COUNT DATE : 08/13/01 WEEK OF YR 33 RECORDER PLACEMENT: RTE 28 REFERENCE MKR: 28 93021011
RECORDER SERIAL #: 0671

NOTES: WEEK 33-EB TUBE COUNT ADDITIONAL DATA:

DY MO	D W	D R	12 TO 1	1 TO 2	2 TO 3	3 TO 4	4 TO 5	5 TO 6	6 TO 7	7 TO 8	8 TO 9	9 TO 10	10 TO 11	11 TO 12	12 TO 1	1 TO 2	2 TO 3	3 TO 4	4 TO 5	5 TO 6	6 TO 7	7 TO 8	8 TO 9	9 TO 10	10 TO 11	11 TO 12	DAY TOTAL	HI COUNT	HI HOUR
									AM												PM								
13	1	1												158	150	154	161	164	152	112	116	69	55	39	25	11			
14	2	1	11	3	5	6	12	42	72	100	98	143	128	138	138	144	127	135	146	120	100	80	52	29	32	22	1883	146	17
15	3	1	10	6	6	2	12	42	85	105	95	112	126	151	124	133	160	160	162	120	104	76	68	42	36	20	1957	162	17
16	4	1	6	11	5	5	18	38	84	96	111	106																	

AVERAGE WEEKDAY HOUR (MON 6AM THRU FRI 12 NOON)

																								ADT
9	7	5	4	14	41	80	100	101	120	127	149	137	144	149	153	153	117	107	75	58	37	31	18	1936

AXLE - FACTORED (VEHICLES) AVG WEEKDAY HOUR (FACTOR USED =0.959)

																								ADT
9	7	5	4	13	39	77	96	97	115	122	143	131	138	143	147	147	112	103	72	56	35	30	17	1858

HRS COUNTED	DAYS COUNTED	AVG HI HR	% AVG DAY	FACTORED HI HOUR	% FACTORED DAY	SEASONAL FACTOR
71	4	153	7.9%	147	7.9%	1.166

SEASONALLY FACTORED
ESTIMATED AADT
1-WAY COUNT
1591

ST. TOURING RTE 28 ON RTE 28 FROM ULSTER CO LINE TO OLD RT 28
STATION: 930021 COUNT DATE: 08/13/01 ST. DIR: 1 RECORDER PLACEMENT: RTE 28

New York State Department of Transportation

PGM. VERSION 3.5 / 4.0

RC/STATION **930021**

COVERAGE AND SPECIAL COUNT HOURLY REPORT

ST. TOURING RTE :	28	ROAD NAME :	RTE 28	MILEPOINT	0210125	NHS	9
SECTION FROM :	ULSTER CO LINE			TO :	OLD RT 28		
FEDERAL DIR.	7	FACTOR GRP	40	FUNCTIONAL CLASS	06	HPMS NUMBER:	
COUNT DATE :	08/13/01	WEEK OF YR	33	RECORDER PLACEMENT:	RTE 28		

COUNTY : **DELAWARE**
TOWN : **MIDDLETOWN**
BIN NUMBER:

REFERENCE MKR: **28 93021011**
RECORDER SERIAL #: **0671**
ADDITIONAL DATA:

NOTES: **WEEK 33-WB**

TUBE COUNT

DY MO	D W	D R	12 TO 1	1 TO 2	2 TO 3	3 TO 4	4 TO 5	5 TO 6	6 TO 7	7 TO 8	8 TO 9	9 TO 10	10 TO 11	11 TO 12	12 TO 1	1 TO 2	2 TO 3	3 TO 4	4 TO 5	5 TO 6	6 TO 7	7 TO 8	8 TO 9	9 TO 10	10 TO 11	11 TO 12	DAY TOTAL	HI COUNT	HI HOUR
									AM												PM								
13	1	2												151	132	142	151	182	170	138	118	62	64	49	40	26			
14	2	2	12	6	7	2	8	26	40	49	74	92	138	118	124	133	148	171	176	157	104	80	64	40	45	22	1836	176	17
15	3	2	21	6	8	1	6	13	48	58	92	110	144	154	124	144	140	212	179	168	104	71	87	70	56	36	2052	212	16
16	4	2	39	7	6	4	3	12	46	63	89	130																	

AVERAGE WEEKDAY HOUR (MON 6AM THRU FRI 12 NOON)

																								ADT
24	6	7	2	6	17	45	57	85	111	141	141	127	140	146	188	175	154	109	71	72	53	47	28	1952

AXLE - FACTORED (VEHICLES) AVG WEEKDAY HOUR (FACTOR USED = 0.959)

																								ADT
23	6	7	2	6	16	43	55	82	106	135	135	122	134	140	180	168	148	105	68	69	51	45	27	1873

HRS COUNTED	DAYS COUNTED	AVG HI HR	% AVG DAY	FACTORED HI HOUR	% FACTORED DAY	SEASONAL FACTOR
71	4	188	9.6%	180	9.6%	1.168

SEASONALLY FACTORED

ESTIMATED AADT
1-WAY COUNT
1604

ST. TOURING RTE	**28**	ON	**RTE 28**	FROM	**ULSTER CO LINE**	TO	**OLD RT 28**
STATION:	**930021**	COUNT DATE:	**08/13/01**	ST. DIR:	**2**	RECORDER PLACEMENT:	**RTE 28**

New York State Department of Transportation

PGM. VERSION 3.5/ 4.0

RC/STATION **860233**

COVERAGE AND SPECIAL COUNT HOURLY REPORT

ST. TOURING RTE :	**28**	ROAD NAME :	**RTE 28**	MILEPOINT	**0123579**	NHS	**9**
SECTION FROM :	**BIG INDIAN RD CR 47**			TO :	**DELAWARE CO LN**		
FEDERAL DIR.	**3**	FACTOR GRP	**40**	FUNCTIONAL CLASS	**06**	HPMS NUMBER:	

COUNTY : **ULSTER**
TOWN : **SHANDAKEN**
BIN NUMBER:

COUNT DATE : **04/09/01** WEEK OF YR **15** RECORDER PLACEMENT: **RTE 28**

REFERENCE MKR: **28 86012336**
RECORDER SERIAL #: **1395**
ADDITIONAL DATA:

NOTES: **WEEK 15-EB** **TUBE COUNT**

DY MO	D W	D R	12 TO 1	1 TO 2	2 TO 3	3 TO 4	4 TO 5	5 TO 6	6 TO 7	7 TO 8	8 TO 9	9 TO 10	10 TO 11	11 TO 12	12 TO 1	1 TO 2	2 TO 3	3 TO 4	4 TO 5	5 TO 6	6 TO 7	7 TO 8	8 TO 9	9 TO 10	10 TO 11	11 TO 12	DAY TOTAL	HI COUNT	HI HOUR
									AM												PM								
9	1	1											104	91	102	93	76	107	97	78	44	50	18	30	14	6			
10	2	1	4	2	8	6	16	34	88	102	106	95	90	97	100	103	88	92	82	86	76	45	29	19	13	16	1397	106	9
11	3	1	4	6	6	1	12	44	86	98	89	96	86	93	94	100	98	104	94	80	59	40	28	18	17	9	1372	104	16
12	4	1	6	2	7	2	16	36	66	93	108																		

AVERAGE WEEKDAY HOUR (MON 6AM THRU FRI 12 NOON)

																								ADT
5	3	7	3	15	38	80	98	101	96	97	94	99	99	87	101	91	81	60	45	25	22	15	10	1372

AXLE - FACTORED (VEHICLES) AVG WEEKDAY HOUR (FACTOR USED = 0.973)

																								ADT
5	3	7	3	15	37	78	95	98	93	94	91	96	96	85	98	89	79	58	44	24	21	15	10	1334

HRS COUNTED	DAYS COUNTED	AVG HI HR	% AVG DAY	FACTORED HI HOUR	% FACTORED DAY	SEASONAL FACTOR
71	4	101	7.4%	98	7.3%	0.992

SEASONALLY FACTORED
ESTIMATED AADT
1-WAY COUNT
1345

ST. TOURING RTE **28** ON **RTE 28** FROM **BIG INDIAN RD CR 47** TO **DELAWARE CO LN**
STATION: **860233** COUNT DATE: **04/09/01** ST. DIR: **1** RECORDER PLACEMENT: **RTE 28**

New York State Department of Transportation

PGM. VERSION 3.5 / 4.0

RC/STATION 860231

COVERAGE AND SPECIAL COUNT HOURLY REPORT

ST. TOURING RTE : 28 ROAD NAME : RTE 28 MILEPOINT 0122852 NHS 9 COUNTY : ULSTER
SECTION FROM : RT 214 PHOENICIA TO : RT 42 SHANDAKEN TOWN : SHANDAKEN
FEDERAL DIR. 3 FACTOR GRP 40 FUNCTIONAL CLASS 06 HPMS NUMBER: BIN NUMBER:

COUNT DATE : 05/06/02 WEEK OF YR 19 RECORDER PLACEMENT: RTE 28 REFERENCE MKR: 28 86032259
RECORDER SERIAL #: 1015
NOTES: WEEK 19-EB TUBE COUNT ADDITIONAL DATA:

DY MO	D W	D R	12 TO 1	1 TO 2	2 TO 3	3 TO 4	4 TO 5	5 TO 6	6 TO 7 AM	7 TO 8	8 TO 9	9 TO 10	10 TO 11	11 TO 12	12 TO 1	1 TO 2	2 TO 3	3 TO 4	4 TO 5	5 TO 6	6 TO 7 PM	7 TO 8	8 TO 9	9 TO 10	10 TO 11	11 TO 12	DAY TOTAL	HI COUNT	HI HOUR
6	1	1														156	142	180	176	142	112	73	74	35	21	12			
7	2	1	7	6	6	8	24	70	136	225	177	173	154	158	160	158	120	146	164	160	116	68	46	34	30	14	2360	225	8
8	3	1	10	10	3	7	29	57	146	220	164	135	149	154	145	142	132	174	164	122	124	76	48	49	18	10	2288	220	8
9	4	1	4	8	4	6	18	56	164	192	188	192	124																

AVERAGE WEEKDAY HOUR (MON 6AM THRU FRI 12 NOON)

																								ADT
7	8	4	7	24	61	149	212	176	167	142	156	153	152	131	167	168	141	117	72	56	39	23	12	2344

AXLE - FACTORED (VEHICLES) AVG WEEKDAY HOUR (FACTOR USED = 0.973)

																								ADT
7	8	4	7	23	59	145	206	171	162	138	152	149	148	127	162	163	137	114	70	54	38	22	12	2278

HRS COUNTED	DAYS COUNTED	AVG HI HR	% AVG DAY	FACTORED HI HOUR	% FACTORED DAY	SEASONAL FACTOR
70	4	212	9.0%	206	9.0%	1.070

SEASONALLY FACTORED
ESTIMATED AADT
1-WAY COUNT
2129

ST. TOURING RTE 28 ON RTE 28 FROM RT 214 PHOENICIA TO RT 42 SHANDAKEN
STATION: 860231 COUNT DATE: 05/06/02 ST. DIR: 1 RECORDER PLACEMENT: RTE 28

New York State Department of Transportation

PGM. VERSION 3.5 / 4.0

RC/STATION 860233

COVERAGE AND SPECIAL COUNT HOURLY REPORT

ST. TOURING RTE : 28 ROAD NAME : RTE 28 MILEPOINT 0123579 NHS 9 COUNTY : ULSTER
SECTION FROM : BIG INDIAN RD CR 47 TO : DELAWARE CO LN TOWN : SHANDAKEN
FEDERAL DIR. 7 FACTOR GRP 40 FUNCTIONAL CLASS 06 HPMS NUMBER: BIN NUMBER:

COUNT DATE : 04/09/01 WEEK OF YR 15 RECORDER PLACEMENT: RTE 28 REFERENCE MKR: 28 86012336
RECORDER SERIAL #: 1395

NOTES: WEEK 15-WB

TUBE COUNT

ADDITIONAL DATA:

DY MO	D W	D R	12 TO 1	1 TO 2	2 TO 3	3 TO 4	4 TO 5	5 TO 6	6 TO 7 AM	7 TO 8	8 TO 9	9 TO 10	10 TO 11	11 TO 12	12 TO 1	1 TO 2	2 TO 3	3 TO 4	4 TO 5	5 TO 6	6 TO 7 PM	7 TO 8	8 TO 9	9 TO 10	10 TO 11	11 TO 12	DAY TOTAL	HI COUNT	HI HOUR
9	1	2											72	78	100	90	88	102	122	144	94	49	34	38	22	20			
10	2	2	12	6	4	1	3	14	18	56	44	56	78	84	91	96	88	118	144	136	102	48	32	52	34	24	1343	144	17
11	3	2	12	12	3	3	3	12	18	48	52	84	60	82	99	99	98	124	126	138	112	80	48	59	26	13	1409	138	18
12	4	2	7	6	4	1	4	12	24	52	73																		

AVERAGE WEEKDAY HOUR (MON 6AM THRU FRI 12 NOON)

																								ADT
10	8	4	2	3	13	20	52	56	70	70	81	97	95	91	115	131	140	103	59	38	50	27	19	1354

AXLE - FACTORED (VEHICLES) AVG WEEKDAY HOUR (FACTOR USED =0.973)

																								ADT
10	8	4	2	3	13	19	51	54	68	68	79	94	92	89	112	127	136	100	57	37	49	26	18	1316

HRS COUNTED	DAYS COUNTED	AVG HI HR	% AVG DAY	FACTORED HI HOUR	% FACTORED DAY	SEASONAL FACTOR
71	4	140	10.3%	136	10.3%	0.992

SEASONALLY FACTORED
ESTIMATED AADT
1-WAY COUNT
1327

ST. TOURING RTE 28 ON RTE 28 FROM BIG INDIAN RD CR 47 TO DELAWARE CO LN
STATION: 860233 COUNT DATE: 04/09/01 ST. DIR: 2 RECORDER PLACEMENT: RTE 28

New York State Department of Transportation

PGM. VERSION 3.5 / 4.0

RC/STATION **860231**

COVERAGE AND SPECIAL COUNT HOURLY REPORT

ST. TOURING RTE : **28** ROAD NAME : **RTE 28** MILEPOINT **0122852** NHS **9** COUNTY : **ULSTER**
SECTION FROM : **RT 214 PHOENICIA** TO : **RT 42 SHANDAKEN** TOWN : **SHANDAKEN**
FEDERAL DIR. **7** FACTOR GRP **40** FUNCTIONAL CLASS **06** HPMS NUMBER: BIN NUMBER:

COUNT DATE : **05/06/02** WEEK OF YR **19** RECORDER PLACEMENT: **RTE 28** REFERENCE MKR: **28 86032259**
RECORDER SERIAL #: **1015**
NOTES: **WEEK 19-WB** **TUBE COUNT** ADDITIONAL DATA:

DY MO	D W	D R	12 TO 1	1 TO 2	2 TO 3	3 TO 4	4 TO 5	5 TO 6	6 TO 7	7 TO 8	8 TO 9	9 TO 10	10 TO 11	11 TO 12	12 TO 1	1 TO 2	2 TO 3	3 TO 4	4 TO 5	5 TO 6	6 TO 7	7 TO 8	8 TO 9	9 TO 10	10 TO 11	11 TO 12	DAY TOTAL	HI COUNT	HI HOUR
								AM												PM									
6	1	2														152	180	209	236	216	166	145	109	82	40	38			
7	2	2	22	10	8	8	7	24	60	96	109	106	124	122	153	146	173	224	228	211	164	154	106	96	75	38	2464	228	17
8	3	2	26	10	7	10	6	26	55	87	103	114	144	132	146	134	156	211	241	224	192	132	130	99	73	30	2492	241	17
9	4	2	24	9	7	4	3	20	64	82	104	134	108																

AVERAGE WEEKDAY HOUR (MON 6AM THRU FRI 12 NOON) ADT
25 10 7 7 5 23 60 88 105 118 125 127 150 144 170 215 236 217 174 144 115 92 63 35 2455

AXLE - FACTORED (VEHICLES) AVG WEEKDAY HOUR (FACTOR USED = 0.973) ADT
24 10 7 7 5 22 58 86 102 115 122 124 146 140 165 209 230 211 169 140 112 90 61 34 2389

HRS COUNTED	DAYS COUNTED	AVG HI HR	% AVG DAY	FACTORED HI HOUR	% FACTORED DAY	SEASONAL FACTOR
70	4	236	9.6%	230	9.6%	1.070

SEASONALLY FACTORED
ESTIMATED AADT
1-WAY COUNT
2233

ST. TOURING RTE **28** ON **RTE 28** FROM **RT 214 PHOENICIA** TO **RT 42 SHANDAKEN**
STATION: **860231** COUNT DATE: **05/06/02** ST. DIR: **2** RECORDER PLACEMENT: **RTE 28**

STATION: 860230

New York State Department of Transportation

Traffic Count Hourly Report

Page 1 of 2

ROUTE/RD #: NY 28 ROAD NAME: Rte 28
DIRECTION: Northbound FACTOR GROUP: 40
STATE DIR CODE: 1 WK OF YR: 18
DATE OF COUNT: 04/28/2003
NOTES: Week 18-Nb

FROM: RT 212 MT TREMPER
REC. SERIAL #: 0458
PLACEMENT: Rte 28
@ REF MARKER: 28 86012222
COUNT TYPE: AXLE PAIRS ADDL DATA:

TO: RT 214 PHOENICIA
FUNC. CLASS: 06
NHS: yes
JURIS: Other
COUNT TAKEN BY: JSV

COUNTY: Ulster
TOWN: SHANDAKEN
BIN:
RR CROSSING:
HPMS SAMPLE:

DATE	DAY	12 TO 1	1 TO 2	2 TO 3	3 TO 4	4 TO 5	5 TO 6	6 TO 7	7 TO 8	8 TO 9	9 TO 10	10 TO 11	11 TO 12	12 TO 1	1 TO 2	2 TO 3	3 TO 4	4 TO 5	5 TO 6	6 TO 7	7 TO 8	8 TO 9	9 TO 10	10 TO 11	11 TO 12	DAILY TOTAL	DAILY HIGH COUNT	DAILY HIGH HOUR
		AM												PM														
28	M												188	166	167	182	233	280	295	244	144	117	84	69	46			
29	T	24	18	11	7	0	12	51	100	134	153	146	129	169	179	212	249	301	261	234	142	107	122	68	47	2876	301	16
30	W	41	13	7	4	2	13	49	109	130	169	112	152	167	200	214	266	310	293	232	202	154	130	91	58	3118	310	16
1	T	50	18	18	3	13	24	44	104	148	170	146	166	198	190	237	244	312	313	247	187	145	142	107	68	3294	313	17
2	F	48	26	7	13	9	21	53	97	161	177																	

AVERAGE WEEKDAY HOURS (Axle Factored, Mon 6AM to Fri Noon)

																								ADT
39	18	11	7	6	17	47	98	137	160	130	148	168	177	203	235	269	278	228	182	126	115	81	53	2937

DAYS Counted	HOURS Counted	WEEKDAYS Counted	WEEKDAY Hours	AVERAGE WEEKDAY High Hour	AVERAGE WEEKDAY % of day	Axle Adj. Factor	Seasonal/Weekday Adjustment Factor
5	95	5	95	301	10%	0.960	0.955

ESTIMATED (one way)

AADT
3075

46

COMMUNITY
CONSULTING
SERVICES INC.

HIDDEN COSTS OF ADDED TRAFFIC FROM BELLEAYRE RESORT WILL EXCEED LOCAL ECONOMIC BENEFITS

Sometime after 2014, when the construction of the proposed Belleayre Resort is scheduled to be completed, everyone using the Route 28 corridor will bear some portion of the costs of added Resort traffic. These local hidden costs, totaling $16.2 million a year, will exceed the $16 million a year in off-site spending in the corridor (for other than gasoline) projected in the DEIS by Resort visitors and employees and by others with new jobs resulting from the added business.[1] Both estimates assume 85% occupancy 300 days a year[2]. The cost of trips that begin or end outside the region is more than twice as much, $44 million annually.

The hidden costs to motorists, their passengers, and visitors and residents of the area due to increased vehicular use include the costs of lost travel time, physical injury, heath effects, noise impacts, damage to our roads and utilities. Other costs are paid through taxes such as the control of water pollution, oil spills, greenhouse emissions, the lost value of highway land removed from tax rolls, and, most apparent today, the foreign policy and defense costs of protecting the supply of imported oil. These harms to society and to households and the general economy are not well recognized by the public because they increase by a small margin with each added mile of travel and because they are spread among the entire public, both vehicle users and non users, buried in items such as lower productivity, higher consumer prices and higher insurance costs. But taking them together, even using a low range of vehicle related costs due to Resort car and truck use greatly reduce the realistic local economic benefits of the Resort. The costs are based on the well-documented costs per vehicle mile travel published by the Victoria Transport Policy Institute (VTPI).[3]

A companion Route 28 corridor analysis indicates that the cost of added travel time due to Resort traffic may be twice as great as shown here, over $2 million a year, because it appears that the DEIS erred in basing its impact analysis on ski days, when State data show summer travel is about double winter conditions.

The externality costs of vehicle use for the Belleayre Resort are summarized in Table 1, with back-up on how these costs were derived in Tables 2 and 3. They were derived by estimating travel associated with the Belleayre Resort and multiplying the miles per year for roadway sections by VTPI's cost factors, appended.[4] Since VTPI's figures are based on nationwide averages and do not take into account New York's much greater cost of living; they err by being on the low side. They do not differentiate by vehicle type and only provide for two types of travel: urban and rural. Rural roads, like Route 28, have more frequent and severe accidents than do expressways. These costs also do not account for the high proportion of SUVs in the Route 28 corridor, which produce more severe accidents and higher emissions and more noise.

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[1] It is assumed that 90% of $3,466,789 for Automotive Services goes to non-local suppliers of gasoline, so $3.1 million is deducted from $19.1 million of Corridor Expenditures (DEIS, Table 7-1).

[2] Sales depend on the additional uncertainty assumed in the DEIS that time share owners with average household incomes of $71,000 will spend an average of $170/day in the corridor.

[3] Littman, T., "Transportation Cost and Benefit Analysis, Techniques, Estimates and Implications," Tables 6, 7 and 8, Victoria Transport Policy Institute, June 2003, www.vtpi.org/htm .

[4] The exception is travel time cost, which for Route 28 uses VTPI's Urban Off Peek factor to approximate the delays that are calculated in a Route 28 corridor analysis by Brian Ketcham,

Added Travel Time Costs

New York State's urbanized areas already suffer heavily from too many cars and trucks trying to move on its limited roadway system. Congestion losses, in terms of reduced productivity for businesses – wasted time for all motorists – are huge. For the Belleayre Resort, with most of the travel in rural areas, the cost of slower travel as a result of adding nearly 77 million miles of travel totals more than $4 million a year; and for the Route 28 corridor alone, using the VPTI factors, totals more than $1 million.[5] As noted above, a more detailed travel time analysis of Route 28 doubles this cost, assuming a value of $10 an hour for 6,000 lost person hours over 40 days a year. The longer trips are the added costs imposed on all motorists and their passengers as a consequence of the Resort project.

Air Pollution

all Related to NYCity

Much of New York State (most in the New York City metro area) will continue to be in severe non-attainment for safe levels of ozone and fine particulate emissions for the foreseeable future. Cars and trucks cause more than half the state's ozone problem. Motor vehicles also cause half of New York's toxic air pollutants, including fine particulate emissions at street level from diesel trucks and buses. Auto pollution attacks the human respiratory system, causing serious health problems, especially among the young and old for people suffering from chronic respiratory disorders such as asthma. Asthma is the biggest cause of school absenteeism in the nation and is several times more prevalent in New York's low-income areas. Diesel particulates are known to cause cancer. Acid rain eats away at New York's buildings along with harming the State's wildlife and food crops.

Ulster/Delaware City
attainment CO
O2

While new car technology is helping to reduce tailpipe emissions, these gains are overwhelmed by the increase in car and truck use and the growth in SUVs. In order to meet federal clean air health standards, New York must reduce vehicular activity by about 1% per year from 1990 levels. Instead, car and truck use state wide is actually growing by more than 2% per year. Any action that will increase auto use will undermine this goal. The health and property damage from automotive air pollution resulting from the Belleayre Resort will total about $3 million annually of which nearly $1 million will occur in the Route 28 corridor.

Vehicular Noise

Traffic noise is perhaps the most pervasive automotive irritant to most New Yorkers. It is hard to find a place you cannot hear cars and trucks roaring by, especially along Route 28. The result is loss of sleep, inability to concentrate, reduced productivity and general irritability. The cost, in terms of damage to health and lost productivity, will total about three-quarters of a million dollars in losses each year because of the Belleayre Resort, with $280,000 annually of these noise related health costs in the Route 28 corridor.

Accident Costs

benefit(s) of improvements - signal + lanes

The most costly harms produced by cars and trucks are the physical damage to human bodies and property. Traffic accidents, death, injury and property damage will total about $15 million in losses each year as a consequence of adding 77 million more miles of travel because of the Belleayre Resort. About a third of these costs are not borne by accident insurance. They constitute losses to businesses which suffer lost productivity, including the need to hire and train additional staff, and the pain and suffering of accident victims themselves, a large proportion of whom are non-motorists in New York State. As noted, car and truck mileage associated with the Belleayre Resort will total about 77 million miles

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[5] See Tables 4 and 5 for the derivation of Belleayre Resort miles of travel.

of travel annually. Using state wide average accident rates, this traffic will result in one more death, 37 injuries and 113 property damage only accidents. For the Route 28 corridor alone, there is likely to be one death every two years, 23 injuries and 67 property damage only accidents at a total cost along Route 28 of a little more than $6 million annually.

Roadway Damage
Heavy trucks barreling along on New York State's crumbling roads cause damage both to the roadway surface and utilities under the road and vibration damage to nearby buildings. Heavy trucks servicing the Belleayre Resort will be responsible for most of the approximately $1.5 million in pavement wear and tear damages on roads to and from the project. Moreover, New York State's deteriorated surfaces in turn will cause motorists to suffer another $900,000 in vehicle damage each year (much of this cost is payments to auto repair shops). For the Route 28 corridor, the Belleayre Resort will add nearly $560,000 a year in pavement damage and nearly $280,000 a year in costs to those traveling along Route 28 and its local feeder roads.

Other Major Societal Costs
And, there are other costs that have not been individually quantified in dollar terms: storm water runoff of road salts and toxic organics that are a major source of water pollution, the damage and clean up costs of oil spills, greenhouse effects of vehicular emissions, the value of land devoted to highways and removed from our tax roles, the value of unpaid parking of cars and trucks which amount to untaxed subsidies to motorists, the cost of disposing of ten million car and truck chassis and a quarter billion tires each year nationwide, the social costs to those deprived of auto access, the foreign policy and defense costs of protecting our supplies of imported oil (the current Iraq war), and a similar array of hidden costs due to the manufacture of vehicles and the storage and refinement of petroleum products. Taken together, these additional costs total more than $19 million a year in damages to the region's economy and to its citizens ($7 million of which is along the Route 28 corridor).

Brian T. Ketcham, P.E.
Community Consulting Services, Inc.
June 14, 2004

TABLE 1

ANNUAL EXTERNALITY COSTS OF THE BELLEAYRE RESORT, 2014
SUMMARY OF RESULTS

	ROUTE 28 CORRIDOR EFFECTS ONLY	BELEAYRE RESORT TOTAL TRAVEL IMPACTS
Pavement Wear & Tear	$560,224	$1,486,166
Vehicular Wear & Tear Costs	$280,112	$894,556
Added Travel Time Costs	$1,015,405	$4,137,834
Air Pollution	$910,363	$3,086,321
Noise Impacts	$280,112	$784,394
Accident Costs, Internal	$4,201,677	$9,893,148
Accident Costs, External	$1,960,783	$4,719,621
Other Externality Costs	$7,002,795	$19,238,046
TOTALS	$16,211,471	$44,240,085

Community Consulting Services, June 14, 2004

TABLE 2

ANNUAL EXTERNALITY COSTS OF THE BELLEAYRE RESORT, 2014

	Urban Peak	Urban Off-Peak	Rural Travel	TOTALS
Vehicle Miles Traveled	6,259,219	6,259,219	64,098,778	76,617,216
Resulting externality Costs				
Pavement Wear & Tear	$179,014	$179,014	$1,128,138	$1,486,166
Vehicular Wear & Tear Costs	$165,243	$165,243	$564,069	$894,556
Added Travel Time Costs	$1,872,758	$220,325	$2,044,751	$4,137,834
Air Pollution	$681,629	$571,467	$1,833,225	$3,086,321
Noise Impacts	$110,162	$110,162	$564,069	$784,394
Accident Costs, Internal	$605,892	$826,217	$8,461,039	$9,893,148
Accident Costs, External	$385,568	$385,568	$3,948,485	$4,719,621
Other Externality Costs	$3,057,003	$2,079,313	$14,101,731	$19,238,046
SUBTOTALS	$7,057,269	$4,537,308	$32,645,508	$44,240,085

Externality Cost Factors Per Vehicle Mile of Travel, 2014

	Urban Peak	Urban Off-Peak	Rural Travel
Pavement Wear & Tear	$0.026	$0.026	$0.016
Vehicular Wear & Tear Costs	$0.024	$0.024	$0.008
Added Travel Time Costs	$0.272	$0.032	$0.029
Air Pollution	$0.099	$0.083	$0.026
Noise Impacts	$0.016	$0.016	$0.008
Accident Costs, Internal	$0.088	$0.120	$0.120
Accident Costs, External	$0.056	$0.056	$0.056
Other Externality Costs	$0.444	$0.302	$0.200

Truck adjustment factor: 1.1 (to adjust for the very much higher truck cost factors)
Externality cost factors derived from "Transportation Cost and Benefit Analysis, Techniques, Estimates and Implications," Victoria Transport Policy Institute, June 2003, except for rural congestion costs that were derived for the Rt. 28 corridor.
Community Consulting Services, June 14, 2004

TABLE 3

ANNUAL EXTERNALITY COSTS OF THE BELLEAYRE RESORT, 2014, ROUTE 28 CORRIDOR ONLY

	Urban Peak	Urban Off-Peak	Rural Travel	TOTALS
Vehicle Miles Traveled	0	0	31,830,887	31,830,887
Resulting externality Costs				
Pavement Wear & Tear	$0	$0	$560,224	$560,224
Vehicular Wear & Tear Costs	$0	$0	$280,112	$280,112
Added Travel Time Costs	$0	$0	$1,015,405	$1,015,405
Air Pollution	$0	$0	$910,363	$910,363
Noise Impacts	$0	$0	$280,112	$280,112
Accident Costs, Internal	$0	$0	$4,201,677	$4,201,677
Accident Costs, External	$0	$0	$1,960,783	$1,960,783
Other Externality Costs	$0	$0	$7,002,795	$7,002,795
SUBTOTALS	$0	$0	$16,211,471	$16,211,471

	Urban Peak	Urban Off-Peak	Rural Travel
	Externality Cost Factors Per Vehicle Mile of Travel, 2014		
Pavement Wear & Tear	$0.026	$0.026	$0.016
Vehicular Wear & Tear Costs	$0.024	$0.024	$0.008
Added Travel Time Costs	$0.272	$0.032	$0.029
Air Pollution	$0.099	$0.083	$0.026
Noise Impacts	$0.016	$0.016	$0.008
Accident Costs, Internal	$0.088	$0.120	$0.120
Accident Costs, External	$0.056	$0.056	$0.056
Other Externality Costs	$0.444	$0.302	$0.200

Truck adjustment factor: 1.1 (to adjust for the very much higher truck cost factors)

Externality cost factors derived from "Transportation Cost and Benefit Analysis, Techniques, Estimates and Implications," Victoria Transport Policy Institute, June 2003, except for rural congestion costs that were derived for the Rt. 28 corridor.

Community Consulting Services, June 14, 2004

TABLE 4

ATTENDANCE AT BELLEAYRE RESORT (FULL PROJECT IMPACTS)

							Weekly		
						VMT Local	VMT Nearby	VMT NYC	
	Prop. Sat.		% Local	% New	% NYC	8	50	150	TOTAL
Monday	0.4	2560	60%	40%	20%	12,288	25,600	76,800	114,688
Tuesday	0.5	3200	60%	40%	20%	15,360	32,000	96,000	143,360
Wednesday	0.5	3200	60%	40%	20%	15,360	32,000	96,000	143,360
Thursday	0.6	3840	60%	40%	20%	18,432	38,400	115,200	172,032
Friday	0.7	4480	50%	50%	30%	17,920	44,800	201,600	264,320
Saturday	1	6400	50%	50%	30%	25,600	64,000	288,000	377,600
Sunday	0.9	5760	60%	40%	20%	27,648	57,600	172,800	258,048
	4.6	29440			Annual VMT	6,895,616	15,308,800	54,412,800	76,617,216
			PROP LOCAL ROADS			1	0.7	0.25	
			LOCAL VMT			6,206,054	8,572,928	13,603,200	28,382,182
			LOCAL ARTERIAL			689,562	2,143,232	2,143,232	4,976,026
			EXPRESSWAYS			0	4,592,640	38,666,368	43,259,008
			URBAN EXP				918,528	11,599,910	12,518,438
			RURAL EXP				3,674,112	27,066,458	30,740,570
			TOTALS			6,895,616	15,308,800	54,412,800	76,617,216

ACCIDENT COSTS ASSOCIATED WITH THE FULL (85%) OCCUPANCY OF THE BELLEAYRE RESORT (FULL PROJECT IMPACTS)

		Accident Rates/MVM			Accidents per Year			TOTALS
Roadway Type	Ann. VMT	Death	Injury	PDO	Death	Injury	PDO	
Rural Local Road	28382000	0.02	0.72	2.07	0.57	20.5	58.7	
Rural Local Arterial	4976000	0.02	0.82	2.34	0.11	4.1	11.6	
Rural Expressway	30740600	0.002	0.20	0.89	0.05	6.2	27.3	
Urban Expressway	12518400	0.005	0.53	1.25	0.06	6.6	15.6	
TOTALS	76617000				0.79	37	113	
		Cost per Accident			Total Annual Accident Costs			
Rural Local Road		$3,287,200	$92,700	$5,200	$1,861,375	$1,900,038	$305,232	$4,066,644
Rural Local Arterial		$3,287,200	$92,700	$5,200	$369,311	$376,982	$60,560	$806,853
Rural Expressway		$3,245,600	$94,000	$5,200	$174,002	$582,691	$141,830	$898,522
Urban Expressway		$3,435,500	$94,500	$3,800	$214,347	$623,293	$59,441	$897,081
TOTAL COST					$2,619,034	$3,483,004	$567,064	$6,669,101

Source of accident rates and value per accident/injury: New York State Department of Transportation web site. 2002 $'s.

Community Consulting Services (5/25/04)

TABLE 5

ATTENDANCE AT BELLEAYRE RESORT (ROUTE 28 CORRIDOR ONLY)

						VMT Local	VMT Nearby	VMT NYC	
	Prop. Sat.		% Local	% New	% NYC	8	35	39	TOTAL
Monday	0.4	2560	0.6	0.4	0.2	12,288	17,920	19,968	50,176
Tuesday	0.5	3200	0.6	0.4	0.2	15,360	22,400	24,960	62,720
Wednesday	0.5	3200	0.6	0.4	0.2	15,360	22,400	24,960	62,720
Thursday	0.6	3840	0.6	0.4	0.2	18,432	26,880	29,952	75,264
Friday	0.7	4480	0.5	0.5	0.3	17,920	31,360	52,416	101,696
Saturday	1	6400	0.5	0.5	0.3	25,600	44,800	74,880	145,280
Sunday	0.9	5760	0.6	0.4	0.2	27,648	40,320	44,928	112,896
	4.6	29440				6,895,616	10,716,160	14,147,328	31,759,104
PROP LOCAL ROADS						1	1	1	
LOCAL VMT						6,206,054	9,532,989	12,585,322	28,324,364
LOCAL ARTERIAL						761,345	1,183,171	1,562,006	3,506,523
EXPRESSWAYS						0	0	0	0
URBAN EXP							0	0	0
RURAL EXP							0	0	0
TOTALS						6,987,399	10,716,160	14,147,328	31,830,887

ACCIDENT COSTS ASSOCIATED WITH THE FULL (85%) OCCUPANCY OF THE BELLEAYRE RESORT, ROUTE 28 CORRIDOR ONLY

		Accident Rates/MVM			Accidents per Year			TOTALS
Roadway Type	Ann. VMT	Death	Injury	PDO	Death	Injury	PDO	
Rural Local Road	28,324,364	0.02	0.72	2.07	0.57	20.5	58.6	
Rural Local Arterial	3,506,523	0.02	0.82	2.34	0.08	2.9	8.2	
Rural Expressway	0	0.002	0.20	0.89	0.00	0.0	0.0	
Urban Expressway	0	0.005	0.53	1.25	0.00	0.0	0.0	
TOTALS	31,830,887				0.64	23	67	
		Cost per Accident			Total Annual Accident Costs			
Rural Local Road		$3,287,200	$92,700	$5,200	$1,857,595	$1,896,179	$304,612	$4,058,386
Rural Local Arterial		$3,287,200	$92,700	$5,200	$260,249	$265,654	$42,676	$568,579
Rural Expressway		$3,245,600	$94,000	$5,200	$0	$0	$0	$0
Urban Expressway		$3,435,500	$94,500	$3,800	$0	$0	$0	$0
TOTAL COST					$2,117,843	$2,161,833	$347,289	$4,626,965

Source of accident rates and value per accident/injury: New York State Department of Transportation web site. 2002 $'s.

Community Consulting Services (6/14/04)

Table 6, Urban Peak

2014 U.S. Dollars per mile

Mode	Average Car	Compact Car	Electric Car	Van or Pickup	Rideshare Passenger	Diesel Bus	Electric Trolley	Motor-cycle	Bicycle	Walk	Telework	Distribution
Average Occupancy	1.1	1.1	1.1	1.1	1	25	30	[illegible]	1	1	1	
Vehicle Ownership	0.330	0.290	0.413	0.429	0.000	0.000	0.000	0.403	0.080	0.000	0.320	Internal-Fixed
Vehicle Operation	0.235	0.171	0.331	0.331	0.005	8.400	14.400	0.099	0.032	0.064	0.000	Internal-Variable
Operating Subsidy	0.000	0.000	0.000	0.000	0.000	10.000	13.920	0.000	0.000	0.000	0.000	External
Travel Time	0.405	0.405	0.405	0.405	0.288	14.000	16.800	0.668	0.560	1.600	0.000	Internal-Variable
Internal Crash	0.088	0.097	0.088	0.088	0.080	0.120	0.144	0.399	0.080	0.080	0.000	Internal-Variable
External Crash	0.056	0.053	0.056	0.056	0.000	0.320	0.320	0.123	0.003	0.003	0.000	External
Internal Parking	0.080	0.072	0.080	0.080	0.000	0.000	0.000	0.064	0.005	0.000	0.000	Internal-Fixed
External Parking	0.192	0.182	0.192	0.192	0.000	0.000	0.000	0.144	0.010	0.000	0.000	External
Congestion	0.272	0.272	0.272	0.272	0.000	0.544	0.544	0.272	0.014	0.005	0.000	External
Road Facilities	0.026	0.026	0.061	0.034	0.000	0.112	0.112	0.014	0.002	0.002	0.000	External
Land Value	0.038	0.038	0.038	0.038	0.000	0.038	0.038	0.038	0.002	0.002	0.000	External
Traffic Services	0.024	0.024	0.024	0.024	0.000	0.024	0.024	0.024	0.003	0.003	0.003	External
Transport Diversity	0.008	0.008	0.008	0.008	0.000	0.000	0.000	0.006	0.000	0.000	0.000	External
Air Pollution	0.099	0.082	0.026	0.179	0.003	0.296	0.125	0.170	0.000	0.000	0.000	External
Noise	0.016	0.016	0.005	0.016	0.000	0.080	0.048	0.160	0.000	0.000	0.000	External
Resource Externalities	0.046	0.022	0.011	0.062	0.002	0.243	0.072	0.019	0.000	0.000	0.005	External
Barrier Effect	0.024	0.024	0.024	0.024	0.000	0.061	0.061	0.024	0.002	0.000	0.000	External
Land Use Impacts	0.112	0.112	0.112	0.112	0.000	0.000	0.000	0.112	0.000	0.000	0.112	External
Water Pollution	0.021	0.021	0.011	0.021	0.000	0.021	0.011	0.021	0.000	0.000	0.000	External
Waste	0.003	0.003	0.003	0.003	0.000	0.003	0.003	0.003	0.000	0.000	0.000	External
Internal Fixed	*0.410*	*0.362*	*0.493*	*0.509*	*0.000*	*0.000*	*0.000*	*0.467*	*0.085*	*0.000*	*0.320*	
Internal Variable	*0.728*	*0.673*	*0.824*	*0.824*	*0.373*	*22.520*	*31.344*	*1.166*	*0.672*	*1.744*	*0.000*	
External	*0.938*	*0.883*	*0.843*	*1.042*	*0.005*	*11.742*	*15.278*	*1.133*	*0.035*	*0.014*	*0.120*	
Totals	*2.075*	*1.918*	*2.160*	*2.374*	*0.378*	*34.262*	*46.622*	*2.766*	*0.792*	*1.758*	*0.440*	

Community Consulting Services, June 10, 2004

Table 7, Urban Off-Peak ***2014 U.S. Dollars per mile***

Mode	Average Car	Compact Car	Electric Car	Van or Pickup	Rideshare Passenger	Diesel Bus	Electric Trolley	Motor-cycle	Bicycle	Walk	Telework	Distribution
Average Occupancy	1.5	1.5	1.5	1.5	1	8	10	1	1	1	1	
Vehicle Ownership	0.330	0.290	0.413	0.429	0.000	0.000	0.000	0.403	0.080	0.000	0.320	Internal-Fixed
Vehicle Operation	0.205	0.149	0.288	0.288	0.005	1.680	3.840	0.086	0.032	0.064	0.000	Internal-Variable
Operating Subsidy	0.000	0.000	0.000	0.000	0.000	3.200	4.640	0.000	0.000	0.000	0.000	External
Travel Time	0.408	0.408	0.408	0.408	0.246	3.584	4.480	0.272	0.480	1.600	0.000	Internal-Variable
Internal Crash	0.120	0.132	0.120	0.120	0.080	0.038	0.048	0.699	0.080	0.080	0.000	Internal-Variable
External Crash	0.056	0.053	0.056	0.056	0.000	0.320	0.320	0.123	0.003	0.003	0.000	External
Internal Parking	0.080	0.072	0.080	0.080	0.000	0.000	0.000	0.064	0.005	0.000	0.000	Internal-Fixed
External Parking	0.064	0.061	0.064	0.064	0.000	0.000	0.000	0.048	0.003	0.000	0.000	External
Congestion	0.032	0.032	0.032	0.032	0.000	0.064	0.064	0.032	0.002	0.002	0.000	External
Road Facilities	0.026	0.026	0.061	0.034	0.000	0.112	0.112	0.014	0.002	0.002	0.000	External
Land Value	0.038	0.038	0.038	0.038	0.000	0.038	0.038	0.038	0.002	0.002	0.000	External
Traffic Services	0.016	0.016	0.016	0.016	0.000	0.016	0.016	0.016	0.002	0.002	0.002	External
Transport Diversity	0.008	0.008	0.008	0.008	0.000	0.000	0.000	0.008	0.000	0.000	0.000	External
Air Pollution	0.083	0.067	0.021	0.150	0.003	0.258	0.104	0.138	0.000	0.000	0.000	External
Noise	0.016	0.016	0.005	0.016	0.000	0.080	0.048	0.160	0.000	0.000	0.000	External
Resource Externalities	0.040	0.021	0.010	0.053	0.002	0.210	0.061	0.016	0.000	0.000	0.005	External
Barrier Effect	0.016	0.016	0.016	0.016	0.000	0.040	0.040	0.016	0.000	0.000	0.000	External
Land Use Impacts	0.112	0.112	0.112	0.112	0.000	0.000	0.000	0.112	0.000	0.000	0.112	External
Water Pollution	0.021	0.021	0.011	0.021	0.000	0.021	0.011	0.021	0.000	0.000	0.000	External
Waste	0.003	0.003	0.003	0.003	0.000	0.003	0.003	0.003	0.000	0.000	0.000	External
Internal Fixed	*0.410*	*0.362*	*0.493*	*0.509*	*0.000*	*0.000*	*0.000*	*0.467*	*0.085*	*0.000*	*0.320*	
Internal Variable	*0.733*	*0.689*	*0.816*	*0.816*	*0.331*	*5.302*	*8.368*	*1.058*	*0.592*	*1.744*	*0.000*	
External	*0.531*	*0.490*	*0.453*	*0.619*	*0.005*	*4.360*	*5.458*	*0.746*	*0.013*	*0.010*	*0.118*	
Totals	*1.674*	*1.540*	*1.762*	*1.944*	*0.336*	*9.662*	*13.826*	*2.270*	*0.690*	*1.754*	*0.438*	

Community Consulting Services, June 10, 2004

Table 8, Rural Travel *2014 U.S. Dollars per mile*

Mode	Average Car	Compact Car	Electric Car	Van or Pickup	Rideshare Passenger	Diesel Bus	Electric Trolley	Motor-cycle	Bicycle	Walk	Telework	Distribution
Average Occupancy	1.5	1.5	1.5	1.6	1	5	10	1	1	1	1	.
Vehicle Ownership	0.330	0.290	0.413	0.429	0.000	0.000	0.000	0.403	0.080	0.000	0.320	Internal-Fixed
Vehicle Operation	0.174	0.128	0.245	0.245	0.003	1.680	3.840	0.080	0.032	0.064	0.000	Internal-Variable
Operating Subsidy	0.000	0.000	0.000	0.000	0.000	2.000	4.640	0.000	0.000	0.000	0.000	External
Travel Time	0.360	0.360	0.360	0.360	0.216	1.864	3.728	0.240	0.480	1.600	0.000	Internal-Variable
Internal Crash	0.120	0.132	0.120	0.120	0.080	0.024	0.048	0.699	0.080	0.080	0.000	Internal-Variable
External Crash	0.056	0.053	0.056	0.056	0.000	0.320	0.320	0.123	0.003	0.003	0.000	External
Internal Parking	0.040	0.037	0.040	0.040	0.000	0.000	0.000	0.032	0.002	0.000	0.000	Internal-Fixed
External Parking	0.032	0.030	0.032	0.032	0.000	0.000	0.000	0.024	0.002	0.000	0.000	External
Congestion	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	External
Road Facilities	0.016	0.016	0.037	0.021	0.000	0.067	0.067	0.008	0.000	0.000	0.000	External
Land Value	0.038	0.038	0.038	0.038	0.000	0.038	0.038	0.038	0.002	0.000	0.003	External
Traffic Services	0.008	0.008	0.008	0.008	0.000	0.008	0.008	0.008	0.000	0.000	0.000	External
Transport Diversity	0.008	0.008	0.008	0.008	0.000	0.000	0.000	0.008	0.000	0.000	0.000	External
Air Pollution	0.026	0.016	0.006	0.046	0.002	0.112	0.032	0.022	0.000	0.000	0.000	External
Noise	0.008	0.008	0.005	0.008	0.000	0.040	0.024	0.080	0.000	0.000	0.000	External
Resource Externalities	0.034	0.018	0.010	0.045	0.000	0.176	0.051	0.014	0.000	0.000	0.003	External
Barrier Effect	0.008	0.008	0.008	0.008	0.000	0.021	0.021	0.008	0.000	0.000	0.000	External
Land Use Impacts	0.056	0.056	0.056	0.056	0.000	0.000	0.000	0.056	0.000	0.000	0.056	External
Water Pollution	0.021	0.021	0.011	0.021	0.000	0.021	0.011	0.021	0.000	0.000	0.000	External
Waste	0.003	0.003	0.003	0.003	0.000	0.003	0.003	0.003	0.000	0.000	0.000	External
Internal Fixed	*0.370*	*0.326*	*0.453*	*0.469*	*0.000*	*0.000*	*0.000*	*0.435*	*0.082*	*0.000*	*0.320*	
Internal Variable	*0.654*	*0.618*	*0.725*	*0.725*	*0.299*	*3.568*	*7.616*	*1.019*	*0.592*	*1.744*	*0.000*	
External	*0.314*	*0.283*	*0.278*	*0.350*	*0.002*	*2.806*	*5.216*	*0.414*	*0.006*	*0.003*	*0.059*	
Totals	*1.338*	*1.228*	*1.456*	*1.544*	*0.301*	*6.374*	*12.832*	*1.869*	*0.680*	*1.747*	*0.379*	

Community Consulting Services, June 10, 2004

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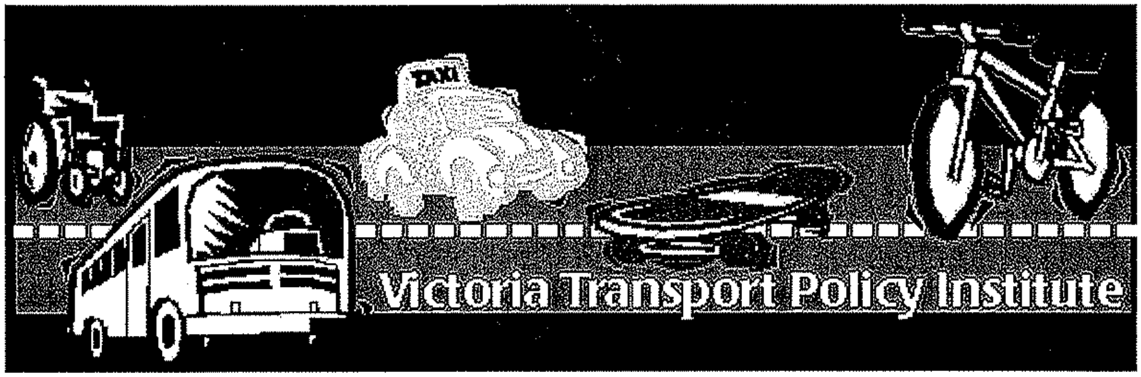

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Transportation Cost and Benefit Analysis

Techniques, Estimates and Implications

Victoria Transport Policy Institute

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Updated June 2003

PENGAD-Bayonne, N.J.
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Welcome to the Online edition of *Transportation Cost and Benefit Analysis: Techniques, Estimates and Implications*, a guidebook for quantifying the full costs and benefits of different transportation modes. This 300-page document is a comprehensive study of transportation benefit and costing research, and a guidebook for applying this information in planning and policy analysis.

This document is unique in several important ways. It is one of the most comprehensive studies of its type, including many categories of costs and benefits that are often overlooked, and the only one that is regularly expanded and updated as new information becomes available. It provides extensive reference information, mostly available through the Internet, allowing users to obtain additional information when needed. It explains economic evaluation techniques and how to apply them. It is the only study that provides costs values in a format designed to easily calculate the full costs and benefits of transportation policy and planning alternatives.

Individual chapters include detailed information on various categories of transportation costs and benefits, including summaries of previous monetized estimates. Using the best available data, it provides monetized estimates of twenty costs for eleven travel modes under three travel conditions. Costs are categorized according to various attributes: whether they are internal or external, fixed or variable, market or nonmarket. Examples illustrate how this information can be applied for transportation policy and planning decisions.

The Guidebook also summarizes previous transportation impact studies, describes how nonmarket impacts are estimated, discusses major findings, evaluates criticisms of transportation costing, and explores implications and applications of this research.

This project is currently under development. We regularly update and revise the Guidebook. Please let us know if you have comments or suggestions for improving this information.

Email: tca@vtpi.org

Contents

Executive Summary	This is a short, 5-page summary of this guidebook.
1. Introduction	This chapter describes the context and scope of this guidebook, the value of measuring transportation costs, defines and discusses the concepts of "transport" and "cost," and categorizes costs based on various attributes.
2. Literature Review	This chapter reviews various studies of the full costs of transportation, covering both personal and freight

	transport costs.
3. Economic Evaluation	This chapter describes basic economic evaluation principles and techniques, and how they relate to transportation cost analysis. It discusses evaluation of optimal pricing, project investment and policy analysis, and transportation equity.
4. Cost Quantification Techniques	This chapter describes various techniques for quantifying and monetizing (measuring in monetary units) transportation impacts.
5.0 Costs – Overview and Definitions	This chapter describes the information that is included in each of the cost chapters and defines the modes that are considered.
5.1 Vehicle Costs	This chapter examines direct user financial costs for vehicles, transit fares and telework equipment.
5.2 Travel Time	This chapter examines the value of travel time, and travel time savings. It describes various estimates of travel time values for different user types and travel conditions.
5.3 Safety and Health	This chapter examines the safety and health risks of transportation activities, including crash damages, personal security and public health. It describes how these impacts are measured, how they vary by mode and travel conditions, and how they are distributed.
5.4 Parking	This chapter explores the costs of providing parking facilities. It estimates the costs of different types of parking spaces and the number of parking spaces per vehicle. It discusses the distribution of parking costs.
5.5 Congestion	This chapter examines traffic congestion costs, that is, delay and risk due to interference between road users. It describes how congestion is measured, factors that affect congestion, various estimates of congestion costs, and the benefits of congestion reductions.
5.6 Roadway Facilities	This chapter examines public expenditures on roadway facilities. It describes roadway construction, maintenance and operating costs, and how those costs are allocated to different types of vehicles.
5.7 Roadway Land Value	This chapter investigates the amount of land devoted to roads, the value of this land, and how this cost can be allocated to road users.
5.8 Traffic Services	This chapter explores the costs of public services for vehicle traffic, including law enforcement, emergency services and street lighting.
5.9 Transportation Diversity	This chapter explores the value of transportation diversity and the costs of reduced transport options. Transportation diversity provides a variety of benefits, including efficiency, equity, option value and resilience.
5.10 Air Pollution	This chapter describes vehicle air pollutants, how emissions of different vehicles can be quantified, factors that affect emission rates, and the costs of vehicle air pollution.
5.11 Noise	This chapter provides information on vehicle noise costs, including general information on how noise is quantified, the noise emissions of various types of vehicles, and estimates of their noise costs.
5.12 Resource Consumption	This chapter describes the external costs of resource consumption (particularly petroleum and other forms of energy), and therefore the benefits of conservation and increased efficiency.
5.13 Barrier Effect	This chapter describes the barrier effect (also called "severance"), which refers to delays that roads and traffic cause to nonmotorized travel.

5.14 Land Use Impacts	This chapter examines how transportation decisions affect land use patterns, and the economic, social and environmental impacts that result. It describes various external costs of increased pavement and automobile-oriented development, and benefits that can result from more resource-efficient land use patterns.
5.15 Water Pollution and Hydrologic Impacts	This chapter describes water pollution and hydrologic impacts (changes in surface and ground water flow) associated with transportation facilities and vehicle use.
5.16 Waste Disposal	This chapter describes external costs associated with disposal of vehicle wastes.
6. Cost Summary	Previous chapters in this guidebook provided monetized estimates of 20 costs for 11 modes under three travel conditions, totaling 660 individual estimates. This chapter summarizes and analyzes these estimates.
7. Evaluating Transportation Benefits	This chapter discusses techniques for quantifying transportation benefits, including benefits of marginal cost savings, external benefits, consumer surplus benefits, economic productivity and development, and benefits of transportation diversity.
8. Criticism of Transportation Costing	This chapter evaluates various criticisms of transportation costing.
9. Implications	Economic evaluation techniques and cost described in this guidebook are used in this chapter to analyze the impacts of current pricing on economic efficiency, economic development, land use, stakeholder perspectives, and travel patterns.
10. Applications and Case Studies	This chapter explores some implications of transportation economic evaluation with regard to optimal pricing, economic efficiency, land use, stakeholder perspectives, and travel patterns.
11. Conclusions	This chapter summarizes major conclusions and provides recommendations for improving transportation system efficiency and equity.
12. Bibliography	This chapter lists some of the literature used in this guidebook.
Transportation Cost Analysis Spreadsheet	This spreadsheet contains estimates of twenty costs for eleven modes under three travel conditions from the *Transportation Cost and Benefit Analysis* report. The spreadsheet is structured to allow these costs to be analyzed in various ways.

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This guidebook is produced by the Victoria Transport Policy Institute to help improve transportation planning and evaluation. It is an ongoing project. Please send us your comments and suggestions for improvement.

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2. Transportation Cost Literature Review

This chapter summarizes previous transport cost studies, including several that focus on freight costs.

1. Keeler, et al, *The Full Costs of Urban Transport; Intermodal Comparisons*, Institute of Urban and Regional Development (Berkeley), 1975.
This report compares commuting costs of automobile, bus and rail in the San Francisco Bay area. It includes marginal congestion costs, public services, noise, air pollution, facilities, accidents, parking, and user costs. This is the oldest study of its type. The analysis is still highly regarded.

2. Mark Hanson, Results of Literature Survey and Summary of Findings: The Nature and Magnitude of Social Costs of Urban Roadway Use, U.S. Federal Highway Administration (Washington DC), July 1992.
This report identifies external costs of urban roadway transport and describes costing methods. It also includes recommendations for better calculating external costs, incorporating costs into user prices, and applying least-cost planning to transportation.

3. James MacKenzie, Roger Dower, and Donald Chen, *The Going Rate*, World Resources Institute (Washington DC; www.wri.org), 1992.
This is a comprehensive study of U.S. motor vehicle costs. Cost categories include roadway facilities and services, parking, air pollution and global warming, security costs of importing oil, congestion, traffic accidents, noise, and land loss. The report's conclusion that driving incurs $300 billion annually in external costs has been widely quoted.

4. Per Kågeson, *Getting the Prices Right; A European Scheme for Making Transport Pay its True Costs*, European Federation for Transport and Environment (www.t-e.nu), 1993.
This study estimates pollution, crash and infrastructure costs in European countries. Cost summaries for the UK are shown in Table 2-1. Similar estimates are made for other countries.

Table 2-1 **External Transport Costs** (ECU/1000 passenger km)

Mode	Air Pollution	CO_2	Noise	Accidents	Total	Total ($/mile)
Car	14.6	4.5	0.9	8.9	28.9	$0.060
Electric train	0.9	2.2	0.2	3.8	7.1	$0.015
Aircraft	7.3	9.2	1.2	0.2	17.9	$0.037

5. KPMG, *The Cost of Transporting People in the British Columbia Lower Mainland*, Transport 2021/Greater Vancouver Regional District (Vancouver; www.gvrd.bc.ca), March 1993.
This study develops cost estimates for 12 modes using local research and generic estimates. Costs are listed in Table 2-2.

Table 2-2 **Costs of Transporting People in B.C. Costs**

Direct User	Indirect Parking	Transport Infrastructure	Time	Urban Sprawl	Environmental and Social
Fixed vehicle costs. Variable vehicle costs. Parking fees.	Residential. Commercial. Government.	Road construction. Road maintenance. Road land value. Transit land value. Protection services.	Personal. Commercial delays.	Infrastructure. Loss of open space. Future transport.	Unaccounted accident costs. Air pollution. Noise pollution. Water pollution.

6. Works Consultancy, *Land Transport Externalities*, Transit New Zealand (Wellington), 1993.
This comprehensive study is part of New Zealand's efforts to rationalize transport planning. It attempts to describe all external costs of road transport, and identify costing methodologies. Cost categories are shown in Table 2-3. Cost estimates will be developed in future reports.

Table 2-3 **Works Consultancy Cost Categories**

Pollution Effects	Intrusion Effects	Interference Effects	Land Use
Air Pollution & Dust Impacts on the Global Atmosphere Effects on Water Systems Noise & Vibration Disposal of Waste	Visual Effects Habitat impacts. Effects on Landscape Archaeological Sites Cultural & Spiritual Effects Recreational Effects Strategic Effects	Community Disruption Urban and Rural Blight and Stress of Change Lighting Effects Community Severance and Accessibility Hazard Effects	

7. Peter Miller and John Moffet, *The Price of Mobility*, Natural Resources Defense Council (www.nrdc.org), 1993.
This study attempted to quantify total costs for automobiles, buses, and rail transport in the U.S. It is one of the most comprehensive efforts in terms of costs described and quantified. Costs included are listed in Table 2-4.

Table 2-4 **The Full Cost of Transportation in the U.S.A.**

Personal	Gov. Subsidies	Societal	Unquantified
Automobile ownership. Transit fares.	Capital and operating. Local government.	Energy. Congestion. Parking. Accidents. Noise. Vibration. Air pollution. Water pollution.	Wetland lost. Farmland lost. Historic property. Property value impacts. Inequity. Sprawl.

8. Apogee Research, *The Costs of Transportation*, Conservation Law Foundation (Boston; www.clf.org), March 1994.
This study estimates user, accident, congestion, parking, road facilities and services, air pollution, water pollution, energy, and noise costs. Urban sprawl and aesthetic degradation are mentioned but not estimated. A costing model is developed which calculates the total cost of trips by nine modes, in three levels of urban density, during peak and off-peak periods. This model is applied to case studies of Boston and Portland, Maine urban travel costs.

9. FRA, *Environmental Externalities and Social Costs of Transportation Systems - Measurement, Mitigation and Costing*, Federal Railroad Administration, Office of Policy (Washington DC), 1993.
This study describes various social costs associated with motor vehicle transportation. It includes two charts that describe a taxonomy of costs and mitigation strategies, summarized in Table 2-5.

Table 2-5 **Federal Railroad Administration Costs**

Social Costs				
Land Use	*Community Disruption*	*Energy*	*Safety*	*Congestion*
Direct land use for facilities. Alters land use patterns (sprawl).	Divides community. Impacts local government. Visual pollution. Relocation impacts.	Oil spills. Air pollution. Political instability from foreign oil. Oil price fluctuations affecting world economy.	Accidents cause death, injuries, insurance and legal costs, lost productivity, medical costs, emotional losses, congestion.	Wasted time. Wasted fuel. Added pollution. Lost productivity. Vehicle repair and insurance costs. Stress. Land use impacts.

Environmental Costs				
Air	*Noise*	*Water*	*Electromagnetic Fields*	*Hazardous Materials*
Carbon Monoxide VOCs SO^2 NOx CO^2 Air Toxics Particulates CFCs Odor	Construction/ repair Night operations Engines Wheels/tires Congestion Braking/acceleration Idling Whistles	Air pollution fallout Fuel releases and spills Construction/ maintenance De-icing Runoff from roads and parking lots	(Cost of electric vehicles) Possible biological hazard Possible hazard to migrating birds Problems to electronic equipment	Accidental releases Intentional releases

10. CEC, *California Transportation Energy Analysis Report*, California Energy Commission (www.energy.ca.gov), 1994.

This report attempted to "*fully evaluate the economic and environmental costs of petroleum use, and the economic and environmental costs of other transportation fuels, including the costs and values of environmental externalities, and to establish a state transportation energy policy that results in the least environmental and economic cost to the state.*" Costs considered include congestion, accidents, infrastructure maintenance, services, air pollution (including global warming), petroleum spills, and energy security. These are monetized (per vehicle mile or gasoline equivalent gallon), and presented as a point value or range.

11. "The Costing and Costs of Transport Externalities: A Review," *Victorian Transport Externalities Study*, Environment Protection Authority (Melbourne, Australia), 1994.

This report discusses external cost implications, reviews costing methods, and estimates some costs.

12. OTA, *Saving Energy In U.S. Transportation*, Office of Technology Assessment (Washington DC), 1994.

This report provides a comprehensive analysis of transportation costs and their economic and environmental impacts. Includes estimates of total U.S. motor vehicle costs based on research by Mark Delucchi of UC Davis. Discusses various policy options for improving energy efficiency.

13. John Poorman, *Estimating Marginal Monetary Costs of Travel in the Capital District*, Capital District Transportation Committee (Albany), April 1995.

This report describes a Least Cost framework and model, with performance measures and monetized costs for evaluating transport investments and policies, and comparing various modes.

14. Douglass Lee, *Full Cost Pricing of Highways*, USDOT Volpe National Transportation Systems Center (www.volpe.dot.gov), January 1995.
This study analyzes optimal pricing for economic efficiency. Table 2-6 summarizes Lee's estimates of external costs.

Table 2-6 **Estimates of Highway Costs Not Recovered From Users** ($1,000/yr)

Cost Group	Cost Items	Estimate
Highway Capital	Land (interest)	$74,705
	Construction:	
	Capital Expenditures	42,461
	Interest	26,255
	Land acquisition and clearance	
	Relocation of prior uses and residents	
	Neighborhood Disruption	
	Removal of wetlands, acquirer recharge	
	Uncontrolled construction noise, dust and runoff	
	Heat island effect	
Highway Maintenance	Pavement, ROW, and structure maintenance	20,420
Administration	Administration and research	6,876
	Traffic police	7,756
Parking	Commuting	52,877
	Shopping, recreation, services	14,890
	Environmental degradation	
Vehicle Ownership	Disposal of scrapped or abandoned vehicles	706
Vehicle Operation	Pollution from tires	3,000
	Pollution from used oil and lubricants	408
	Pollution from toxic materials	1
Fuel and Oil	Strategic Petroleum Reserve	4,365
	Tax subsidies to production	9,000
Accidental Loss	Government compensation for natural disaster	
	Public medical costs	8,535
	Uncompensated losses	5,850
Pollution	Air	43,444
	Water	10,861
	Noise and vibration	6,443
	Noise barriers	5,117
Social Overhead	Local fuel sales tax exemptions	4,302
	Federal gasohol exemption	1,129
	Federal corporate income tax	3,389
	State government sales taxes	13,218
	Local government property taxes	15,962
	Total	$382,134
	Current User Revenues	52,096
	Loss	330,037
	cents/VMT	$0.152

15. IBI Group, *Full Cost Transportation Pricing Study*, Transportation and Climate Change Collaborative (Toronto), November 1995.
This study estimates costs for truck, rail, automobile, public transit and air travel in Ontario, Canada. Reviews cost estimates from previous studies. Costs are divided into user charges, external costs, and "basic subsidies" (government costs minus revenues). This is used to evaluate potential measures to encourage sustainable transport.

16. William Black, Dean Munn, Richard Black and Jirong Xie, *Modal Choices: An Approach to Comparing the Costs of Transportation Alternatives*, Transportation Research Center, Indiana University (Bloomington), 1996.
The report and ALTERNAT software provide a framework for comparing highway, bus and rail projects. Costs are listed in Table 7. Estimates are based on previous published research.

Table 2-7 **Costs Recognized In *Modal Choices* Model**

- Accident costs not covered by insurance.
- Capital costs not covered through transport taxes.
- Operating costs of vehicles.
- Parking costs (fines and fees only)
- Air pollution costs
- Rehabilitation costs
- Value of time (personal and commercial)

17. David Maddison, David Pearce, Olof Johansson, Edward Calthrop, Todd Litman, and Eric Verhoef, *The True Costs of Road Transport*, Blueprint #5, Earthscan (London), 1996.
This book discusses the economic efficiency and equity implications of roadway transport externalities. Develops estimates of external costs in the U.K., including air pollution, noise, congestion, roadway facility costs, and accident costs. Also includes individual chapters on roadway externalities in Sweden, North America, The Netherlands, and international estimates.

18. Christopher Zegras with Todd Litman, *An Analysis of the Full Costs and Impacts of Transportation in Santiago de Chile,* International Institute for Energy Conservation (www.iiec.org), March 1997.
This is one of the first comprehensive transport cost studies in the developing world. Includes vehicle, roadway, parking, congestion, crash, and environmental costs. Although automobile ownership is relatively low compared with developed countries, rapid (10% annual) growth in vehicle ownership imposes considerable medium-term costs in terms of increased congestion, facility needs, pollution, etc. Because Chile imports most vehicles and fuel, increased automobility also imposes macroeconomic costs by capturing a major portion of foreign exchange and potential investment funds.

19. Mark Delucchi, *Annualized Social Cost of Motor Vehicle Use in the United States, Based on 1990-1991 Data*, University of California at Davis (www.its.ucdavis.edu and www.ota.fhwa.dot.gov/scalds/DELUCCHI.pdf), 1996-97; summarized in "Total Cost of Motor-Vehicle Use," *Access* (www.uctc.net), No. 8, Spring 1996, pp. 7-13.
This series of 20 comprehensive reports attempts to identify, categorize and estimate total U.S. motor vehicle costs. Table 2-8 summarizes ranges of major cost categories.

Table 2-8 **Delucchi's Estimates of Motor Vehicle Costs**

Cost Item	Examples	Per Veh. Year	Per Veh. Mile
Personal nonmonetary costs of using motor vehicles	Motorist personal travel time and accident pain and suffering.	$2,180-3,189	17.4-25.5¢
Private-sector motor-vehicle goods and services	Vehicle expenses, paid travel time.	$5,020-5,659	40.2-45.3¢
Bundled private sector costs	Parking subsidized by businesses.	$337-1,181	2.7-9.4¢
Public infrastructure and services	Public roads, parking subsidized by local governments.	$662-1,099	5.3-8.8¢
Monetary externalities	External accident damages, congestion.	$423-780	3.4-6.2¢
Nonmonetary externalities	Environmental damages, crash pain.	$1,305-3,145	10.4-25.2¢
Total		*$9,927-15,053*	*$0.79-1.20*

20. *1997 Federal Highway Cost Allocation Study Final Report* (and *Addendum*), Federal Highway Administration, USDOT (www.fhwa.dot.gov/policy/hcas/summary/index.htm), 1997 and 2000.
This report is concerned with whether various motor vehicle categories (automobiles, light trucks, and various types of heavy vehicles) are charged according to the costs they impose on the highway system. Focuses on Federal user fees and federal highway payments, but also includes costs for total roadway expenditures, plus costs of congestion, crashes, air pollution and noise (based mainly on Delucchi's estimates). Table 2-9 summarizes these costs.

Table 2-9 **Vehicle Costs Under Various Conditions** (1997 cents per mile)

Vehicle/Highway	Pavement	Congestion	Crashes	Air Pol.	Noise	Total
Autos/Rural Interstate	0	0.78	0.98	1.14	0.01	2.91
Autos/Urban Interstate	0.1	7.70	1.19	1.33	0.09	10.41
40 kip 4-axle SU Truck/Rural Int.	1.0	2.45	0.47	3.85	0.09	7.86
40 kip 4-axle SU Truck/Urban Int.	3.1	24.48	0.86	4.49	1.50	34.43
60 kip 4-axle SU Truck/Rural Int.	5.6	3.27	0.47	3.85	0.11	13.30
60 kip 4-axle SU Truck/Urban Int.	18.1	32.64	0.86	4.49	1.68	57.77
60 kip 5-axle Comb/Rural Int.	3.3	1.88	0.88	3.85	0.17	10.08
60 kip 5-axle Comb/Urban Int.	10.5	18.39	1.15	4.49	2.75	37.28
80 kip 5-axle Comb/Rural Int.	12.7	2.23	0.88	3.85	0.19	19.85
80 kip 5-axle Comb/Urban Int.	40.9	20.06	1.15	4.49	3.04	69.64

SU = Single Unit; Comb. = Combination

21. Patrick Decorla-Souza and Ronald Jensen-Fisher, "Comparing Multimodal Alternatives in Major Travel Corridors," *Transportation Research Record 1429*, 1997, pp. 15-23.
This report develops estimates of various costs for comparing investment alternatives, as indicated in Table 2-10.

Table 2-10 **Examples of Unit Costs**

Cost Item	Automobile	Bus	Rail
Vehicle Operation	7.4 cents/VMT	$1.50-3.00/Trip	$4.25/Trip
Vehicle Ownership	$3.12/Trip		
Parking, Downtown	$3.00		
Parking, Other	$1.00		
Highway Operations	1.8 cents/VMT	2.9 cents/VMT	
Added Highway Capacity	62¢/Peak-VMT	99¢/Peak-VMT	
Public Services	1.1 cent/VMT	1.1 cent/VMT	0.22 cents/VMT
Accident (Market)	4.2 cents/VMT	8.4 cents/VMT	1.68 cents/VMT
Accidents (Nonmarket)	7.8 cents/VMT	15.6 cents/VMT	3.12 cents/VMT
Air Pollution	2.4 cents/VMT		
Water Pollution	0.2 cents/VMT		
Noise	0.16 cents/VMT		
Solid/Chemical Waste	0.2 cents/VMT		
Oil Extraction	1.5 cents/VMT		

22. Gunther Ellwanger, "External Environmental Costs of Transport - Comparison of Recent Studies," *Social Costs and Sustainable Mobility*, ZEW, Physica-Verlag, 2000, pp. 15-20.
This paper provides estimates of external costs for Car, Bus, Rail, Air and Water-way transport (passenger and freight) based on four European studies: IWW/INFRAS, EU Green Paper, ECMT and ZEQ -QUITS. Results of these studies are illustrated in Table 2-11.

Table 2-11 **External Costs of Transport in Western Europe**

	Passenger (ECU/1,000 Pkm)		**Freight (ECU/1,000 Tkm)**	
	Road	**Rail**	**Road**	**Rail**
IWW/INFRAS	50.1	10.0	58.4	7.3
ECMT, 1996	50-65	10-19	18-30	4-7.5
ECMT, 1998	49	12	62	9
EU-Greenbook	35.5	8.0	33.2	5.3
ZEW-QUITS	44.3	4.9	30.6	2.8

23 Silvia Banfi, et al, *External Costs of Transport: Accident, Environmental and Congestion Costs in Western Europe*, INFRAS (www.infras.ch) and IWW (www.infras.ch), March 2000.
This study develops estimates of accidents, noise, air pollution, climate change risks, other environmental and non-environmental effects, and congestion for four modes (road, rail, air and water transport) in 17 European countries for 1995 and 2010. Calculates total costs per country, and marginal costs. Marginal costs are intended for pricing.

24. Tom Sansom, C. A. Nash, Peter J Mackie, J. D. Shires and S. M. Grant-Muller, *Surface Transport Costs and Charges*, Institute for Transport Studies, University of Leeds (www.its.leeds.ac.uk/projects/STCC/surface_transport.html), for the UK DETR, July 2001.

This study compares the social costs of road and rail transport with current user charges. UK roadway costs are estimated for 1998 on two different bases - marginal costs associated with an additional vehicle km, and fully allocated costs. The resultant analysis framework and empirical results are intended to inform policy making in the areas of charging, taxation and subsidies. The analysis includes infrastructure, vehicle, congestion, crash, and pollution costs. Estimates that automobile use generally covers costs, but underprices with respect to marginal costs.

Table 2-12 **UK Road Costs and Revenues** (1998 UK Pence Per Veh-Km)

	Fully Allocated Costs		**Marginal Costs**	
	High	**Low**	**High**	**Low**
Costs				
Infrastructure capital costs	0.78	1.34	n/a	n/a
Infrastructure operating costs and depreciation	0.75	0.97	0.42	0.54
Vehicle operating costs	0.87	0.87	0.87	0.87
Congestion	n/a	n/a	9.71	11.16
Mohring effect (public transit vehicle only)	n/a	n/a	-0.16	-0.16
External accident costs	0.06	0.78	0.82	1.40
Air pollution	0.34	1.70	0.34	1.70
Noise	0.24	0.78	0.02	0.78
Climate change	0.15	0.62	0.15	0.62
VAT not paid	0.15	0.15	0.15	0.15
Cost subtotal	*3.34*	*7.20*	*12.32*	*17.05*
Revenues				
Fares (public transit vehicles only)	0.84	0.84	0.84	0.84
Vehicle excise duty	1.10	1.10	0.14	0.14
Fuel duty	4.42	4.42	4.42	4.42
VAT on fuel duty	0.77	0.77	0.77	0.77
Subtotal of revenues	*7.14*	*7.14*	*6.17*	*6.17*
Difference (costs-revenues)	*-3.79*	*0.07*	*6.15*	*10.88*
Ratio (revenues/costs)	*2.13*	*0.99*	*0.50*	*0.36*

This table summarizes estimated costs and revenue of UK road transport using two perspectives, full allocation (i.e., total costs allocated to users) and marginal (incremental costs).

Cost Estimates Summarized

The table below identifies which costs are described or estimated in each report. This shows the range of perspectives and efforts applied to transport costs.

Table 2-13 **Transport Costs in Current Literature (C = Costed; D = Described)**

Study No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Cost Categories	Keeler	Han-son	Mac Kenz ie	Kåg-eson	KPMG	Works N.Z.	Miller & Moffet	Apo-gee, CLF	US DOT, FRA	CEC	EPA, Aust.	OTA	CDT C	Doug Lee,	IBI	Black	Mad-dison	IIEC	De-lucchi	FHW A	DS & JF	Elwan-ger	INFRA S	Sansom, et al
Vehicle Costs	C			D	C		C	C				C	C		C	C		C	C		C			C
Travel Time	C			D	C			C				C	C			C		C	C					
Accidents	C	D	C	C	C		C	C	D	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C
Parking	C	D	C		C		C	C				C	C	C	C	C		C	C		C			
Congestion	C	D	C	D	C		C	C	D	C	C	C	C		C	D	C	C	C	C	C	C	C	C
Facilities	C	D	C	C	C		C	C		C		C	C	C	C	C	C	C	C	C	C			C
Roadway Land	C	D	D		C		D	C				C	C	C		D		C	C					
Mun. Services	C	D	C	D	C		C	C		C		C	C	C	C	D		C	C		C			C
Local Air Pollution	C	D	C	C	C	D	C	C	D	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C
Global Air Pollution		D	C	C		D	C	C	D	C		C	C		C	D	C	C	C			C	C	C
Noise&Vibration	C	D	C	C	C	D	C	C	D		C	C	C	C		D	C	C	C	C	C	C	C	C
Resources/Energy		D	C		C	D	C	C	D	C		C	C	C		D		D	C		C		C	
Barrier Effect		D		D		D							C			D	D							
Land Use/Sprawl				D	C	D	D	D					C			D		D	D			C	C	C
Inequity							D						C			D		D	D					
Water		D		D	C	D	C	C	D	C		C	C	C		D		D	C		C	C		
Waste Disposal						D						C	C	C		D		D	C		C			

Freight Cost Studies

The studies below focus on freight transport costs.

F-1. Transport Concepts, *External Costs of Truck and Train*, Brotherhood of Maintenance of Way Employees (Ottawa), October 1994.
This study compares external costs of train and truck freight transport to justify increased truck taxes or increased subsidies for rail. Table 2-14 summarizes their results.

Table 2-14 **External Costs of Train Vs. Truck** (1994 Canadian Cents per Tonne Kilometer)

Cost	Intercity Truck Average	Truck Semi Trailer	Truck B-Train	Rail System Average	Rail Piggy Back	Rail Con-tainer	Rail Box Car	Rail Hopper Car
Accidents	0.40	0.40	0.40	0.06	0.06	0.06	0.06	0.06
Pollution	0.71	0.72	0.58	0.23	0.36	0.29	0.25	0.15
Interference (congestion)	0.64	0.65	0.52	-	-	-	-	-
Infrastructure	0.67	0.69	0.52	-	-	-	-	-
Cash Subsidy	0.09	-	-	0.28	0	0	0	0
Cost Subtotal	2.51	2.46	2.02	0.57	0.42	0.35	0.31	0.21
Fuel Taxes	-0.29	-0.29	-0.22	-0.06	-0.09	-0.07	-0.04	-0.04
License Fees	-0.07	-0.07	-0.07	-	-	-	-	-
Revenue Subtotal	-0.36	-0.36	-0.29	-0.06	-0.09	-0.07	-0.04	-0.04
Net External Costs	*2.15*	*2.10*	*1.73*	*0.51*	*0.33*	*0.28*	*0.27*	*0.17*

F-2. Transmode Consultants Inc., *Ontario Freight Movement Study*, National Round Table on the Environment and the Economy (Toronto), November 1995.
This study focuses primarily on air pollution, particularly greenhouse gas emissions. Component 2 uses case studies to evaluate the feasibility of more efficient practices.

F-3. Committee for Study of Public Policy for Surface Freight Transport, *Paying Our Way; Estimating Marginal Social Costs of Freight Transport*, National Academy Press (www.trb.org), 1996.
This study uses previous cost research and case studies to estimate and compare marginal costs of freight transport, including internal costs to carriers, congestion, accidents, air pollution, energy consumption externalities, noise, and public facility costs. The study concludes that external costs represent an additional 7-20% cost over existing internal costs, and tend to be higher for truck and barge than for rail. The greatest external costs are associated with urban freight distribution where congestion and high population densities increase these costs. Policy applications and further research needs are discussed.

F-4. Thomas Bue Bjørner, "Environmental Benefits from Better Freight Transport Management: Freight Traffic in a VAR Model," *Transportation Research D*, Vol. 4, No. 1, January 1999, pp. 45-64.
This article summarizes various estimates of the external costs of freight. Concludes that these costs (air pollution, noise, accidents and congestion) are about four times higher for one truck-kilometer than for a private car.

F-5. David Gargett, David Mitchell and Lyn Martin, *Competitive Neutrality Between Road and Rail*, Bureau of Transport Economics, Australia (www.dotrs.gov.au/programs/bte/btehome.htm), Sept. 1999.
This study uses estimates of the full costs of road and rail freight to estimate the price changes that would result from full-cost pricing. The study indicates that current pricing tends to favor trucks over rail by failing to internalize many costs.

Table 2-15 **External Costs of Rail Vs. Truck** (Australian Cents Per Net Tonne-Km)

	Rail			Truck		
	Cost	Payment	Balance	Cost	Payment	Balance
Infrastructure Use	0.87	0.87	0.0	0.97	0.64	0.33
Accident Costs	0.03	0.01	0.02	0.32	0.16	0.16
Enforcement Costs	NA	0.0	0.0	0.05	0.0	0.05
Congestion	NA	0.0	0.0	0.03	0.0	0.03
Air Pollution	0.004	0.0	0.004	0.01	0.0	0.01
Noise	0.02	0.0	0.02	0.034	0.0	0.034
	0.924	0.88	0.044	1.454	0.84	0.614

This table indicates the estimated external costs of each mode, how much they pay under the current price structure, and the balance of external costs that result.

F-6. David Forkenbrock, "External Costs of Intercity Truck Freight Transportation," *Transportation Research A*, Vol. 33, No. 7/8 (www.elsevier.com/locate/tra), Sept./Nov. 1999, pp. 505-526; David Forkenbrock, "Comparison of External Costs of Rail and Truck Freight Transport," *Transportation Research A*, Vol. 35, No. 4, May 2001, pp. 321-337.
These articles summarize existing intercity truck internal costs. Internal costs are estimated at $1.25 per vehicle-mile, or 8.42¢ per ton-mile in 1994 (these values are disaggregated by cost category and trip length). Rail external costs are much smaller in magnitude but larger as a portion of internal (private) costs. Estimates external costs as indicated in Table 2-16. Concludes that heavy truck road user charges would need to approximately triple to internalize these costs.

Table 2-16 **Estimated External Costs of Intercity Truck**

Cost Category	1994 Cents Per Ton-Mile
Accidents	0.59
Air pollution	0.08
Greenhouse gases	0.15
Noise	0.04
Roadway external costs	0.25
Total	*1.11*

F-7. H. Link, J.S. Dodgson, M. Maibach and M. Herry, *The Costs of Road Infrastructure and Congestion in Europe*, Physcia-Verlag (www.springer.de), 1999.
This book is based on the final report of a project funded by the European Commission (DGVII) entitled "Infrastructure Capital, Maintenance and Road Damage Costs for Different Heavy Goods Vehicles in the EU" (Project No.: B1-B97-B2 7040-SIN 5317-ETU). It examines the ways in which the costs of transport infrastructure and congestion can be calculated and allocated to different types of traffic, focusing mainly on road freight transport.

F-8. Oxford Economic Research Associates, *The Environmental and Social Costs of Heavy Goods Vehicles and Options for Reforming the Fiscal Regime*, English, Welsh, and Scottish Railway, (www.ews-railway.co.uk), 1999.
This report investigates the full social and environmental costs of road freight, including factors such as pollution and uncovered costs of structural damage, and concludes that road freight currently pays only 70% of its full costs. Including interest payments on the capital costs of road infrastructure lowers the ratio of paid costs to full costs to 59%. The report discusses alternatives for incorporating full costs into road freight charges, including a time-based payment along the lines of the Eurovignette scheme currently in use in several European countries, or a distance-based scheme in operation in Sweden and New Zealand.

F-9. David Gargett, David Mitchell and Lyn Martin, *Competitive Neutrality Between Road and Rail*, Bureau of Transport Economics, Australia (www.dotrs.gov.au/programs/bte/btehome.htm), Sept. 1999.
This study compares freight costs for road and rail under various pricing conditions. Describes the broad economic implications of tax changes.

F-10. "Comparison of Inland Waterways and Surface Freight Modes," *TR NEWS 221*, Transportation Research Board (www.trb.org), July-August 2002, p. 10-17.
This articles compares includes information comparing various freight modes, as summarized in the table below.

Table 2.17 **Freight Modes Compared** (per ton-mile)

	Costs	**Fuel**	**Hydrocarbons**	**CO**	**NOx**
Units	*Cents*	*Gallons*	*Lbs.*	*Lbs.*	*Lbs.*
Barge	0.97	0.002	0.09	0.20	0.53
Rail	2.53	0.005	0.46	0.64	1.83
Truck	5.35	0.017	0.63	1.90	10.17

Information Resources

Information on transportation cost analysis studies are described below.

David Anderson and Gerard McCullough, *The Full Cost of Transportation in the Twin Cities Region*, Center for Transportation Studies, University of Minnesota (www1.umn.edu/cts), 2000.

Silvia Banfi, et al, *External Costs of Transport; Accident, Environmental and Congestion Costs in Western Europe*, INFRAS (www.infras.ch) and IWW (www.iww.uni-karlsruhe.de), 2000.

John DeCicco and Hugh Morris, *The Costs of Transportation in Southeastern Wisconsin*, American Council for an Energy-Efficient Economy (Washington DC; www.aceee.org), 1998.

Mark Delucchi, *Annualized Social Cost of Motor Vehicle Use in the United States, Based on 1990-1991 Data*, Institute of Transportation Studies, University of California at Davis (www.ota.fhwa.dot.gov/scalds/DELUCCHI.pdf and www.its.ucdavis.edu), 1996.

Jos M.W. Dings, Marc D. Davidson, Maartje N. Sevenster, *External And Infrastructure Costs Of Road And Rail Transport - Analysing European Studies*, CE (www.ce.nl) for the Dutch Ministry of Transport, Water Management and Public Works, 2003.

Huib van Essen, Olivier Bello, Jos Dings, Robert van den Brink, *To Shift Or Not To Shift, That's The Question: The Environmental Performance Of Freight And Passanger Transport Modes In The Light Of Policy Making*, CE (www.ce.nl) for the Dutch Ministry of Transport, Water Management and Public Works, 2003.

Gunther Ellwanger, "External Environmental Costs of Transport - Comparison of Recent Studies," *Social Costs and Sustainable Mobility*, ZEW, Physica-Verlag (www.springer.de), 2000, pp. 15-20.

European Transport Pricing Initiatives (www.transport-pricing.net) includes various efforts to develop more fair and efficient pricing, including *ExternE* (http://externe.jrc.es) *TRACE* (www.hcg.nl/projects/trace/trace1.htm) and *UNITE* (www.its.leeds.ac.uk/projects/unite).

ExternE – Externalities of Energy, European Commission (http://externe.jrc.es), 1998.

FHWA, *Surface Transportation Efficiency Analysis Model*, FHWA (www.fhwa.dot.gov/steam), 1998.

FHWA, *1997 Federal Highway Cost Allocation Study*, USDOT (www.fhwa.dot.gov/policy/hcas/summary/index.htm), 1997a.

David Greene, Donald Jones & Mark Delucchi, *Full Costs and Benefits of Transportation*, Spinger (www.springer.de), 1997.

Gunther Ellwanger, "External Environmental Costs of Transport - Comparison of Recent Studies," *Social Costs and Sustainable Mobility*, ZEW, Physica-Verlag (www.springer.de), 2000, pp. 15-20.

Mark Hanson, "Automobile Subsidies and Land Use: Estimates and Policy Review," *Journal of the American Planning Association* (www.planning.org), Winter 1992.

Quentin Heaney, Margaret O'Mahony, and Eithne Gibbons, "External Costs Associated with Interregional Transport," *Transportation Research Record 1659* (www.trb.org), 1999, pp. 79-86.

ICLEI, *Uncovering Auto Subsidies: Calculating How Much Your Local Government Spends Subsidizing Cars*, Cities for Climate Protection, International Council for Local Environmental Initiatives (www.iclei.org/co2/auto/cars.htm), 1997.

ICTA, *The Real Price of Gasoline*, International Center for Technology Assessment (Washington DC; www.icta.org), 1997.

KPMG and Litman, *The Costs of Transporting People in the City of Edmonton*, City of Edmonton, September, 1996.

Richard Lake, et al., *Pricing and Climate Change; Phase 1: Needs Assessment*, Policy Group, Road Pricing, Transport Canada (www.tc.gc.ca/pol/en/RoadPricing/English/Intro.htm), 1999.

Douglass Lee, *Full Cost Pricing of Highways*, Volpe Transport Centre (www.volpe.dot.gov), 1995.

Todd Litman, *Transportation Cost Bibliographic Database*, VTPI (www.vtpi.org), 2001.

James Murphy and Mark Delucchi, *Review of Some the Literature on the Social Cost of Motor-Vehicle Use*, Institute of Transportation Studies, UC Davis (www.uctc.net/papers/313.pdf), 1997.

James Murphy and Mark Delucchi, "A Review of the Literature on the Social Cost of Motor Vehicle Use in the United States," *Journal of Transportation And Statistics*, Vol. 1, No. 1, Bureau of Transportation Statistics (www.bts.gov), January 1998, pp. 15-42.

Richard C. Porter, *Economics at the Wheel; The Costs of Cars and Drivers*, Academic (www.hbuk.co.uk/ap), 1999.

PSRC, *The Costs of Transportation; Expenditures on Surface Transportation in the Central Puget Sound Region for 1995*, Puget Sound Regional Council (www.psrc.org/costs.pdf), 1996.

David Urbanczyk and Jeanette Corlett, *The Cost of Driving in the Chicago Metropolitan Region*, Metropolitan Planning Council (Chicago), Working Paper No. 2, Feb. 1995.

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"Efficiency - Equity - Clarity"

Transportation Cost Analysis

Summary

by

Todd Litman
Victoria Transport Policy Institute

November 29, 1999

Abstract
This paper summarizes the comprehensive study, *Transportation Cost Analysis; Techniques, Estimates and Implications*. It discusses the importance of transportation costing research, defines major cost categories, describes how costs are estimated, summarizes major findings, and explores implications of this research. It provides estimates of twenty costs for eleven personal transport modes under three travel conditions. Costs are categorized according to various attributes: whether they are internal or external, fixed or variable, market or nonmarket. This creates a framework for comparing the travel costs of different modes under various conditions. The report also discusses the application of transport costing to decision making, and responds to various criticisms. An appendix summarizes previous transportation cost studies.

This analysis indicates that on average about a third of automobile costs are external and about a quarter are internal but fixed. This implies that current transport pricing is economically inefficient (prices do not accurately reflect costs) and inequitable (since people who drive more than average tend be subsidized overall by people who drive less than average). As illustrated in examples, transportation planning often overlooks significant costs, which tends to skew decisions toward capacity expansion and away from demand management. The use of more comprehensive costing in transport planning and pricing could improve the efficiency and equity of our transportation system.

Preface

I began serious research into transportation costing about a decade ago as a masters thesis project. Even before it was completed I received requests for data and copies of my study, which lead to consulting contracts, and eventually a career as a transport researcher and policy consultant. This work has been exciting, rewarding, and often frustrating.

Cost estimates have proven to have many uses, from estimating the value of a particular transit improvement or bicycling program, to determining optimal road user prices under various travel conditions. Although it is called "cost analysis," this information is the basis for identifying and measuring benefits of alternative policies. Our research has spawned numerous studies, guides and reports, including more than two dozen posted at our website, and many more performed by other researchers which rely to various degrees on our costing information.

In my experience there is little to be gained from simply totaling estimated transportation costs. To say that "motor vehicles cost society XX billions of dollars a year" is by itself not very useful. The real benefit comes when cost estimates are converted into appropriate forms for incorporating into a particular planning or policy decision. But the numbers can be tricky. Anybody working with them should have an idea of how the estimates were developed and how they may vary from one situation to another. It is also important to understand some basic economic concepts that relate to how cost data can be used to evaluate efficiency and equity.

Until now much of this information has only been available in our comprehensive report, *Transportation Cost Analysis; Techniques, Estimates and Implications*. This detailed document has chapters on each of the cost categories, hundreds of references, and numerous examples. Because of its cost and size, this information has not been widely accessible.

I have long planned to write a summary report that presents the most important information, analysis and conclusions in *Transportation Cost Analysis*. It was a challenge to boil the extensive data (which is already a condensation of many hundreds of documents) into a short but still useful paper. As you read this report bear in mind that for each reference, example or page of discussion there is five to ten times as much information in *Transportation Cost Analysis*, and far more information in the original sources.

Please contact our institute if you have comments, questions or criticisms of this report. We always appreciate feedback.

Why Study Transportation Costs

A smart consumer investigates all costs prior to making a major transportation investment. Before purchasing a car you want to know its fuel consumption, insurance, licensing, maintenance and repair costs. Similarly, before buying a bus, train or airline ticket you should determine if there are additional fees, and whether the ticket can be changed or refunded. Your interest is not limited just to direct financial costs. You want to know how the options compare in comfort and safety. This information lets you determine which will best serve your needs. You may be willing to pay more for greater long-term economy, flexibility, comfort, safety.

Just as consumers need accurate and comprehensive cost information when making personal transport decisions, communities need such information for transport planning and policy making. Yet, many transport decisions are based on relatively limited cost information. Several recent studies have added important new transport cost data. This paper describes and summarizes that research, and discusses the implications and applications of this information.

Accurate cost analysis by public agencies is particularly important because transportation is "co-produced" by governments (which supply facilities and services, and make land use policies) and consumers (who own and operate vehicles, and make travel and make land use decisions), so government policies and actions "leverage" consumers' travel decisions. For example, if an area becomes hostile to pedestrians, not only are people who currently walk there worse off, it also shifts potential walking and public transit trips to automobile, leading to increased traffic congestion, road and parking facility costs, accidents, environmental damages, consumer costs and automobile dependency. Thus, public agency decisions can have cascading effects on transport behavior and costs.

The common management admonition to "work smarter, not harder" applies to transport. It reminds us that beyond an optimal level, increased movement may represent inefficiency, not net benefits. If a transport system is distorted by mispricing and inappropriate investments, new technologies that increase vehicle speeds or traffic capacity may exacerbate rather than solve problems. Planning for increased traffic is relatively easy, an engineering exercise to find the cheapest way to accommodate more vehicles. But planning for *optimal* transport is more complex. It is an economic exercise that must take into account all significant costs and benefits. Comprehensive cost analysis is therefore essential for identifying the most optimal transport policies.

Research into transportation costs is sometimes criticized as being "anti-automobile," which inaccurately represents this as an ideological rather than an economic issue. Transport cost research is no more anti-automobile than dietary research is anti-food. This investigation does not mean that automobiles are "bad," or that governments should forbid driving. It does suggest that communities would benefit from more comprehensive analysis of the impacts that result when comparing travel alternatives.

What is Transportation Costing All About?
Transportation costing is often misunderstood. Many people assume that it is simply an ideological argument that automobiles are bad and motorists should be punished with higher taxes or arbitrary regulations. This is incorrect.

Virtually any discussion of transportation involves costing. Consumers are concerned about their expenses, time and accident risk. Tax payers are concerned with their financial burdens. Transportation professionals tend to be concerned with facility expenses, congestion and accident risk. Increasingly people are concerned with environmental impacts. Recent transportation costing studies simply provide a formal structure to these widely-recognized issues. They are descriptive, not perscriptive. The methodologies and estimates they provide are intended to be modified as needed to reflect the conditions and values of a particular community.

Transportation costing has many applications. It provides a vocabulary for discussing impacts, both positive and negative. It helps identify what is favorable and beneficial as much as it identifies options that are unfavorable and harmful. It is useful for determining and evaluating programs, policies, investments, designs, and rules, as well as pricing and taxes.

Consider this example: Imagine that you are mayor of a city. A business wants permission to offer helicopter shuttle service from suburbs to downtown. It would need the city to build suitable terminals. You must determine with other city officials and citizens whether such as service is worthwhile and what regulations it would require.

You might begin by brainstorming potential impacts: benefits to users, congestion reduction, noise and air pollution, accident risk to users and others, the value of land, land use impacts (Would it encourage or discourage city center development?), economic development (Would it make your city more productive?) and equity implications.

But brainstorming means that you are starting from scratch. Existing transportation costing studies and guides provide a framework for identifying and evaluating impacts. They give a name and definition to each impact. They discuss the extent and implications of impacts. They describe techniques for measuring impacts and examples of existing estimates. This can help identify which impacts are likely to be most significant in your situation. Perhaps you will decide to commission more detailed studies of some of these costs, for example to determine the magnitude of helicopter noise and accident risk, and the full costs and risks of building helicopter terminals.

You might also want to consider the fees and taxes that would be charged for this service. Should the city demand cost recovery for its terminal investment? Should parking at terminals be free or market-based? Should the company be required to mitigate or compensate nearby businesses and residents for noise impacts? If so, by how much?

Perhaps, after this proposal is announced other groups suggest alternative congestion reduction strategies: new highways, subways, road pricing, or increased downtown residential development. Each suggestion has its own merits and costs, some of which you may not have considered previously. Comparing them requires an even broader transportation costing framework.

Basic Concepts for Transportation Costing

This section defines some terms used in this report.

Let's begin by defining **transportation** (or "transport," which means the same thing and is shorter) and considering how it is measured. Transport is often assumed to mean vehicle movement, measured as *vehicle trips* or *Vehicle Miles Traveled* (VMT), *traffic speed*, roadway *Level of Service* (LOS), or *vehicle delay*, but this ignores other travel options. Defining transport as **mobility,** measured in *person-trips*, *person-miles*, *trip speed* or *personal delay* recognizes walking, cycling and transit modes. But even this definition is limited. The ultimate objective of transport is **access**, the ability to reach desired goods and activities.[1] This definition recognizes options such as communications, delivery services and more efficient land use that can improve access with reduced mobility. Access is measured in **generalized cost**, which includes both financial and time costs, and is commonly called "convenience."

What most people call a "problem" economists often call a **cost**. This emphasizes that problems can be compared and quantified. Economists define costs as "benefits foregone." Costs and benefits therefore have a mirror-image relationship: a cost can be defined as benefits foregone and a benefit can be defined as reduced costs. In practice, most transport benefits are measured as cost reductions. For example, road improvements provide benefits consisting of reduced congestion, vehicle and accident costs.

Costs have various attributes. We consider both **market** costs, which involve goods regularly purchased with money (also called "financial" or "pecuniary" costs, or simply "expenses"), and **nonmarket** costs, such as personal time, discomfort, and environmental damages. Environmental and social impacts are sometimes called "intangibles" with the implication that they are unmeasurable. However, techniques are now available to measure and **monetize** (measure in monetary units) these impacts.[2] Nonmarket impacts often have values comparable in magnitude to impacts traditionally considered in transport planning, such as roadway and vehicle expenses.[3]

Another important attribute is whether a cost is **variable** (increases with consumption) or **fixed** (not related to consumption). For example, fuel is a variable cost while vehicle insurance is considered a fixed cost, since insurance premiums do not increase significantly with mileage. Economists often use a somewhat more precise term: **marginal** costs are the costs of a particular unit of consumption. If your garage has two parking spaces, owning one or two vehicles has no marginal residential parking cost, but a third vehicle incurs a marginal parking cost if you want covered parking, since it requires adding garage space.

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[1] *Mobility and Access; Transportation Statistics Annual Report 1997*, BTS (www.bts.gov), 1997.

[2] John Gowdy and Sabine O'Hara, *Economic Theory for Environmentalists*, St. Lucie Press (Delray Beach), 1995.

[3] Dr. Peter Bein, *Monetization of Environmental Impacts of Roads*, Planning Services Branch, B.C. Ministry of Transportation and Highways (Victoria, www.th.gov.bc.ca/bchighways), 1997.

The distribution of costs is another important attribute. Some costs are **internal**, meaning that they are borne directly by the user (e.g., car, bus or airplane passenger), while others are **external**, meaning that they are borne by somebody other than the user. Cost distribution is most precise when defined at the **individual** level, referring to the impacts each consumer imposes and bears. However, costs are often analyzed at the **group** or **sector** level for convenience, but such analysis can be arbitrary since it is affected by how groups are defined, and does not take into account impacts imposed within the group.

For example, consider vehicle noise costs. Within a neighborhood some households may have noisy cars, others have quite cars, and some have no cars. If we define residents as a group, all noise in the neighborhood can be considered an internal cost. If we define car owners as a group, then only vehicle noise imposed on households that do not own a car is an externality. But the fact that people suffering from vehicle noise own a car does not really internalize this cost. If all vehicle owning households impose and bear the same noise impacts, equity impacts could balance out, but in practice some households produce more vehicle noise or are more sensitive to such impacts. And regardless of equity impacts, only if each individual motorist directly bears the noise costs they impose would they have an appropriate incentive to control their noise emissions.

Price refers to the costs that directly affect consumers' purchase decisions. For this analysis we define price as *perceived-internal-variable costs*, which includes both market costs such as fuel for a vehicle or fares for a transit trip, and nonmarket costs such as time, discomfort and accident risk.

Costs—A Primer

A dog can often be obtained at minimal initial price, or even for free. But pet owners quickly discover that a dog imposes many *costs*. Some, such as pet food, are *market costs*. Others, such as the nuisance of cleaning up after the animal, are *nonmarket costs*, although these can sometimes be *monetized* using a market cost as a reference, such as what it costs to hire somebody to clean up after the dog. Some pet costs, such as purchasing a doghouse, are *fixed*, you pay the same regardless of how long you have the dog, while others, such as food, are *variable* because the dog consumes some each day. In addition to the *internal* costs borne by their owners, dogs can impose *external* costs on other people, including noise, odors, and fear. It a dog bites another dog owner, this is an external cost at the *individual level* but could be considered an internal cost at the *sector level* if dog owners are defined as a group.

A basic tenet of economics is that **economic efficiency** is maximized when prices reflect marginal costs, which means that resources provide maximum benefit. For example, unmetered electricity (consumers pay a fixed fee regardless of how much power they use) encourages wasteful energy use. Metered electrical power gives consumers an incentive to use power more economically efficient because prices reflect the marginal cost of providing the service.

Horizontal equity refers to whether people with similar needs and abilities are treated the same. It requires **cost recovery** (consumers pay for the goods they use) unless there is a specific reasons to **subsidize** one good or group of consumers. **Vertical equity** refers to how people with differing needs and abilities are treated. It assumes that disadvantaged people should receive greater support from society than those who are relatively advantaged. For example, special mobility services for people with disabilities, and discounted fares for students and elderly passengers reflect vertical equity objectives. Note that horizontal and vertical equity often conflict.

Economic neutrality means that comparable goods are treated equally. For example, it implies that taxes and regulations should not discriminate between similar goods or consumers. This helps achieve both economic efficiency and horizontal equity. Violations of this principle are called **market distortions**.

Transportation Costs

This section discusses transport costs and how they are measured. Cost values are in U.S. dollars unless noted otherwise.

User Expenses

This category includes vehicle costs and fares. Several companies publish estimates of typical vehicle costs.[4] Table 1 illustrates an example of this information. These estimates tend to overstate depreciation and insurance, and understate maintenance and repair costs compared to the overall vehicle fleet because they assume a relatively new car (typically the first four years of vehicle life).

Table 1 **American Automobile Association Vehicle Cost Estimates**[5]

	Medium Car (Cavalier LS)	**Large Car** (Taurus SE)	**Luxury Car** (Grand Marquis)	**SUV** (Blazer)	**Van** (Caravan SE)
Gas & oil	5.0¢	6.3¢	7.4¢	7.2¢	6.8¢
Maintenance	2.9¢	3.1 ¢	3.2¢	3.4¢	3.2¢
Tires	1.3¢	1.4¢	1.4¢	1.4¢	1.3¢
Operating costs/mile	*9.2¢*	*10.8¢*	*12.0¢*	*12.0¢*	*11.3¢*
Insurance	$912	$856	$933	$1,312	$950
License & registration	$175	$223	$279	$396	$379
Depreciation	$2,819	$3,294	$3,979	$3,556	$3,409
Financing	$598	$802	$1,040	$929	$885
Ownership costs/year	*$4,504*	*$5,175*	*6,231*	*$6,193*	*$5,623*

Vehicle costs are usually divided into *ownership* (fixed) and *operating* (variable) costs.[6] Lifecycle cost analysis (Table 2) and consumer surveys (Table 3) indicate lower average annual expenditures.

Table 2 **Lifecycle Costs for Selected Vehicles (1991 ¢/mile)**[7]

	Depreciation	**Insurance**	**Maintenance**	**Parking & Tolls**	**Tires**	**Finance Charges**	**Lic. & Reg.**	**Fuel & Oil**	**Fuel Taxes**	**Total**
Vehicle Type	Fixed*	Fixed*	Variable	Variable	Variable	Fixed	Fixed	Variable	Variable	
Sub-Compact	8.6	7.1	4.0	1.3	0.7	1.6	0.8	3.5	1.3	28.9
Intermediate	10.7	7.0	4.2	1.3	1.0	2.0	0.9	4.6	1.7	33.4
Full-size Van	14.2	8.5	4.2	1.3	1.4	2.9	1.2	8.1	3.0	44.8
Full-size Pickup	9.5	7.2	4.3	1.3	1.2	2.2	0.9	6.2	2.3	35.1

* Actually partly fixed as discussed above.

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[4] Runzheimer International (www.runzheimer.com); Intellichoice (www.intellichoice.com).

[5] *Your Driving Costs 1998*, American Automobile Association (Heathrow, FL), 1998, based on data from Runzheimer International (www.runzheimer.com). Canadian data is available from *Driving Costs*, Canadian Automobile Association (www.caa.ca).

[6] Some costs often considered fixed are actually partly variable. For example, increased mileage reduces a vehicle's resale value, increases maintenance and repair costs, and increases the risk of crashes and traffic citations. These longer-term distance-based costs average 10¢ or more per mile for a typical automobile.

[7] Jack Faucett Associates, *The Costs of Owning and Operating Automobiles, Vans and Light Trucks, 1991*, FHWA (Washington DC), 1992.

Table 3 **Average Transportation Expenditures (1997 U.S. Dollars)**[8]

	Per Household	Portion of Household Total	Per Vehicle Year	Per Vehicle Mile
Vehicle purchases	$2,856	7.9%	$1,428	11.4¢
Gasoline and motor oil	$1,110	3.1%	$555	4.4¢
Vehicle finance charges	$305	0.8%	$153	1.2¢
Maintenance and repairs	$720	2.0%	$360	2.9¢
Vehicle insurance	$779	2.2%	$390	3.1¢
Other vehicle charges	$508	1.4%	$254	2.0¢
Total vehicle expenses	$6,278	17.4%	$3,139	25.1¢
Public transport expenses	$390	1.1%	$195	NA
Total transportation expenses	*$6,669*	*18.5%*	*$3,335*	*NA*

Roadway investment computer models calculate vehicle operating costs (fuel, oil and tires, and sometimes depreciation and maintenance) for various vehicle classes and road conditions, but typically ignore fixed costs.[9] Highway engineering models predict vehicle operating costs under various road conditions.[10]

Table 4 summarizes public transit modes costs. Marginal transit service costs tend to be significantly lower than the average costs (a 10% increase in transit usage requires less than a 10% increase in costs and subsidies). This is indicated by the fact that transit service cost recovery increases in areas with per-capita transit use.[11]

Table 4 **1996 Public Transit Costs**[12]

	Bus	Trolley Bus	Light Rail	Heavy Rail	Commuter Rail
Operating Expenses (m)	$8,995	$135	$440	$3,402	$2,294
Capital Funding (m)	$1,920	$19.1	$847	$2,228	$1,690
Total Expenses (m)	$10,915	$154	$1,287	$5,630	$3,984
Passenger Fare Revenue (m)	$3,446	$55	$144	$2,322	$1,145
Subsidy (m)	$7,469	$99	$1,143	$3,308	$2,839
Vehicle Revenue Miles (m)	1,577	13.1	36.7	527	221
Total Expenses Per Revenue Mile	$6.92	$11.75	$34.78	$10.68	$18.03
Annual Passenger Miles (m)	16,802	184	955	11,530	8,350
Average Vehicle Occupancy	10.7	14.0	26.0	21.9	37.7
Total Expenses Per Passenger Mile	$0.65	$0.84	$1.35	$0.49	$0.48
Revenue Per Passenger Mile	$0.21	$0.30	$0.15	$0.20	$0.14
Subsidy Per Passenger Mile	$0.44	$0.54	$1.20	$0.29	$0.34

m=million

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[8] 1997 Consumer Expenditure Survey, BLS (ftp://ftp.bls.gov/pub/special.requests/ce).

[9] *Highways Design and Maintenance (HDM) 4 Model*, World Bank (www.RoadSource.com); *MicroBENCOST*, Texas Transportation Institute (http://tti.tamu.edu), 1997.

[10] *Highways Design and Maintenance (HDM) 4 Model*, World Bank (Washington DC; www.RoadSource.com); *MicroBENCOST*, Texas Transportation Institute (College Station), 1997.

[11] Peter Newman and Jeff Kenworthy, *Sustainability and Cities; Overcoming Automobile Dependency*, Island Press (Covelo; www.islandpress.org), 1998, p. 117; Todd Litman and Felix Laube, *Automobile Dependency and Economic Development*, VTPI (www.vtpi.org), 1998.

[12] *1996 National Transit Summaries and Trends* and *1998 APTA Transit Fact Book*, American Public Transit Association (Washington DC; www.apta.com), 1998.

Travel Time

Travel time costs include the value of personal (unpaid) travel time, wages and benefits of employee's time spent in travel, and the time value of equipment and goods in transit. Although a small amount of recreational travel has zero time cost (people would rather be traveling than doing other activities), most time spent in travel represents a cost. The value of this cost has been measured by studying travelers' willingness to pay for a faster option, and studies of travel time costs to businesses.[13] Table 5 illustrates travel costs for various modes.

Table 5 **Commute Trip Time, Length and Speed by Mode**[14]

	Automobile	Transit	Walking	All
Commute Travel Time (min.)	19.0	49.9	9.6	19.7
Commute Trip Length (miles)	11.0	12.6	0.5	10.7
Commute Average Speed (mph)	34.7	15.2	3.1	32.3

Average travel time, distance and speed vary by mode.

Travel time costs vary depending on conditions. For example, drivers' travel time costs tends to increase with congestion, and transit riders' travel time increases if vehicles or waiting conditions are uncomfortable. Time costs are high for unexpected delays and for relatively long (more than 30 minutes) commute trips. Time costs for waiting at a transit stop and involuntary walking trips tend be high, but under favorable circumstances people often choose to walk or bicycle for exercise and enjoyment although they have faster alternatives, in which case additional travel time has no incremental cost.[15]

Table 6 illustrates a typical schedule for calculating travel time costs based on prevailing wages. This is used to calculate the value of transport improvements that save time.

Table 6 **Travel Time Values Used by B.C. Ministry of Transportation**[16]

	Travel Time Values
Commercial vehicle driver	Wage rate plus fringe benefits
Personal vehicle driver	50% of current average wage
Adult car or bus passenger	35% of current average wage
Child passenger under 16 years	25% of current average wage

Congestion increases travel time costs for drivers by the following amounts according to Level of Service (LOS) ratings:

LOS D: multiply by 1.33 LOS E: multiply by 1.67 LOS F: multiply by 2.0

This travel time schedule includes higher rates for drivers under congested conditions.

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[13] Mark Wardman, "The Value of Travel Time," *Journal of Transport Economics and Policy*, Vol. 32, No. 3, Sept. 1998, pp. 285-316; Kenneth Gwilliam, *The Value of Time in Economic Evaluation of Transport Projects; Lessons from Recent Research*, World Bank (Washington DC; www.worldbank.org), 1997.

[14] Alan Pisarski, *Travel Behavior Issues in the 90's*, USDOT (Washington DC), July 1992, p. 70.

[15] Kenneth Small, "Project Evaluation," in *Transportation Policy and Economics*, Brookings (www.brookings.edu), 1999, available at http://socrates.berkeley.edu/~uctc/text/papersuctc.html.

[16] William Waters, *The Value of Time Savings for The Economic Evaluation of Highway Investments in British Columbia*, BC Ministry of Transportation and Highways (www.th.gov.bc.ca/bchighways), 1992.

Traffic Crash and Risk[17]

Traffic crash costs include deaths, injuries, pain, disabilities, lost productivity, grief, material damage, and crash prevention expenses. Studying tradeoffs between financial expenses and safety (such as consumer expenditures on vehicle safety equipment) helps indicate the value society places on marginal changes in risk. This information is used to evaluate investments and policies that affect transport safety. Table 7 indicates the values assigned to various types of crashes. One major study estimated that motor vehicle accidents costs totaled $358 billion in 1988, a major component of which are nonmarket costs such as pain and lost quality of life.[18] The National Highway Traffic Safety Administration estimates traffic crash monetary costs (excluding pain and lost quality of life) at $150 billion, averaging about 6.5¢ per vehicle mile.[19]

Table 7 **FHWA Accident Costs Per Injury (1994 dollars)**[20]

KABC Scale			Abbreviated Injury Scale (AIS)		
Severity	Descriptor	Cost ($)	Severity	Descriptor	Cost ($)
K	Fatal	2,600,000	AIS 6	Fatal	2,600,000
A	Incapacitating	180,000	AIS 5	Critical	1,980,000
B	Evident	36,000	AIS 4	Severe	490,000
C	Possible	19,000	AIS 3	Serious	150,000
PDO	Property Damage Only	2,000	AIS 2	Moderate	40,000
			AIS 1	Minor	5,000

Some crash costs are external, either at the individual or sector level.[21] Table 8 indicates external crash costs (costs imposed on pedestrians, expenses not paid by drivers, and the incremental crash risk associated with increased traffic volumes) for various vehicles. In addition to crash damage costs, there are additional costs from avoidance measures, including traffic safety programs and reduced pedestrian and bicycle travel.

Table 8 **Estimated Highway External Crash Costs (Cents Per Vehicle Mile)**[22]

	Rural Highways			Urban Highways			All Highways		
	High	Med.	Low	High	Med.	Low	High	Med.	Low
Automobile	9.68	3.15	1.76	4.03	1.28	0.78	6.02	1.94	1.13
Pickup & Van	10.21	3.31	1.75	4.05	1.27	0.74	6.70	2.15	1.17
Buses	14.15	4.40	2.36	6.25	1.89	1.08	9.55	2.94	1.62
Single Unit Trucks	5.97	2.00	0.97	2.21	0.71	0.40	3.90	1.29	0.65
Combination Trucks	6.90	2.20	1.02	3.67	1.16	0.56	5.65	1.79	0.84
All Vehicles	*9.52*	*3.09*	*1.68*	*3.98*	*1.26*	*0.76*	*6.12*	*1.97*	*1.11*

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[17] The term "crash" is preferred over "accident" by many traffic safety professionals because it emphasizes that such events are not simply random events, but have an ultimate cause that can be eliminated.

[18] Ted Miller, *The Costs of Highway Crashes*, FHWA (www.fhwa.dot.gov), FHWA-RD-055, 1991.

[19] Lawrence Blincoe, *Economic Cost of Motor Vehicle Crashes 1994*, NHTSA (Washington DC; www.nhtsa.doc.gov/people/economic/ecomvc1994.html), 1995.

[20] Homberger, et al, *Fundamentals of Traffic Engineering*, 14th Edition, Institute of Transportation Studies (Berkeley; www.its.berkeley.edu), UCB-ITS-CN-96-1, 1996, p. 9-13.

[21] Rune Elvik, "The External Costs of Traffic Injury: Definition, Estimation, and Possibilities for Internalization," *Accident Analysis and Prevention*, Vol. 26, No. 6, 1994, pp. 719-732.

[22] *1997 Federal Highway Cost Allocation Study*, USDOT (www.fhwa.dot.gov), Table V-24.

Parking

This includes construction, maintenance, operating and land costs of off-street parking facilities. Parking facilities are usually incorporated into the cost of buildings, but parking demand depends on vehicle use and should therefore be considered a cost of driving. Parking facility costs are often considered "sunk" (they must be paid whether or not they are being used), but since the main resource of most parking facilities is land, which always has alternative uses, virtually all parking has a marginal opportunity cost.

Table 9 summarizes typical costs of various types of parking facilities. Actual costs depend on real estate prices, facility design, and conditions. Commercial urban parking facilities must typically rent for about $100 per month per space to recover costs.[23] An off-street residential parking space adds about $600 per year or more to housing costs.[24]

Table 9 **Typical Parking Facility Costs**[25]

	Surface Parking	**Structured Parking**	**Underground**
Construction Costs	$2,000	$10,000	$17,000
Land Costs	$3,000	$2,000	$0
Total Construction	$5,000	$12,000	$17,000
Annualized Capital Costs	$500	$1,000	$1,700
Annual Operations & Maintenance	$100	$500	$700
Total Annualized Cost	$600	$1,500	$2,400
Monthly Parking Cost	*$50*	*$125*	*$200*

Mark Delucchi estimates annual off-street parking costs include $15 to $41 billion for residential parking, $48 to $162 billion for business supplied parking, and $12 to $20 billion for municipal and institutional supplied parking, totaling $75 to $223 billion.[26] This averages $414 to $1,232 per vehicle year, or 3.3¢ to 9.7¢ per motor vehicle mile.

Most non-residential parking costs are external. Only 5% of automobile commuters pay full parking costs, and free parking is provided for 99% of non-commute trips.[27] Some economists define free parking as a "bundled good" rather than an externality because the cost is part of commercial transactions. However, since people often have no viable alternative (employees cannot usually choose a higher wage, and consumers cannot usually choose lower retail prices in exchange for foregoing free parking) and must bear the cost regardless of use (e.g., customers who use alternative modes pay for bundled parking they do not use) these costs are external at the individual level and functionally an external costs with respect to both economic efficiency and equity.

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[23] Richard Willson, *Suburban Parking Economics and Policy: Case Studies of Office Worksites in Southern California*, FHWA (www.fhwa.dot.gov/environment), 1992.

[24] Patrick Hare, et al, *Trip Reduction and Affordable Housing*, Transportation Research Board, 1991.

[25] John Dorsett, "The Price Tag of Parking," *Urban Land* (www.udi.org), May 1998, pp. 66-70; Robert Weant and Herbert Levinson, *Parking*, Eno Foundation (www.enotrans.com), 1990.

[26] Mark Delucchi, *Annualized Social Cost of Motor-Vehicle Use in the U.S., 1990-1991*, Vol. 6, Institute of Transportation Studies (Davis; www.engr.ucdavis.edu/~its), UCD-ITS-RR-96-3 (6), 1997.

[27] 1990 NPTS, *Summary of Travel Trends*, USDOT (Washington DC) 1992.

Congestion

This is the incremental delay, stress, vehicle operating costs and pollution that results from each additional vehicle added to the traffic stream. It is an externality in terms of economic efficiency, and to some degree in terms of equity due to differences in the cost per passenger-mile imposed by different modes. Because it consists mainly of additional costs expenses imposed on other motorists, it is inappropriate to add congestion and user costs together when calculating total costs for automobile users as a group.

Several approaches are used to calculate congestion costs.[28] The Texas Transportation Institute developed an index for comparing congestion in different cities, and estimated annual congestion costs total $74 billion in the U.S.[29] Another study which modeled congestion costs on the five classes of highways concluded that appropriate congestion fees on these roads average 4¢ -5¢ per vehicle mile, with total annual congestion costs of $44 to $98 billion in the U.S.[30] Delucchi estimates U.S. traffic congestion external costs, including travel time delay and increased fuel consumption, totaled $34 to $146 billion in 1991.[31] Different types of vehicles cause different amounts of congestion, which is measured in units called "passenger car equivalents" or PCEs.[32]

Table 10 illustrates estimated congestion costs for various vehicles and conditions.

Table 10 **Estimated Highway Congestion Costs (Cents Per Vehicle Mile)**[33]

	Rural Highways			Urban Highways			All Highways		
	High	Med.	Low	High	Med.	Low	High	Med.	Low
Automobile	3.76	1.28	0.34	18.27	6.21	1.64	13.17	4.48	1.19
Pickup & Van	3.80	1.29	0.34	17.78	6.04	1.60	11.75	4.00	1.06
Buses	6.96	2.37	0.63	37.59	12.78	3.38	24.79	8.43	2.23
Single Unit Trucks	7.43	2.53	0.67	42.65	14.50	3.84	26.81	9.11	2.41
Combination Trucks	10.87	3.70	0.98	49.34	16.78	4.44	25.81	8.78	2.32
All Vehicles	4.40	1.50	0.40	19.72	6.71	1.78	13.81	4.70	1.24

Most congestion studies only consider costs imposed on motor vehicle users. The delay and accident risk costs that vehicle traffic and highways impose on non-motorized travel is called the "barrier effect" or "severance." Some studies have quantified this cost in terms of travel delay and non-motorized trips foregone.[34] This indicates that such costs can be significant, particularly in urban areas.

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[28] *Quantifying Congestion*, TRB (Washington DC; www.nas.edu/trb), NCHRP Project 7-13, 1997.

[29] David Schrank and Tim Lomax, *Mobility Study - 1982 to 1996*, Texas Transportation Institute (http://mobility.tamu.edu/study/summary.stm), 1998.

[30] Robert Repetto, et al., *Green Fees: How a Tax Shift Can Work of the Environment and the Economy*, World Resources Institute (Washington DC; www.wri.org), 1992.

[31] Mark Delucchi, *Annualized Social Cost of Motor-Vehicle Use in the U.S., 1990-1991*, Institute of Transportation Studies (Davis; www.engr.ucdavis.edu/~its), UCD-ITS-RR-96-3, 1997.

[32] *A Policy on Geometric Design of Highways and Streets*, AASHTO (www.aashto.org), 1990, p. 261.

[33] *1997 Federal Highway Cost Allocation Study*, USDOT (www.fhwa.dot.gov), Table V-23.

[34] J.M. Clark and B.J. Hutton, *The Appraisal of Community Severance*, Transport Research Laboratory (UK; www.trl.co.uk), Report #135, 1991; Donald Rintoul, *Social Cost of Transverse Barrier Effects*, B.C. Ministry of Transportation and Highways (Victoria, www.th.gov.bc.ca/bchighways), 1995.

Roadway Costs

This includes the costs of building, maintaining and operating public roads. Roadway expenditure data can be obtained from government accounts.[35] Table 11 summarizes results of a recent cost allocation study showing the average roadway costs imposed by different vehicle classes on different types of roads, their user payments, and the residual external costs. Federal, state and provincial highway expenses are largely funded by special user charges (fuel taxes, registration fees and road tolls) and so can be considered internal costs. Local roads and municipal traffic services (traffic police, street lighting, planning, and emergency services) are largely funded by local taxes and are therefore external costs since residents pay regardless of their travel patterns.[36]

Table 11 **Roadway Cost Responsibility Per Mile (Year 2000)**[37]

Vehicle Class	Federal Costs	State Costs	Local Costs	**Total Costs**	**User Payments**	**External Costs**
Automobiles	$0.007	$0.020	$0.009	$0.035	$0.026	$0.009
Pickups and Vans	$0.007	$0.020	$0.009	$0.037	$0.034	$0.003
Single Unit Trucks	$0.038	$0.067	$0.041	$0.146	$0.112	$0.034
Combination Trucks	$0.071	$0.095	$0.035	$0.202	$0.157	$0.044
Buses	$0.030	$0.052	$0.036	$0.118	$0.046	$0.072
All Vehicles	*$0.011*	*$0.025*	*$0.011*	*$0.047*	*$0.036*	*$0.010*

Land is another resource cost of roads and other transport facilities. Virtually all land has alternative uses, either for market activities such as buildings and farms, or for nonmarket activities such as greenspace. To describe this another way, transport options that require less land provide economic and environmental benefits by leaving more land available for other uses. Except when additional right-of-way is purchased for a road project, land devoted to roads is usually considered a sunk cost and users pay no equivalent of rent or property taxes. Economic neutrality requires that land be priced and taxed at the same rate for competing uses.[38] Failure to consider roadway land value in investment and pricing decisions underprices road transport relative to rail (which pays rent and taxes on right-of-way), and underprices transport relative to other goods, reducing economic efficiency. One study estimates the total value of land devoted to the U.S. road system has an annualized value of $75 billion, or 3.4¢ per VMT.[39]

Motor vehicle users need not be charged for all road costs since roads also provide access for non-motorized modes and public services. A portion of roadway costs can be assigned to "basic mobility" and motorists charged only additional costs associated with their vehicle use. But since basic mobility can be provided by a much cheaper road system, most current roadway expenditures can be assigned to motor vehicle use.

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[35] *Highway Statistics*, FHWA (www.fhwa.dot.gov/ohim), 1998.

[36] Mark Delucchi, *Annualized Social Cost of Motor-Vehicle Use in the U.S., 1990-1991; Report #7*, Institute of Transportation Studies (Davis; www.engr.ucdavis.edu/~its), 1998.

[37] *1997 Federal Highway Cost Allocation Study*, USDOT (www.fhwa.dot.gov), tables II-6, IV-11, V-21.

[38] Gabriel Roth, *Roads in a Market Economy*, Avebury (Aldershot), 1996.

[39] Douglass Lee, *Full Cost Pricing of Highways*, Volpe Tran. Center (http://ohm.volpe.dot.gov), 1995.

Air Pollution

This includes damages caused by harmful air emissions from motor vehicles including carbon monoxide (CO), particulates (PM), nitrogen oxides (NOx), hydrocarbons (HC, also called Volatile Organic Compounds or VOCs), sulfur oxides (SOx), carbon dioxide (CO_2), methane (CH_4), CFCs, road dust, and toxic gases such as benzene.[40]

Some people claim that vehicle emission rates have declined by 90% or more over the last few decades, but this is an exaggeration. Per mile tailpipe emissions under standard test conditions have declined significantly due to emission controls, but actual emission reductions are much smaller for several reasons: catalytic converters are only effective after an engine heats up, "hot-soak" emissions occur after the engine stops, tests do not reflect real driving conditions, and some air pollutants are not emitted from tailpipes.[41] Increased vehicle mileage has offset much of the per mile emission reduction gains, so many urban areas continue to experience vehicle air pollution problems.

A number of studies have estimated the cost per unit of pollutant.[42] Table 12 summarizes estimated costs for various emissions in U.S. urban areas based on two different analysis methods: marginal damage costs caused by the pollutant, and the marginal costs of controlling (reducing) a pollutant. Costs also vary depending on geographic factors.

Table 12 **Estimated Emission Values (1989 $/ton)**[43]

Emission	Damage Costs	Control Costs
NOx	$4,820	$10,634
ROG	$2,420	$9,944
PM_{10}	$6,507	$3,687
SOx	$2,903	$7,111
CO	N/A	$2,714

This information is used to calculate air pollution costs per mile for various vehicle types. Some studies focus on just a few impacts and so give an incomplete estimate of total air pollution costs. For example, Small and Kazimi estimated Southern California air pollution costs from gasoline automobiles to average about 3.3¢ per vehicle mile, with lower costs in most other regions.[44] However, this estimate only includes human health impacts from tailpipe particulate and ozone emissions. It excludes other damage and pollutant categories, some of which may be quite significant, a point made by the authors but ignored by many who use their results.

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[40] *Indicators of the Environmental Impacts of Transportation*, Office of Policy and Planning, USEPA (Washington DC; www.epa.gov/tp), EPA 230-R-96-009, 1996, pp. 63-75.

[41] *Mobility and Access, Transportation Statistics Annual Report 1997*, BTS, (www.bts.gov), p. 109-110.

[42] M.Q. Wang, D.J. Santini & S.A. Warinner, *Methods of Valuing Air Pollution and Estimated Monetary Values of Air Pollutants in Various U.S. Regions*, Argonne National Lab (www.ipd.anl.gov), 1994.

[43] M.Q. Wang, D.J. Santini & S.A. Warinner, "Monetary Values of Air Pollutants in Various U.S. Regions," *Transportation Research Record 1475*, 1995, pp. 33-41.

[44] Ken Small and Camilla Kazimi, "On the Costs of Air Pollution from Motor Vehicles," *Journal of Transport Economics and Policy*, January 1995, pp. 7-32.

Recent research indicates that the greatest vehicle air pollution human mortality risk results from fine particulates, some of which (such as brake and tire wear, and road dust) are not affected by tailpipe emission controls.[45] Table 13 summarizes a relatively comprehensive estimate of vehicle air pollution costs.

Table 13 **Air Pollution Health Costs by Motor Vehicle Class ($1990 / VMT)**[46]

Vehicle Class	Low Estimate	Middle Value	High Estimate
Light Gasoline Vehicle	0.008	0.069	0.129
Light Gasoline Truck	0.012	0.100	0.188
Heavy Gasoline Vehicle	0.024	0.260	0.495
Light Diesel Vehicle	0.016	0.121	0.225
Light Diesel Truck	0.006	0.061	0.116
Heavy Diesel Truck	0.054	0.644	1.233
Weighted Fleet Average	*0.011*	0.112	*0.213*

There is particular uncertainty about climate change emission costs. Some critics argue that there is insufficient proof that global climate change is occurring, or that benefits will offset costs.[47] However, an increasing body of independent scientific evidence indicates that climate change is a significant risk. The Intergovernmental Panel on Climate Change, an organization of leading scientific experts, concluded, "The balance of evidence suggests a discernible human influence on global climate" which could impose many costs to society.[48] Similarly, the American Geophysical Union concluded that, "the present level of scientific uncertainty does not justify inaction in the mitigation of human-induced climate change".[49] Table 14 summarizes one estimate of greenhouse emission costs. This indicates a greenhouse gas cost of 18¢ to 56¢ U.S. per gallon of gasoline, or about 0.9¢ to 2.8¢ per mile.

Table 14 **Greenhouse Gas Damage Costs**[50]

Emission	Units	Low	Mid Point	High
Carbon Dioxide	ECU/tonne carbon	74	152	230
Carbon Dioxide	ECU/tonne CO_2	20	42	63
Methane	ECU/tonne CH_4	370	540	710
Nitrous Oxide	ECU/tonne N_2O	6,800	21,400	36,000

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[45] Seaton, et al., "Particulate Air Pollution and Acute Health Effects," *The Lancet*, Vol. 345, Jan. 21, 1995, pp. 176-178; Brock Williams, et al., "Latex Allergen in Respirable Particulate Air Pollution," *Journal of Allergy Clinical Immunology*, Vol. 95, 1995, pp. 88-95.

[46] Donald McCubbin and Mark Delucchi, *Social Cost of the Health Effects of Motor-Vehicle Air Pollution*, Institute of Transportation Studies (Davis; www.engr.ucdavis.edu/~its), 1996, Table 11.7-6.

[47] See *The Greening of Planet Earth* and other publications by the Western Fuels Association (www.westernfuels.org) and Green Earth Society (www.greeningearthsociety.org).

[48] See websites http://gcmd.nasa.gov, www.unfccc.de and www.ipcc.ch for information.

[49] *Climate Change and Greenhouse Gases*, American Geophysical Union (www.agu.org), 1998.

[50] *ExternE; Newsletter 6*, European Commission (http://externe.jrc.es), March 1998.

Other Pollutants

Motor vehicle traffic also imposes noise pollution.[51] Traffic noise tends to increase with traffic speed, accelerations, the portion of heavy vehicles and motorcycles, and development density. Table 15 shows estimated noise costs per vehicle on a major highway. Noise costs tend to be much higher on local urban roads, where traffic tends to be closer to residences. European studies indicate higher vehicle noise costs (averaging the equivalent of 0.7¢ per automobile mile), probably due to greater densities and more awareness of traffic noise impacts.[52]

Table 15 **Costs Per Noise Passenger Car Equivalent (1993 Cents Per Mile)**[53]

mph:	**20**	**25**	**30**	**35**	**40**	**45**	**50**	**55**	**60**
Urban, CBD	0.02	0.03	0.05	0.07	0.10	0.13	0.16	0.20	0.24
Urban Fringe	0.02	0.03	0.08	0.13	0.19	0.25	0.32	0.40	0.51
Urban, Outer CBD	0.00	0.01	0.02	0.03	0.05	0.06	0.08	0.10	0.12
Urban, Residential	0.02	0.03	0.05	0.07	0.10	0.13	0.16	0.19	0.23
Urban, Rural Character	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.02
Rural, Sparse Development	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Rural, Dense Development	0.02	0.03	0.06	0.08	0.12	0.16	0.20	0.24	0.28

This table indicates estimated residential noise costs for motor vehicle travel on 110,000 average annual daily traffic highways

Roads and motor vehicles use also contribute to water pollution, hydrologic impacts and waste disposal (such as used tires) which impose a variety of costs on society.[54] Some studies have attempted to quantify these costs.[55]

Resource Consumption Externalities

These include uncompensated environmental damages associated with extraction, processing and transport of resources (such as petroleum and other minerals); macroeconomic and political costs of importing resources; and impacts on future generation of reduced non-renewable resources. That energy independence and conservation are national policy objectives reflects these costs.[56] A number of studies have estimated the monetary values of these costs.[57]

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[51] Noise Pollution Clearinghouse (www.nonoise.org); *1997 Federal Highway Cost Allocation Study*, USDOT, Table V-22.

[52] Emile Quinet, "Full Social Cost of Transportation in Europe," *The Full Costs and Benefits of Transportation*, Springer (Berlin), 1997, pp. 69-111, Table A1.

[53] Daniel Haling and Harry Cohen, "Residential Noise Damage Costs Caused by Motor Vehicles," *Transportation Research Record 1559*, 1997, pp. 84-93.

[54] *Indicators of the Environmental Impacts of Transportation*, USEPA (www.epa.gov/tp), 1996, pp. 41-69; NEMO, www.canr.uconn.edu/ces/nemo; Center for Watershed Protection, www.pipeline.com/~mrrunoff.

[55] Dr. Peter Bein, *Monetization of Environmental Impacts of Roads*, Planning Services Branch, B.C. Ministry of Transportation and Highways (Victoria, www.th.gov.bc.ca/bchighways), 1997.

[56] David Greene and K.G. Duleep, "Costs and Benefits of Automotive Fuel Economy Improvement," *Transportation Research A*, Vol. 27A, No. 3, pp. 217-235, 1993.

[57] Harold Hubbard, "The Real Cost Of Energy," *Scientific American*, Vol. 264, No. 4, April 1991.

Land Use Impacts[58]

This includes negative economic, environmental and social impacts resulting when land is paved for transport facilities, and from lower-density urban expansion (sprawl). There is general agreement that sprawl can increase the costs of providing services (roads, utilities and emergency response) and future transport, and that pavement and sprawl reduce greenspace benefits, increase stormwater costs, and have "heat island" effects.[59] There are also indications that automobile-oriented development patterns reduce community functions that depend on neighborhood interactions, although there is less agreement on this issue. To describe this another way, there are economic, environmental and social benefits from greenspace and denser, more accessible communities which tend to be reduced as a result of automobile oriented land use patterns.

These costs are variable and some are difficult to quantify with available data. Paving an acre of land in existing industrial areas may have minimal external costs, while paving an acre of unique wildlife habitat or building a new highway that encourages residential development is an area that is currently agricultural may have significant external costs.

This is not to deny that pavement and low-density development provide benefits, but these are largely internal. There is little evidence that you benefit if your neighbors pave their lawns or build on existing farms and forests. Internal benefits cannot be assumed to offset the external costs of sprawl. Only by passing the incremental costs on to users can markets convey the true costs of consumption decisions, and thus allow consumers to make efficient tradeoffs between benefits and costs.

There is general agreement among economists that these impacts should be considered in project and policy analysis. For example, when evaluating a new highway that could encourage additional greenfield development, the land use impacts of this decision should be identified, and any economic, environmental and social costs should be described and monetized if possible.[60] Similarly, when evaluating an increase in parking requirements, increased stormwater drainage costs should be estimated.

There is less agreement as to whether these should be considered costs of motor vehicle *use*. The justification for doing so is that roads and parking facilities are developed in response to vehicle traffic demand, and motor vehicles degrade the urban environment and accommodate longer trips, thus encouraging urban periphery development. Although it may be difficult to assign a particular unit of pavement to a particular vehicle trip, over the long term driving encourages increased pavement and sprawl. Conversely, walking, cycling and public transit tend to encourage higher-density, centralized land use patterns with less per capita pavement.

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[58] Robert Burchell, et al., *The Costs of Sprawl – Revisited*, TCRP Report 39, Transportation Research Board (www.nas.edu/trb), 1998; Todd Litman, *Land Use Impact Costs of Transportation*, VTPI (www.vtpi.org), 1998.

[59] Chester Arnold and James Gibbons, "Impervious Surface Coverage: The Emergence of a Key Environmental Indicator," *Am. Planning Association Journal*, Vol. 62, No. 2, Spring 1996, pp. 243-258; *Indicators of the Environmental Impacts of Transportation*, USEPA (www.epa.gov/tp), 1996.

[60] *Social Cost of Alternative Land Development Scenarios*, FHWA (www.fhwa.dot.gov), 1998.

Option and Equity Value

Consumers benefit from having a range of travel choices. This creates a "robust" transport system that accommodates unpredicted demands. Even people who usually drive benefit from a diverse transport system when they are temporarily unable to drive (their car breaks down or an earthquake damages roads), because it reduces traffic congestion (some travelers shift to non-automotive modes if they are efficient, comfortable and affordable), because it reduces the need to chauffeur dependents, and for recreational purposes. Just as ship passengers value having lifeboats although they don't expect to use them on a particular trip, consumers may value having a range of transport options, including ones they don't currently use. Economists call this "option value."

Increased travel options for disadvantaged groups (people with disabilities, low incomes, youths and elderly) improve transportation equity.[61] Improvements to walking, bicycling, ridesharing, public transit, telecommuting and more accessible land use (such as affordable housing that is accessible to services and employment areas) tend to provide this benefit.[62]

Transport systems experience significant economies of scale. As more people walk, ride bicycles, use rideshare programs, or ride transit, more services can be provided for these modes. It is virtually impossible to provide high quality, affordable mobility to non-drivers in automobile dependent communities.[63]

As with land use impacts, there is general agreement that these costs should be considered in planning and policy decisions that affect future travel choices. For example, when comparing various congestion reduction options (e.g., road widening, transit improvements, and TDM programs), planners should indicate whether they will affect travel choices for non-drivers. There is less agreement as to whether reduced option and equity value should be considered a cost of motor vehicle *use*, for example, as a mileage surcharge. The justification for doing this is that driving creates automobile dependency which reduces travel choices. However, these are long-term impacts that are difficult to assign to any particular mile of automobile use.

Although it is difficult to quantify, a lower-bound estimate of this cost can be calculated based on subsidies to public transit services, which, outside of some high-volume corridors, exist primarily for option and equity values. Walking, bicycling, ridesharing, telecommuting and land use management strategies can also increase travel choices and benefit disadvantaged people, and so should be recognized as providing similar benefits.

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[61] Todd Litman, *Evaluating Transportation Equity*, VTPI (www.vtpi.org), 1998.

[62] Elmer Johnson, *Avoiding the Collision of Cities and Cars*, American Academy of Arts and Sciences (Chicago), 1993.

[63] Peter Newman and Jeffrey Kenworthy, *Cities and Automobile Dependency*, Gower (Aldershot), 1989; Todd Litman, *The Costs of Automobile Dependency*, VTPI (www.vtpi.org), 1998.

Summary of Cost Categories

Table 16 summarizes transport costs and indicates their distribution.

Table 16 **Transportation Cost Categories**

Cost	Definition	Distribution
1. Vehicle Ownership	Fixed vehicle expenses.	Internal-Fixed
2. Vehicle Operation	User expenses that are proportional to travel.	Internal-Variable
3. Operating Subsidies	Vehicle expenses not paid by the user.	External
4. User Travel Time	Time spent traveling.	Internal-Variable
5. Internal Accident	Vehicle accident costs borne by users.	Internal-Variable
6. External Accident	Vehicle accident costs not borne by users.	External
7. Internal Parking	Parking costs borne by users.	Internal-Fixed
8. External Parking	Parking costs not borne by users.	External
9. Congestion	Delay each vehicle imposes on other road users.	External
10. Barrier Effect	The disamenity roads and vehicle traffic imposes on pedestrians and bicyclists. Also called "severance."	External
11. Road Facilities	Road expenses not paid by user fees.	External
12. Municipal Services	Public services devoted to vehicle traffic.	External
13. Roadway Land Value	Opportunity cost of land used for roads.	External
14. Air Pollution	Costs of motor vehicle emissions.	External
15. Noise	Costs of motor vehicle noise.	External
16. Resource Consumption	External costs resulting from resource consumption.	External
19. Water Pollution	Water pollution and hydrologic impacts of vehicles & roads.	External
18. Waste Disposal	External costs from motor vehicle waste disposal.	External
19. Land Use Impacts	Economic, environmental and social costs resulting from low density, auto oriented land use.	External
20. Option & Equity Value	Reduced travel choices, especially for disadvantaged people.	External

Table 17 shows these costs grouped by their distribution. These distinctions are important because they determine how a cost affects various decisions. Automobile owners decide how much to drive based primarily on their internal, variable costs. Public agencies tend to place more weight on market costs than on nonmarket costs.

Table 17 **Motor Vehicle Cost Distribution (Italics = Nonmarket)**

	Variable	Fixed
Internal (User)	Fuel Short term parking Vehicle maintenance (part) *User time & stress* *User accident risk*	Vehicle purchase Vehicle registration Insurance payments Long-term parking facilities Vehicle maintenance (part)
External	Road maintenance Traffic law enforcement Insurance disbursements *Congestion delays* *Environmental impacts* *Uncompensated accident risk*	Road construction "Free" or subsidized parking Traffic planning Street lighting *Land use impacts* *Social inequity*

How a cost affects transport decisions tends to vary depending on whether it is internal, external, fixed, variable, market, or nonmarket.

Cost Estimate Summary

This section summarizes estimates for each of the twenty identified costs for eleven travel modes under three travel conditions. Cost values in 1996 U.S. dollars.

The report *Transportation Cost Analysis* provides estimates of the twenty costs described above for the eleven travel modes (defined below in Table 18) under urban peak, urban off-peak and rural travel conditions. Costs are categorized according to whether they are market or nonmarket, internal or external, fixed or variable. This framework is useful for evaluating and comparing the costs of different travel modes, and the incremental costs and potential cost savings from alternative policies and investments.

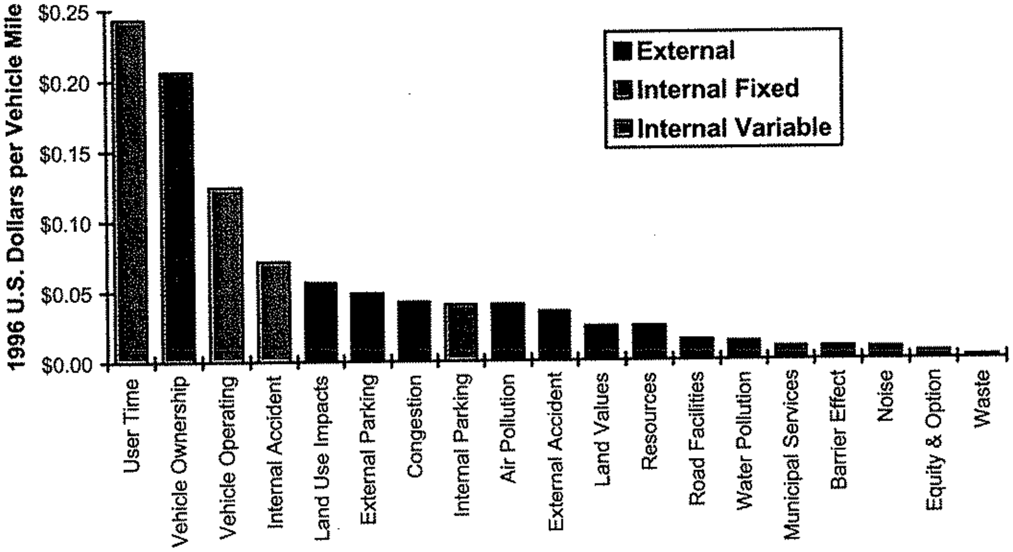
Table 18 **Modes Defined**

	Description
Average Automobile	A medium sized car that averages 21 mpg. Occupancy averages 1.5 overall, and 1.1 for Urban Peak (commute) travel.
Compact Car	A small four passenger car that averages 40 mpg overall.
Electric Car	A battery powered electric car that consumes 0.5 kWh per mile of travel.
Van or *Light Truck*	A van or light truck that averages 15 mpg. Occupancy is same as an automobile.
Rideshare Passenger	The incremental cost of a carpool, vanpool or transit passenger.
Diesel Bus	A 40 foot bus with an Urban Peak occupancy of 25 passengers, and an overall average occupancy of 9.3 passengers, averaging 4.0 mpg.
Electric Bus/Trolley	A bus or trolley with peak period occupancy of 30 passengers, an overall average occupancy of 14 passengers, and 6.5 mpg energy equivalent.
Motorcycle	A medium size motorcycle that averages 50 mpg.
Bicycle	A moderate priced bicycle.
Walk	A relatively healthy person traveling an average of 10 blocks per trip.
Telecommute	Two 11 mile commute trips avoided when employees work from home.

This table defines the eleven travel modes whose costs are estimated.

Figure 1 illustrates average automobile costs in descending magnitude. The largest costs are internal. Travel time, vehicle ownership, vehicle operation and uncompensated accident risk to vehicle occupants are the largest four cost categories. External costs tend to be smaller but are numerous.

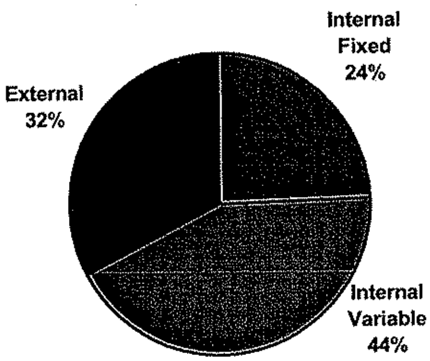
Figure 1 **Automobile Costs Ranked by Magnitude**



The largest costs are internal. External costs are individually small, but numerous.

Figure 2 illustrates the overall distribution of total automobile costs. About a third of total costs are external and about a quarter of costs are internal but fixed. Less than half of total costs are internal-variable (the "price" that affects individual trip decisions).

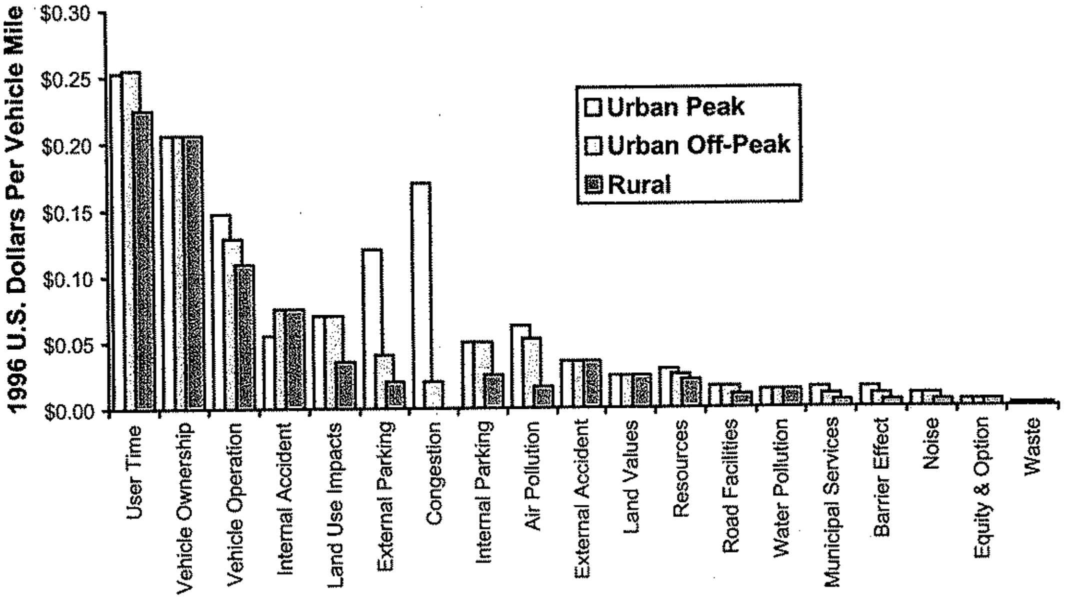
Figure 2 **Automobile Cost Distribution**



Less than half of total automobile costs are internal-variable.

Figure 3 compares automobile costs under different travel conditions. It shows that some costs, particularly congestion and parking are significantly higher under urban peak conditions, but other costs are less affected by travel conditions.

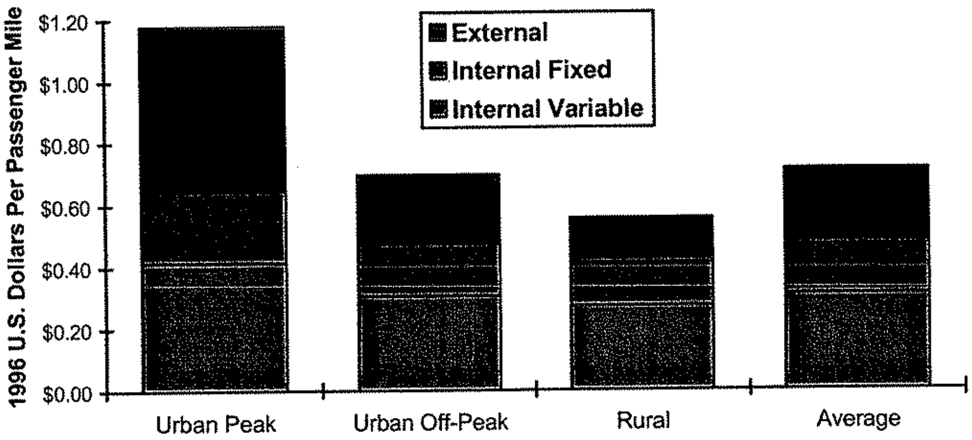
Figure 3 **Automobile Costs By Travel Conditions**



Congestion and parking costs vary significantly depending on travel conditions.

Vehicle-mile costs are converted into passenger-mile costs by dividing these values by vehicle occupancy (the average number of passengers in a vehicle). Figure 4 illustrates the distribution of costs per passenger-mile under different travel conditions.

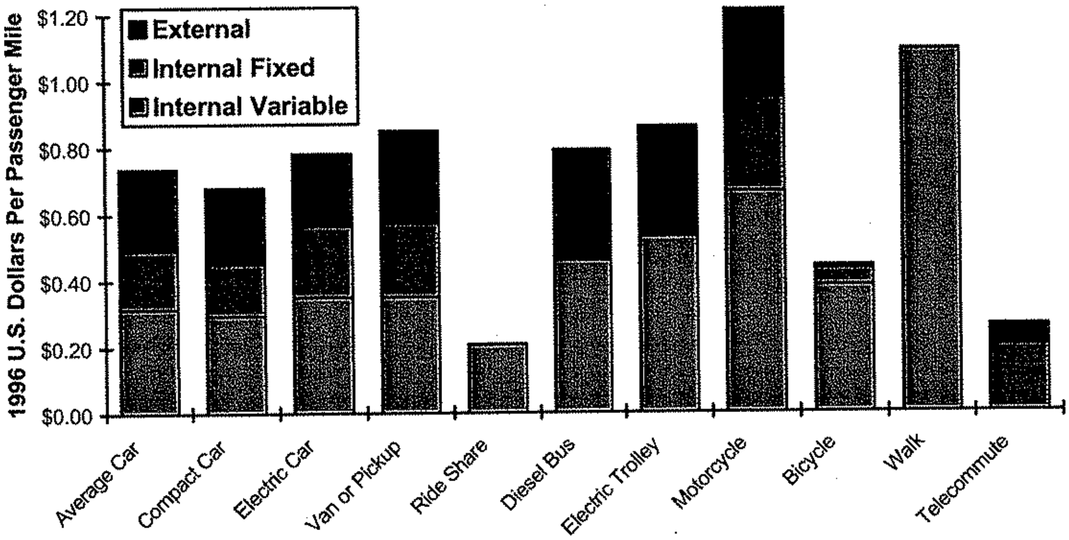
Figure 4 **Automobile Cost Distribution By Travel Conditions**



Costs tend to vary depending on travel conditions.

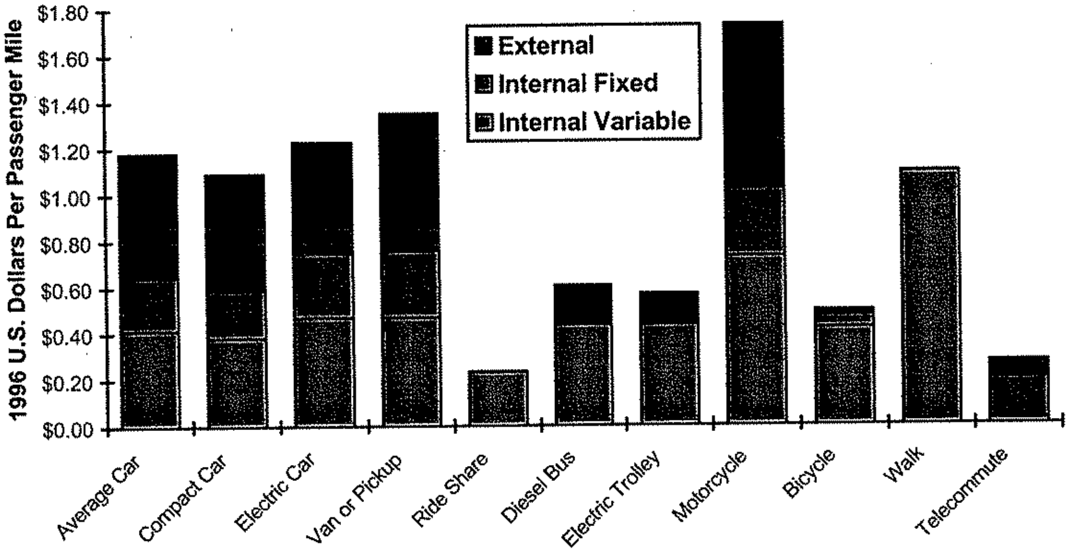
Figure 5 compares the average costs of different modes. Figure 6 compares these costs under Urban Peak conditions.

Figure 5 **Costs By Mode, Overall Average**



The magnitude of costs varies significantly between modes.

Figure 6 **Costs By Mode, Urban Peak Conditions**



Automobile costs are significantly higher under Urban Peak travel conditions, while transit costs are low due to reduced externalities and high load factors.

Here are some points to note from these figures:

- Costs of all personal motor vehicles (cars, vans, trucks, etc.) are significantly higher under urban peak conditions due to higher congestion and parking costs and lower occupancy rates.
- Compact cars have slightly lower costs than an average automobile, but differences in total costs are modest.
- Electric cars have slightly lower external costs (reduced pollution and energy externalities), but this tends to be offset by increased user costs, resulting in slightly higher overall costs.
- Ridesharing is the lowest cost mode since using a seat that would otherwise travel empty incurs minimal incremental cost besides the passenger's travel time and crash risk.
- Transit (bus and trolley) travel costs are much lower under urban peak conditions due to high load factors. This is where public transit provides the greatest potential savings.
- Transit has lower costs per passenger mile than automobile travel under urban peak conditions, but motorists have little incentive to use transit because internal-variable costs are comparable (i.e., they must pay fixed vehicle charges regardless and are not usually charged for congestion, pollution or parking, so they perceive no internal savings from riding transit rather than driving).
- Motorcycle costs tend to be high due to high crash costs, low load factors, and low average annual mileage (less than 3,000 miles per year), resulting in high ownership costs.
- Walking and bicycling have minimal external costs, but high internal variable costs (time and crash risk). Total costs of these modes are highly dependent on the value users place on time spent walking and cycling.
- Telecommuting has internal-fixed costs (home office expenses), and some external costs because it tends to encourage urban sprawl and additional home-based vehicle trips.

Of course, a particular vehicle or trip may have costs that differ significantly from these averages. For example, the air pollution costs of a particular trip may be much higher or lower than these generic estimates, because of the individual vehicle's characteristics, where it is driven, or how it is driven.

Costing Applications

This section describes potential applications of transportation costing information.

1. Evaluating Investment and Policy Options

Comprehensive costing information is essential for making good planning and investment decisions. Consider the following example, based on a real situation.

A highway between a city and nearby suburbs experiences increasing traffic congestion. Planners consider two options for solving this problem: widen the highway at a cost of $250 million, or construct a light rail system parallel to the highway, at a cost of $300 million. Each option could carry 3,000 additional peak-period commuters.

A conventional analysis (which takes into account project construction costs, congestion reduction benefits, vehicle operating costs and transit fares) concluded that the highway option is most cost effective, but it overlooked some significant impacts. It ignored parking and surface street congestion. If 3,000 additional commuters travel by car, somebody (businesses, governments or users) must pay for 3,000 additional parking spaces. The additional vehicles will also exacerbate surface street traffic congestion once they exit the highway. These costs are largely avoided by the transit option.

The conventional analysis also ignored potential consumer benefits of improved transit service. Although automobile and transit trips have comparable variable costs for a typical commute trip (i.e., transit fares are about the same as vehicle fuel costs), this assumes that each traveler has a car, and ignores long-term mileage-based vehicle costs (vehicle "wear-and-tear" costs typically average about 10¢ per mile). Transit improvements increase travel options for non-drivers, and allows vehicle to be shared among household members, allowing some households to own fewer vehicles or defer replacement of an older vehicle. The transit option therefore provides additional option and equity value, and consumer financial savings over the highway option.

Transit also tends to reduce crash risk and pollution, and encourages higher employment and residential densities. This helps preserve greenspace, reduces impervious surfaces, and makes public transit, walking and cycling more feasible for other trips. Transit improvements can therefore help support a community's strategic transport and land use objectives.

The box below illustrates differences between conventional and comprehensive analysis. The conventional analysis considers the highway option $50 million cheaper. But a more comprehensive analysis which takes into account additional benefits and costs concludes that the transit option is most cost effective. This is not to suggest that comprehensive cost analysis always shifts investments from highways to transit. Far from it. Under other circumstances, transit may have greater costs and less benefits, and some communities may choose highways over transport options regardless of their relative costs, just as consumers don't always buy the most cost effective vehicle. But decision makers should have comprehensive information when evaluating options.

Highway Vs. Transit Investments	
Conventional Analysis	
Light Rail:	$300 million
Highway Expansion:	$250 million
Highway Option Net Benefits:	*$50 million*
Costs Not Considered:	
Parking (assuming 3,000 urban parking spaces with average cost of $10,000 each)	~$30 million
Surface street traffic congestion (assuming 3,000 additional vehicles traveling 10 mile per day, 300 days per year on surface streets during peak periods, with an average cost of 20¢ per mile, over 25 years with a 7% discount rate)	~$35 million
Vehicle Ownership Costs (assuming $500 average annual cost savings per transit rider)	~$29 million
Environmental & Social Benefits	Probably substantial
Transit Option Net Benefits	*$44 million+*

Comprehensive analysis is particularly important for evaluating transportation demand management (TDM) programs.[64] For example, consider a third option for improving access along the corridor described above based on TDM strategies, which might include rideshare programs, bus service improvements and fare reductions, financial rewards to commuters who use alternative modes, bicycling and telecommuting promotion, increased parking charges, and road tolls.[65]

When making comparisons between modes it is important to take into account the possible effects of generated traffic (additional vehicle travel that would not otherwise occur).[66] Transit improvements and TDM programs tend to reduce the total amount of motor vehicle travel. On the other hand, highway capacity expansion accommodates and encourages increased motor vehicle travel, thus increasing many associated costs.

Table 19 summarizes this comparison. It indicates that transit improvements and TDM strategies reduce many costs, while highway capacity expansion increases many costs due to the additional traffic it generates. The full benefits of TDM only become evident with such a comprehensive analysis. A conventional analysis that focuses on facility construction costs and vehicle operating costs overlooks many of these benefits.

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[64] Todd Litman, *Guide to Calculating TDM Benefits*, VTPI (www.vtpi.org), 1998.

[65] Todd Litman, *Potential TDM Strategies*, VTPI (www.vtpi.org), 1999.

[66] Todd Litman, *Generated Traffic*, VTPI (www.vtpi.org), 1999.

Table 19 **Cost Impacts of Three Transportation Improvement Options**

Cost	Highway	Transit	TDM
Vehicle Ownership	Same	Reduced	Reduced
Vehicle Operation/Fares	Varies	Varies	Varies
Operating Subsidies/Revenues	Same	Subsidies	Revenues
Travel Time Costs	Varies	Varies	Varies
Internal Accident	Same	Reduced	Reduced
External Accident	Same/Increased	Reduced	Reduced
Internal Parking	Same	Reduced	Increased
External Parking	Increased	Reduced	Reduced
Congestion	Reduced on highway, increased downstream	Reduced	Reduced
Barrier Effect	Increased	Reduced	Reduced
Road Facilities	Increased	Reduced	Reduced
Municipal Services	Increased	Reduced	Reduced
Roadway Land Value	Increased	Reduced	Reduced
Air Pollution	Increased	Reduced	Reduced
Noise	Increased	Reduced	Reduced
Resource Consumption	Increased	Reduced	Reduced
Water Pollution	Increased	Reduced	Reduced
Waste Disposal	Increased	Reduced	Reduced
Land Use Impacts	Increased	Reduced	Reduced
Option & Equity Value	Increased	Reduced	Reduced

Two issues deserve special consideration in this type of analysis:

- Pricing strategies such as road tolls and increased parking fees represent economic transfers, not true resource costs. The costs to users are offset by revenue to the businesses or agencies that collect the charges. Only the transaction costs of paying and collecting the fees are true resource costs.
- Second, shifting from driving to other modes often increases door-to-door travel times, but this does not represent an increased *cost* if it results from a positive incentive, such as improve transit service or parking cash out (see discussion in the section on travel time costs). People only make such a change if they are better off overall. Those who choose transit may prefer to avoid the stress of driving, while those who bicycle may appreciate the exercise.

Framing the Congestion Cost Question

If you ask, *"Do you think that traffic congestion is a serious problem?"* most people would probably say yes. If you ask, *"Would you rather improve roads or implement transportation demand management programs?"* a smaller majority would probably choose the road improvement option. This is essentially how transportation choices are generally framed.

But if you present the choices more realistically by asking, *"Would you rather spend a lot of money widening roads to achieve moderate and temporary reductions in traffic congestion but bear numerous economic, social and environmental costs, or would you rather create a more balanced transportation system?"* the preference for road building may disappear.

2. Optimal Pricing[67]

Comprehensive costing information is essential for optimal pricing. A business that cannot determine its full production costs and underprices its products would go bankrupt. Although low prices stimulate sales and revenues, the firm loses money on each transaction. Similarly, underpricing transport services results in lots of mobility but incurs additional costs that harm the economy overall.

As described earlier, on average less than half of automobile costs are reflected in the price (perceived-internal-variable costs). To describe this another way, the current transport market fails to give individual consumers the savings that result when they drive less. For example, a commuter who shifts from driving to transit reduces congestion, parking, crash and environmental costs, but these savings are not passed through prices to individuals who make such as shift. As a result, consumers lack the incentive to use the most efficient travel option.

Many people find it intuitively sensible that prices should reflect the costs of producing and using a good. This actually reflects two somewhat different principles. Economic efficiency requires that prices reflect marginal costs. Horizontal equity and economic neutrality require cost recovery unless there is a specific reason to subsidize a particular good or group. Although there are exceptions, society is usually best off when prices reflect marginal costs plus additional charges needed for cost recovery.

Although motorists are unlikely to demand, "Raise my prices please!", consumers are usually best off paying directly rather than indirectly for the costs they impose because this allows them to save by reducing consumption. Although it may be fun to purchase an occasional all-you-can-eat meal, such pricing encourages excessive eating. Consumers generally purchase food by the dish so they pay for just what they eat.

A rich vocabulary exists to describe overpricing, which is said to "gouge" or "rip-off" customers. There is no comparable vocabulary for underpricing, yet it is equally harmful since the costs must be borne elsewhere in the economy. If taxes subsidize food, we eat more but have less of things that are taxed, such as jobs, housing and clothes. Food subsidies may be justified for undernourished people, but since over-eating can be as unhealthy as under-eating, it is both economically and medically harmful to subsidize all food for everybody. Similarly, broad underpricing of transport is harmful because it requires subsidies from other economic sectors and results in excessive travel.

These inefficiencies are cumulative. Underpriced parking not only encourages inefficient use of parking facilities, it also causes excessive traffic congestion, road costs, crashes and pollution. Similarly, underpricing road use does not simply lead to excessive congestion and road costs; it also increases parking costs, crashes and pollution. Over the long run, underpriced driving leads to automobile dependency, which reduces travel choices. Economic analysis that focuses on just one factor at a time underestimates the harm that results from price distortions and the potential benefits from price reforms.

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[67] Todd Litman, *Socially Optimal Transport Prices & Markets*, VTPI (www.vtpi.org), 1998.

Of course there are practical constraints to optimal pricing. Transaction costs limit how precisely pricing can reflect costs. For example, although optimal pricing charges users directly for parking, it would probably not be efficient to require motorists to feed coins into a parking meter for a one-minute stop. However, new technologies and management strategies can greatly reduce such transaction costs.

Underpricing may sometimes be justified for the sake of vertical equity. A certain amount of driving could be considered a necessity that merits a low income discount. For example, vehicle mileage fees could be lower for the first few thousand annual miles, making a modest amount of driving more affordable. Similarly, if roads are tolled, each resident might receive a few free passes each year. However, vertical equity does not justify more than a small fraction of current vehicle subsidies.

Many people assume that the best way to internalize vehicle costs is to increase fuel taxes, since this is a traditional way to charge for driving. But fuel taxes are a poor indicator of most external costs. Optimal transport pricing requires several new fees, as shown in Table 20, offset by reductions in vehicle ownership costs, general taxes and consumer prices. These savings could be significant. For example, charging motorists directly for local roads, congestion and pollution could raise enough revenue to eliminate about half of Washington State's sales taxes, one of the highest in the nation.[68] Since sales taxes discourage economic activity and are regressive this increases economic productivity and equity.

Table 20 **Optimal Pricing (Per Vehicle Mile)**[69]

Cost Category	**Weight-Distance Charges**	**Distance-Based Insurance**	**Emission Charges**	**Parking Charges**	**Fuel Taxes**	**Con-gestion Pricing**	**Fines & Fees**	**Totals**
Roadway facilities	$0.035							$0.035
Registration & Lic.	$0.010							$0.010
Roadway land value	$0.024							$0.024
Traffic services	$0.010						$0.001	$0.011
Accidents		$0.080					$0.001	$0.081
Air pollution			$0.030		$0.010		$0.001	$0.041
Noise pollution			$0.005				$0.001	$0.006
Water pollution			$0.005					$0.005
Barrier Effect	$0.005							$0.005
Land use impacts	$0.010							$0.010
Congestion						$0.020		$0.020
Parking facilities	$0.010			$0.040			$0.001	$0.051
Fuel externalities					$0.015			$0.015
General Taxes	$0.003				$0.005			$0.008
Total	$0.107	$0.080	$0.040	$0.040	$0.030	$0.020	$0.005	$0.322
Share of Total	33%	25%	12%	12%	9%	6%	2%	100%

This table summarizes average optimal charges for an automobile. Actual fees would vary depending on vehicle type, travel conditions and other factors.

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[68] Todd Litman, Charles Komanoff & Douglas Howell, *Road Relief*, Climate Solutions www.climatesolutions.org), 1998.

[69] Todd Litman, *Socially Optimal Transport Prices & Markets*, VTPI (www.vtpi.org), 1998.

3. Prioritizing Transportation Problems and Solutions

A comprehensive overview of transport costs is useful for comparing and prioritizing problems and potential solutions. For example:

- Location decisions for public facilities such as schools often involve tradeoffs between real estate costs and access. Decision makers must decide how much extra they should be willing to pay for a location that increases access and reduces users' travel costs.
- Traffic planners must allocate road space between general traffic, HOVs, parking, bicycles and pedestrians. They must decide how much to constrain vehicle traffic to benefit other travel modes and users of public roads.
- Highway planners must decide how much to pay extra for a route or design option that reduces crash risk or environmental impacts.
- Policy makers must decide whether to develop telephone-based traffic information systems which may reduce congestion but can increase accident risk associated with cellular telephone use by drivers.[70]
- Public officials must decide what zoning requirements to establish for parking and road, or what other policies to employ to reduce traffic and parking problems. This involves trading motorists' convenience against economic and environmental costs of increased pavement.

Transport planning frequently assumes that traffic congestion is the main transportation problem communities face, so increasing road capacity is always beneficial. Similarly, many location decisions are made to maximize motorist convenience, by choosing locations near highways with abundant parking. Comprehensive cost analysis raises questions these assumptions.

Our analysis ranks traffic congestion seventh out of the twenty cost categories, as indicated in Figure 1. This indicates that decision makers should give greater emphasis to road safety programs and strategies that allow consumers to reduce their total transport costs, for example, by improving transit services so households can reduce their vehicle ownership expenses, and by dispersing public services into neighborhoods (perhaps by having several smaller facilities rather than a large centralized one).

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[70] Donald Redelmeier and Robert Tibshirani, "Association Between Cellular-Telephone Calls and Motor Vehicle Collisions," *New England Journal of Medicine*, Vol 336, No. 7, 13 Feb. 1997, pp. 453-502.

4. Identifying Win-Win Strategies[71]

Advocates of current policies often claim that there are significant economic costs to environmental protection and social equity. For example, the energy industry argues that efforts to achieve global climate protection would significantly reduce economic productivity and employment.[72] Similar arguments are used to oppose efforts to reduce urban sprawl and encourage alternative travel modes.[73]

However, several "Win-Win" strategies achieve a combination of economic, social and environmental objectives. They are cost effective in terms of economic costs (such as congestion relief, road and parking cost savings, road safety and consumer savings) and provide social and environmental benefits. Such "no regrets" policies are justified regardless of the value assigned to costs such as global warming or urban sprawl.

Win-Win strategies tend to increase consumer choices and reduce market distortions that encourage excessive driving. Although no Win-Win strategy individually solves all transport problems, if fully implemented to the degree that is economically justified they could reduce or eliminate most transport problems. For example, a combination of such strategies are projected to exceed the Kyoto emission reduction targets for transportation while *increasing* economic productivity, consumer choice and equity.[74]

Comprehensive cost analysis is critical to identify and evaluate Win-Win strategies.[75] These strategies are not currently implemented as much as justified because most transport planning only considers a limited range of costs and benefits. Although Win-Win strategies provide a variety of benefits, no single Win-Win strategy is considered the best way to solve any individual problem. Solutions that provide many modest benefits tend to be ignored unless a comprehensive framework is used.

Below are examples of Win-Win strategies:

- Least-cost (or "integrated") transportation planning and funding.
- Regional transportation demand management (TDM) programs.
- Revenue-neutral tax shifts/direct user charges for local road and traffic service costs.
- Distance-based vehicle insurance and registration fees.
- Transportation efficient development and location efficient mortgages.
- More flexible parking requirements.
- Parking "cash out."

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[71] *Win-Win Transportation Solutions*, VTPI (www.vtpi.org), 1998.

[72] Global Climate Change Coalition economic impacts (www.globalclimate.org/economic.htm).

[73] Wendell Cox, The Public Purpose (www.publicpurpose.com); Randal O'Toole, *Ten Urban Transit Myths*, The Reason Foundation (www.reason.org).

[74] Todd Litman, Charles Komanoff & Douglas Howell, *Road Relief*, EOC (Olympia; www.eoc.org), 1998.

[75] Todd Litman, *Comparing Emission Reduction Strategies*, VTPI (www.vtpi.org), 1998.

5. Equity Analysis[76]

Comprehensive costing can help evaluate equity impacts. It considers both market and nonmarket costs imposed and borne by different groups, providing a multi-dimensional perspective to equity analysis.

Horizontal Equity

Comprehensive cost analysis can help determine whether a particular group imposes or bears an excessive portion of transport costs, benefits or subsidies. For example:

- It can help compare subsidies of different modes and groups. Both transit and automobile use receive comparable subsidies per passenger-mile, but since motorists travel more per year on average than non-drivers, they receive more annual subsidy. Non-motorized trips have particularly small external costs compared with automobile and transit travel.
- It can indicate the equity of nonmarket external costs. Motor vehicle traffic tends to impose uncompensated crash risk and pollution impacts on non-motorized travel. This might justify motorist funding of pedestrian and bicycle facilities, both to provide protection from these impacts and as compensation for these external costs.
- It can indicate the equity of costs between geographic groups. An average suburban resident tends to drive in a nearby city more than a city resident drives in suburbs. This could justify more motorist funding of regional transportation costs.
- It can help determine safety program priorities. Current traffic safety programs tend to focus on motor vehicle occupant protection and devote fewer resources to increasing safety for cyclists and pedestrians relative to the risk they bear.

Vertical Equity

Comprehensive cost analysis can help compare how a particular transport project or policy is likely to affect different income and demographic classes. For example:

- It can help determine whether a particular TDM program or price strategy is overall progressive or regressive. TDM programs that provide financial rewards or service improvements for non-drivers are likely to be progressive, while those that increase prices where there are poor travel alternatives may be regressive. It can take into account indirect benefits to non-driving if price incentives (such as road tolls) lead to improved transit, rideshare and non-motorized travel by increasing demand.
- It can help determine the distributional effects of traffic calming and traffic management programs. These are likely to have progressive benefits, since disadvantaged groups are more often urban residents, pedestrians, cyclists, who gain most from increased safety and a better urban environment.
- It can help identify to what transport modes deserve subsidies for the sake of vertical equity. If public transit is subsidized partly to provide basic mobility for disadvantaged groups, pedestrian, bicycling, ridesharing and even telecommuting may deserve similar support.

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[76] Todd Litman, *Evaluating Transportation Equity*, VTPI (www.vtpi.org), 1998.

Travel Effects of More Optimal Transport Markets

People often claim that Americans (or Germans, Mexicans, etc.) have a "love affair with the car," so efforts to reduce driving are futile. Some point out that vehicle travel is inelastic with respect to fuel price (an increase in fuel prices causes a proportionally smaller reduction in vehicle mileage). Others cite the failure of transit subsidies and social marketing campaigns to reduce driving.

But vehicle travel is actually quite elastic with respect to total vehicle costs.[77] Even modest parking fees and road toll significantly effect travel behavior. Driving is inelastic to fuel price because fuel represents a small portion of total vehicle costs (about 18% on average), and motorists respond to long-term fuel price increases by choosing more fuel efficient vehicles. For example, a 100% increase in U.S. federal or state fuel taxes would increase fuel prices by about 25%, a 4% increase in total vehicle costs, increasing an average motorist's daily vehicle expenditures from $8.60 to $8.95. This could be expected to reduce vehicle mileage by about 3%, and total fuel use by 10% over the long term as motorists choose more fuel efficient vehicles.

There is evidence that even relatively wealthy people would prefer to drive less and use alternative transport modes more but are discouraged by a lack of choice and market distortions. For example:

- Middle-class transit use has increased in communities that develop high quality transit systems, and non-motorized travel has increased in communities with good walking and cycling facilities.
- Urban neighborhoods with balanced transport systems are experiencing increasing property values and attracting middle-class households.
- Automobile commuting declines significantly at worksites that offer parking cash out and other TDM strategies.
- Many popular resorts and tourist attractions restrict automobile use.

Optimal transport planning and pricing would not eliminate every automobile trip or cause most households to give up car ownership, but it could have a significant effect on overall vehicle travel. Table 21 shows estimated travel impacts of optimal transport prices and planning. Most individual reforms would affect just a few percent of total vehicle travel but their cumulative impacts could be large.

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[77] Olof Johansson and Lee Schipper, "Measuring the Long-Run Fuel Demand for Cars," *Journal of Transport Economics and Policy*, Vol. 31, No. 3, 1997, pp. 277-292; ICF Incorporated, *Opportunities to Improve Air Quality Through Transportation Pricing Programs*, USEPA (Washington DC; www.epa.gov/omswww/market.htm), 1997.

Table 21 **Travel Impacts of More Optimal Transport Markets**[78]

Strategy	Average Fee Per Mile	Travel Reduction
Weight-distance charges	$0.107	20.0%
Comprehensive, distance-based insurance	$0.080	16.3%
Pollution fees	$0.040	8.7%
Congestion pricing	$0.020	4.5%
Parking charges	$0.040	8.7%
Fuel taxes (increase over current price)	$0.005	1.2%
Least cost transport planning		?
Land use policy reform		?
Other TDM strategies (e.g., increased carsharing, traffic calming, location efficient mortgages, etc.).		?
Totals	*$0.297*	*40-60%*

Note that these reforms could actually make vehicle ownership cheaper, since fixed insurance and registration fees would be reduced, and car sharing (a TDM strategy) would become more common. Many low income households would find driving more affordable, and it would become cost effective to own a vehicle that is only used occasionally. However, vehicle operating costs would be higher and travel options would increase, giving vehicle owners more incentive to use alternative travel options when available.

Although it is difficult to predict the precise impacts of such large price changes, optimal pricing is likely to reduce motor vehicle travel by 40-60% over the long term. The lower estimate probably represents the travel impacts if optimal pricing is implemented alone, and the upper estimate represents the impacts that could result if pricing is implemented with other TDM strategies.

To describe this another way, 40-60% of current motor vehicle travel appears to result from market distortions that underprice driving, reduce consumer choice, and encourage more dispersed and inefficient land use patterns. Given more travel options and more neutral pricing, consumers would choose to drive less and would be better off overall.

These estimates are consistent with international data showing that per capita vehicle travel is 40-60% lower in wealthy countries which have significantly higher fuel taxes and more balanced transport investment policies. However, even in these countries have avoidable market distortions that favor driving. For example, none have distance-based vehicle insurance, parking is often free, and tax policies favor company car subsidies.

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[78] Todd Litman, *Socially Optimal Transport Prices & Markets*, VTPI (www.vtpi.org), 1998.

Criticisms of Transportation Costing[79]

This section discusses some criticisms of transportation costing.

1. Uncertainty of Cost Estimates

Some costs identified in this research are difficult to measure, either due to of limited research or because they are inherently difficult to quantify. For example, parking subsidies are technically easy to calculate but until recently little effort had been made to measure them, while sprawl costs are technically difficult to quantify and attributed to a particular transport activity. However, it is analytically wrong to ignore costs simply because they are difficult to measure. It is better to use the best available cost estimates and apply sensitivity analysis (perform analysis with high- and low-range values).

Excluding or using only low estimates of uncertain costs is often defended as being "conservative," implying that this approach is cautious. Use of the word *conservative* in this context is confusing because it actually results in the opposite of what is implied. Low *cost* estimates undervalue damages and risks, which is less cautious and conservative than would be higher cost estimates. As stated by one expert in nonmarket costing, "*A crude approximation, made as exact as possible and changed over time to reflect new information, would be preferable to the manifestly unjust approximation caused by ignoring these costs, and thus valuing environmental damage as zero.*"[80]

It may be unnecessary to incorporate monetized estimates of all costs in a particular situation. Some estimates are too controversial to address in a transport planning process. Other costs may be too small in a particular situation to be significant. However, costs that are excluded from quantitative analysis because they are difficult to measure should be described qualitatively. For example, if analysis comparing alternative transportation investments does not include a monetized estimate of sprawl costs, it could still have a discussion of the likely land use impacts of the different alternatives, including information on economic, social and environmental costs of increased sprawl.

2. Definition of Externalities

Critics of transport costing often argue that congestion, crash and facility costs are not externalities since they are borne largely by motorists as a group. This claim could be made about almost any cost since most North American households own an automobile. This argument reflects a misunderstanding of the economic concept of externality. It assumes that costs imposed by one member of a group on other members of the same group are internal. This makes no more sense than to suggest that stealing is acceptable if done against somebody who shares a "group" attribute (a common ethnic, consumer or income status). An external cost is a negative impact of consumption that the individual consumer (the user of the good causing the impact) does not bear. External costs fail to give consumers accurate price signals. Whether the cost is borne by somebody who is similar or different from the user does not affect whether it is an externality.

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[79] Todd Litman, *Reply to Criticisms of Transportation Costing*, VTPI (www.vtpi.org), 1998.

[80] Richard Ottinger, "Incorporating Externalities - The Wave of the Future," in *Expert Workshop on Lifecycle Analysis of Energy Systems*, OECD (Paris; www.oecd.org), 1993, p. 54.

The critics' argument reflects sector level analysis, which is common in politics where decisions are based on the influence of groups, but has little meaning in economics which focuses on decisions by individual consumer and firms. Motorists' costs imposed on other motorists might be considered equitable if each had the same costs, but in practice some motorists impose or bear much greater costs than others. In any case, costs imposed by a motorist on others are inefficient (they fail to give accurate price signals) regardless of whether they are borne by another motorists or a non-motorist.

To describe this another way, external costs represent a subsidy of one *activity* at the expense of other *activities*. For example, road and parking subsidies make driving cheaper and housing more expensive. This price distortion encourages consumers to drive more and have lower quality housing than they would choose in a more neutral market. Only if consumers pay directly for the costs they impose can they choose the combination of goods and services that provide them the greatest net benefit. For this reason, economic efficiency requires that costs be internal at the individual level.

3. Transportation Benefits

Critics argue that focusing on costs ignores transport benefits. This is untrue. Virtually all cost studies acknowledge the tremendous benefits provided by transport in general and automobile use in particular. In addition, most transport benefits are measured in terms of reduced costs. For example, road improvements reduce travel time, crashes and vehicle costs. Cost analysis is therefore the basis for measuring benefits as well as costs.

However, the true benefits of driving can only be revealed in a competitive transport market in which consumers have viable travel alternatives with full-cost pricing of each option. If driving is really superior it shouldn't need subsidies. The simple existence of benefits does not justify underpricing. Consumers pay for most goods they use regardless of how beneficial, including food, clothing and shelter, unless there is a specific reason for a subsidy. Broad subsidies for driving are only justified if there are *external marginal benefits* (people benefit overall if their neighbors drive more) that are significantly greater than *external marginal costs*. Studies have found few external benefits from driving, and virtually no external *marginal* benefits.[81]

As an analogy, food provides tremendous benefits, since without it people die. However, this does not mean that increased eating is necessarily beneficial, that current diets are optimal, or that society should subsidize all food. At the margin (i.e., relative to current consumption) many people are better eating less, both because overeating is unhealthy and because reduced food expenditures would leave more resources for other beneficial goods. Similarly, that mobility provides benefits does not prove that *more* driving is better or that all driving should be subsidized. Only if market distortions that encourage excessive driving are removed can consumers optimize their vehicle expenditures.

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[81] Werner Rothengatter, "Do External Benefits Compensate for External Costs of Transport?", *Transportation Research*, Vol. 28A, 1991, p.321-328; Dr. Heini Sommer, Felix Walter, Rene Neuenschwander, *External Benefits of Transport?*, ECOPLAN (Bern), March 1993.

The highway industry argues that roadway investments cause economic growth and external economic benefits,[82] but independent researchers challenge these conclusions.[83] Increasing highway capacity provides only marginal productivity benefits in regions that already have adequate road networks.[84] One study found that U.S. highway expenditures provided relatively high economic returns through the 1980s, but the rate of return has since declined below that of private investments.[85] This is to be expected as fewer expenditures are for new highways that improve basic access to a community (which can have broad external economic benefits), and more expenditures are to increase highway capacity in congested areas (which provides little external economic benefits).

Even if highway expenditures increase economic productivity, they are not necessarily the *best* investment, nor does this prove that underpricing and subsidizing motor vehicle *use* is good policy. Highway improvements can have harmful as well as beneficial impacts on a local economy.[86] Investments in alternative modes and management strategies that encourage more efficient use of existing road capacity tend to provide more economic benefit than expanding existing highways to reduce congestion.[87] Automobile dependency (which results when highway investments are made at the expense of other travel modes) can be economically harmful over the long run by increasing direct and indirect costs, and reducing local employment.[88] Only by considering all costs can society be sure that transport investments and policies optimize economic and society benefits.

The first highway to your town is likely to benefit virtually everybody through reduced consumer costs and increased productivity, but expanding that highway to four or six lanes to reduce peak-period congestion will tend to benefit only the people who use that additional capacity. The community may benefit far more from transit improvements or TDM programs that encourage more efficient use of existing road capacity, or from changes in land use patterns (such as more residential development near employment centers) that reduces commute distances. Certainly, the existence of broad benefits from having a highway to your town does not indicate that you should also subsidize other costs imposed by highway users, such as parking or crash damages.

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[82] *Transportation and the Economy*, AASHTO (www.aashto.org), 1998.

[83] Amy Helling, "Transportation and Economic Development; A Review," *Public Works Management & Policy*, Vol. 2, No. 1, July 1997, pp. 79-93.

[84] Marlon Boarnet, "New Highways & Economic Productivity: Interpreting Recent Evidence," *Journal of Planning Literature*, Vol. 11, No. 4, May 1997, pp. 476-486.

[85] M. Ishaq Nadiri and Theofanis Mamuneas, *Contribution of Highway Capital to Output and Productivity Growth in the US Economy and Industries*, FHWA (www.fhwa.dot.gov/aap/gro98cvr.htm), 1998.

[86] Standing Committee on Trunk Road Assessment, *Transport Investment, Transport Intensity and Economic Growth*, DETR (London; www.roads.detr.gov.uk/roadnetwork/heta/sactra98.htm), 1997.

[87] Phil Goodwin, *Solving Congestion*, Inaugural lecture for the Professorship of Transport Policy, University College London (www.ucl.ac.uk/~ucetwww/pbginau.htm), 1997.

[88] Todd Litman and Felix Laube, *Automobile Dependency and Economic Development*, VTPI (www.vtpi.org), 1998.

4. Sunk Costs – Marginal Pricing

From a marginal cost perspective, cost recovery is unnecessary, so sunk costs need not be included in prices. This suggests, for example, that if parking fees result in some parking spaces left unused, beneficial automobile trips will be foregone and resources wasted. The same argument could be made for roads: the costs have already been paid so consumers may as well use them. Below are countervailing arguments.

- The main input in roads and parking facilities is land, which virtually always has an opportunity cost. Excess capacity can be sold, rented, used for another type of facility, or converted to greenspace.
- Underpricing implies a subsidy, which is horizontally inequitable and a market distortion since most other goods are priced for cost recovery. Since somebody must pay for parking facilities and roads, it may as well be users. Only if there is a particular reason to favor motorists over other consumers, or automobile travel over other modes should roads and parking be subsidized by non-users.
- Charging users directly determines the true demand. Free parking increases demand which results in excessive parking requirements, and stimulates automobile travel and automobile dependency. Priced parking is therefore essential for long-run economic efficiency.
- Underpricing parking "leverages" additional driving that increases other costs. As long as there are other external costs associated with driving (congestion, crashes, pollution, etc.) underpricing parking and roads exacerbates the economic inefficiency of other externalities.

5. Affordability and Vertical Inequity

More optimal pricing and investments are often criticized as harming poor people. Critics claim that road pricing and investments in alternative modes would create an elitist transport system that benefits the rich (who would enjoy uncongested roads), while low income motorists are forced to use inferior travel options, such as public transit, walking and bicycling. But these arguments ignore some important points:

- Current transport pricing harms low income households, who either cannot afford a car or spend an excessive portion of their income on vehicle ownership. A more optimal market could actually increase low income drivers' access to automobiles by reducing fixed insurance costs and increasing carsharing options.
- Our current system is particularly harmful to non-drivers. More optimal transport investments and pricing would increase non-automotive travel options by increasing demand for transit, ridesharing, walking and bicycling.
- Subsidies to driving increase housing costs, taxes, and other consumer costs. A price shift that increases automobile costs while reducing housing and tax cost would tend to benefit low income households, who tend to drive less than average.[89]
- Optimal pricing can be structured to address equity concerns. For example, fees can increase with annual mileage, residents could receive a limited number of free or discounted toll passes (providing a basic amount of affordable driving), and revenues can reduce regressive taxes or improve mobility services for non-drivers, providing overall equity benefits.

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[89] Todd Litman, *Parking Requirement Impacts on Housing Affordability*, VTPI (www.vtpi.org), 1998.

6. Roadway Cost Recovery – Conflicting Studies

The automobile industry has responded to transportation cost research with its own studies which claim that motorists pay more taxes than is spent on roads.[90] But these studies incorrectly treat all taxes as "user fees," including general sales and property taxes on motor vehicles and vehicle fuels.[91] Suggesting that all taxes are "user fees" is equivalent to suggesting that automobiles and vehicle fuel should be exempt from general taxes, representing a subsidy to driving.

Highway advocates also argue that "diversions" of fuel taxes to non-highway accounts represents an overpayment. In fact, many states and provinces that have general sales taxes specifically exempt vehicle fuel, dedicating all fuel tax revenue to transportation accounts. One study concludes that vehicle fuel receives the equivalent of a 30% general tax discount.[92] Using special fuel taxes for non-highway purposes can be considered to offset these general tax exemptions, or they can be considered an excise tax to fund government expenditures that support the petroleum industry.

There are two arguments for using fuel taxes to support public transit in particular. First, transit improvements are often the cheapest way to reduce traffic congestion, and so is simply a cost effective way to benefit motorists. Second, transit funding is justified on equity grounds, both because on a passenger-mile basis driving imposes excessive congestion costs on transit users (horizontal inequity), and because transit users tend to be disadvantaged relative to motorists (vertical inequity).

7. Political Unacceptability

If cost analysis simply indicates that automobile taxes and fees should increase and highway funds should be shifted to transit, it could be irrelevant to decision makers who face anti-tax sentiment and consumer preference for driving. But transportation costing implies a variety of reforms, many of which do not involve new taxes or constraints on driving. Most benefit motorists and non-motorists alike, and many can provide long-term tax and consumer cost savings. Their main barrier is not voter or consumer opposition but residence by institutions that are reluctant to change existing practices.

There is popular support for more balanced transportation, as reflected in voter support for transit funding, and consumer demand for neotraditional neighborhoods. People value having more transport choices and are skeptical of further investments in highways. Anti-tax sentiment can waver. Most communities occasionally have revenue needs that have broad citizen support, whether this is road improvements or a sports facility. Raising such revenues through fuel or parking taxes can help achieve transport objectives. Similarly, developers who implement effective TDM programs could be charged lower impact fees to reflect their smaller contribution to road costs.

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[90] Rayola Dougher, *Estimates of Annual U.S. Road User Payments Versus Annual Road Expenditures*, American Petroleum Institute (Washington DC; www.api.org), March 1995; Z. A. Spindler, *Automobiles in Canada; A Reality Check*, Canadian Automobile Association (Ottawa; www.caa.ca), 1997.

[91] Urban Institute, *Rationalization of Procedures for Highway Cost Allocation*, Trucking Research Institute (Washington DC), 1990, p. 53.

[92] Joe Loper, *State and Local Taxation: Energy Policy by Accident*, The Alliance to Save Energy (Washington DC; www.ase.org), 1994.

8. Costing is Anti-Automobile, Anti-American and Anti-Consumer

Some critics suggest that transportation costing is unpatriotic and harmful to consumers, since North American communities are automobile dependent.[93] Cost-based pricing is described as "punitive," as if intended to castigate motorists for bad behavior.

Such statements reflect an ideological rather than an economic perspective, and a fundamental misunderstanding of transport costing. Transport costing is not a debate about whether automobiles are "good" or "bad," or a popularity contest between modes. It is a technical exercise to identify the full impacts and potential cost savings of various transport options. Price reforms are not a punishment, they simply reflect direct user payment of costs, just as users are expected to pay for most goods they consume.

Transport costing and TDM programs are no more "anti-automobile" than a healthy diet is "anti-food." An optimal diet requires an appropriate balance of foods. An optimal transport system requires an appropriate balance of travel choices. Existing market distortions that underprice driving do not provide overall benefits. A more optimal transportation market would not eliminate automobiles and truck use. In fact, they would probably remain the most common form of transport overall. But some travel would probably shift to other modes, and consumers would be better off overall. Transportation costing is the key to determining what level of automobile use is optimal.

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[93] James Dunn, *Driving Forces*, Brookings (www.brookings.edu), 1998; Z. A. Spindler, *Automobiles in Canada; A Reality Check*, Canadian Automobile Association (Ottawa; www.caa.ca), 1997.

Conclusions

If you ask people to list transportation costs, most would probably include fares for transit, rail and air travel, and vehicle operating expenses. Motorists might include vehicle ownership expenses. Some might include their nonmarket costs such as travel time, comfort and accident risk. They might complain about congestion and other traffic impacts they bear, but may ignore the congestion and other negative impacts they impose. Many might overlook other external costs, such as public expenditures on roads, parking, traffic services, and medical services for crash victims, and particularly nonmarket externalities such as pollution and other ecological impacts. What are the *true* costs of transport? All of these, of course.

Recent research has expanded the range of costs to consider in transportation planning. This information has many potential uses. More comprehensive cost analysis is essential for identifying the most optimal investments, pricing and policies, and for incorporating equity into transport decision making.

Advocates for the current transport system often argue that automobile dependency reflects consumer preferences, but costing research indicates otherwise. Current high levels of motor vehicle use reflect market distortions. Transportation in general, and automobile travel in particular, are underpriced. Motorists typically perceive less than half of their total costs when making trip decisions. In addition, transport planning practices that overlook significant costs skew investment and policy decisions toward automobile dependency and away from alternatives that may be more efficient and equitable overall. As a result, consumers lack viable travel alternatives. Given a less distorted market consumers would choose to drive less and be better off as a result. How much less? It is difficult to predict exactly, but reductions of 40-60% are possible over the long term.

Costing information can help transportation professionals achieve *optimal* levels of motor vehicle use. Widening highways, increasing parking supply, increasing traffic speeds, and minimizing vehicle costs may be futile objectives if they simply exacerbate problems associated with driving. Strategies that encourage more efficient travel behavior are likely to provide greater overall benefit.

This is not a debate over whether driving is "good" or "bad." This research is not "anti-automobile." Rather, it can help indicate ways to benefit motorists and non-motorists alike by increasing consumer choices, efficiency and equity. More optimal pricing could actually increase some people's ability to drive by reducing the fixed vehicle ownership costs and increasing carsharing services. However, higher operating costs would encourage vehicle owners to reduce their driving and use alternatives when available.

There are many reasons to support reforms that increase travel choices and reduce market distortions, so there are opportunities to create broad coalitions involving organizations with a wide range of economic, development, consumer, social and economic objectives.

Appendix

Transportation Cost Literature Review

Several previous studies have attempted to estimate the full costs of transportation.[94] The eighteen cost studies summarized in this appendix were selected because they are especially comprehensive, include original research, or represent a unique perspective. Taken together they indicate current knowledge and trends in this field. Table A-7 summarizes costs in these studies.

1. Keeler, et al, *The Full Costs of Urban Transport; Intermodal Comparisons*, Institute of Urban and Regional Development (Berkeley), 1975. This report compares commuting costs of automobile, bus and rail in the San Francisco Bay area. It includes calculations of marginal congestion costs, public services, noise, air pollution, facilities, accidents, parking, and user costs. This is the oldest study of its type. The analysis is still highly regarded.

2. Michael Cameron, *Transportation Efficiency: Tackling Southern California's Air Pollution and Congestion*, Environmental Defense Fund (Oakland; www.edf.org), 1991. Estimates external transport costs to argue for pricing as a demand management strategy. External costs include air pollution, congestion, and parking. The follow-up study, *Efficiency and Fairness on the Road*, (1994) by the same author extends this research to cover equity impacts.

3. Mark Hanson, *Results of Literature Survey and Summary of Findings: The Nature and Magnitude of Social Costs of Urban Roadway Use*, U.S. Federal Highway Administration (Washington DC), July 1992. Identifies external costs of urban roadway transportation and describes costing methods.

4. James MacKenzie, Roger Dower, and Donald Chen, *The Going Rate,* World Resources Institute (Washington DC; www.wri.org), 1992. A comprehensive study of U.S. motor vehicle costs. Cost categories include roadway facilities and services, parking, air pollution and global warming, security costs of importing oil, congestion, motor vehicle accidents, noise, and land loss. The report's conclusion that driving incurs $300 billion annually in external costs is widely quoted.

5. Per Kågeson, *Getting the Prices Right; A European Scheme for Making Transport Pay its True Costs*, European Federation for Transport and Environment (Bruxelles), 1993. This study estimates pollution, accident and infrastructure costs in European countries. Cost summaries for the UK are shown in Table A-1. Similar estimates are made for other European countries.

Table A-1 **External Transport Costs (ECU/1000 passenger km)**

Mode	Air Pollution	CO_2	Noise	Accidents	Total	Total ($/mile)
Car	14.6	4.5	0.9	8.9	28.9	$0.060
Electric train	0.9	2.2	0.2	3.8	7.1	$0.015
Aircraft	7.3	9.2	1.2	0.2	17.9	$0.037

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[94] For literature reviews see David Greene, Donald Jones and Mark Delucchi, *The Full Costs and Benefits of Transportation*, Spinger (Berlin), 1997; James Murphy and Mark Delucchi, "A Review of the Literature on the Social Cost of Motor Vehicle Use in the United States," *Journal of Transportation And Statistics*, Vol. 1, No. 1, January 1998, pp. 15-42.

6. KPMG, *The Cost of Transporting People in the British Columbia Lower Mainland*, Transport 2021/Greater Vancouver Regional District (Vancouver), March 1993. Develops cost estimates for 12 modes using local research and generic estimates. Costs are listed in Table A-2.

Table A-2 **Costs of Transporting People in B.C. Costs**

Direct User	Indirect Parking	Transport Infrastructure	Time	Urban Sprawl	Environmental and Social
Fixed vehicle costs. Variable vehicle costs. Parking fees.	Residential. Commercial. Government.	Road construction. Road maintenance. Road land value. Transit land value. Protection services.	Personal. Commercial delays.	Infrastructure. Loss of open space. Future transport.	Unaccounted accident costs. Air pollution. Noise pollution. water pollution.

7. Works Consultancy, *Land Transport Externalities*, Transit New Zealand (Wellington), 1993. This comprehensive study is part of New Zealand's efforts to rationalize transport planning. It attempts to describe all external costs of road transport, and identify costing methodologies. Cost categories are shown in Table A-3. Cost estimates will be developed in future reports.

Table A-3 **Works Consultancy Cost Categories**

Pollution Effects	Intrusion Effects	Interference Effects	Land Use
Air Pollution & Dust Impacts on the Global Atmosphere Effects on Water Systems Noise & Vibration Disposal of Waste	Visual Effects Habitat impacts. Effects on Landscape Archaeological Sites Cultural & Spiritual Effects Recreational Effects Strategic Effects	Community Disruption Urban and Rural Blight and Stress of Change Lighting Effects Community Severance and Accessibility Hazard Effects	

8. Peter Miller and John Moffet, *The Price of Mobility*, Natural Resources Defense Council (Washington DC; www.crest.org/efficiency/nrdc/mobility), 1993. Attempts to quantify total costs for automobiles, buses, and rail transport in the U.S. It is one of the most comprehensive efforts in terms of costs described and quantified. Costs included are listed in Table A-4.

Table A-4 **The Full Cost of Transportation in the USA**

Personal	Gov. Subsidies	Societal	Unquantified
Automobile ownership. Transit fares.	Capital and operating. Local government.	Energy. Congestion. Parking. Accidents. Noise. Vibration. Air pollution. Water pollution.	Wetland lost. Farmland lost. Historic property. Property value impacts. Inequity. Sprawl.

9. Apogee Research, *The Costs of Transportation*, Conservation Law Foundation (Boston; www.clf.org), March 1994. Estimates user, accident, congestion, parking, road facilities and services, air pollution, water pollution, energy, and noise costs. Urban sprawl and aesthetic degradation are mentioned but not estimated. A costing model is developed which calculates the total cost of trips by nine modes, in three levels of urban density, during peak and off-peak periods. This model is applied to case studies of Boston and Portland, Maine urban travel costs.

10 Douglass Lee, *Full Cost Pricing of Highways*, USDOT Volpe National Transportation Systems Center (Cambridge; http://ohm.volpe.dot.gov), January 1995. This study analyzes optimal pricing for economic efficiency. Table A-5 summarizes Lee's estimates of external costs.

Table A-5 **Estimates of Highway Costs Not Recovered From Users ($1,000/yr)**

Cost Group	Cost Items	Estimate
Highway Capital	Land (interest)	$74,705
	Construction:	
	Capital Expenditures	42,461
	Interest	26,255
	Land acquisition and clearance	
	Relocation of prior uses and residents	
	Neighborhood Disruption	
	Removal of wetlands, acquirer recharge	
	Uncontrolled construction noise, dust and runoff	
	Heat island effect	
Highway Maintenance	Pavement, ROW, and structure maintenance	20,420
Administration	Administration and research	6,876
	Traffic police	7,756
Parking	Commuting	52,877
	Shopping, recreation, services	14,890
	Environmental degradation	
Vehicle Ownership	Disposal of scrapped or abandoned vehicles	706
Vehicle Operation	Pollution from tires	3,000
	Pollution from used oil and lubricants	408
	Pollution from toxic materials	1
Fuel and Oil	Strategic Petroleum Reserve	4,365
	Tax subsidies to production	9,000
Accidental Loss	Government compensation for natural disaster	
	Public medical costs	8,535
	Uncompensated losses	5,850
Pollution	Air	43,444
	Water	10,861
	Noise and vibration	6,443
	Noise barriers	5,117
Social Overhead	Local fuel sales tax exemptions	4,302
	Federal gasohol exemption	1,129
	Federal corporate income tax	3,389
	State government sales taxes	13,218
	Local government property taxes	15,962
	Total	$382,134
	Current User Revenues	52,096
	Loss	330,037
	cents/VMT	$0.152

11. "The Costing and Costs of Transport Externalities: A Review," *Victorian Transport Externalities Study*, Environment Protection Authority (Melbourne, Australia), 1994. Discusses external cost implications, reviews costing methods, and estimates some costs.

12. *Saving Energy In U.S. Transportation*, Office of Technology Assessment (Washington DC; Washington DC; www.wws.princeton.edu/~ota/ns20/year_f.html), July 1994. Comprehensive analysis of transportation costs and their economic and environmental impacts. Includes estimates of total U.S. motor vehicle costs based on preliminary results by Delucchi.

13. John Poorman, *Estimating Marginal Monetary Costs of Travel in the Capital District*, Capital District Transportation Committee (Albany), April 1995. Describes a Least Cost framework and model, with performance measures and monetized costs for evaluating transport investments and policies, and comparing various modes.

14. IBI Group, *Full Cost Transportation Pricing Study*, Transportation and Climate Change Collaborative (Toronto), November 1995. This study estimates costs for truck, rail, automobile, public transit and air travel in Ontario, Canada. Reviews cost estimates from previous studies. Costs are divided into user charges, external costs, and "basic subsidies" (government costs minus revenues). This is used to evaluate potential measures to encourage sustainable transport.

15. David Maddison, David Pearce, Olof Johansson, Edward Calthrop, Todd Litman, and Eric Verhoef, *The True Costs of Road Transport*, Blueprint #5, Earthscan (London), 1996. Discusses the economic efficiency and equity implications of roadway transport externalities. Develops estimates of external costs in the U.K., including air pollution, noise, congestion, roadway facility costs, and accident costs. Also includes individual chapters on roadway externalities in Sweden, North America, The Netherlands, and international estimates.

16. Christopher Zegras with Todd Litman, *An Analysis of the Full Costs and Impacts of Transportation in Santiago de Chile,* International Institute for Energy Conservation (Washington DC, Santiago; www.iiec.org), sponsored by the Climate Change Division of the U.S. Environmental Protection Agency and the Tinker Foundation, March 1997. This is one of the first comprehensive transport cost studies in the developing world. Most cost categories apply equally, although some costs (such as travel time) must be adjusted to reflect local wages. Although automobile ownership is relatively low compared with developed countries, rapid (10% annual) growth in vehicle ownership imposes considerable medium-term costs in terms of increased congestion, facility needs, pollution, etc. Because Chile imports most vehicles and fuel, increased automobility also imposes macroeconomic costs by capturing a major portion of foreign exchange and potential investment funds.

17. Mark Delucchi, *Annualized Social Cost of Motor Vehicle Use in the United States, Based on 1990-1991 Data*, Institute of Transportation Studies, University of California at Davis (www.ota.fhwa.dot.gov/scalds/DELUCCHI.pdf and www.engr.ucdavis.edu/~its), 1996-97; summarized in "Total Cost of Motor-Vehicle Use," *Access* (http://violet.berkeley.edu/~uctc), No. 8, Spring 1996, pp. 7-13. This series of 20+ detailed reports attempts to identify, categorize and estimate total U.S. motor vehicle costs. Table A-6 summarizes ranges of major cost categories. It is the most comprehensive transportation cost study.

Table A-6 **Delucchi's Estimates of Motor Vehicle Costs**

Cost Item	Examples	Per Veh. Year	Per Veh. Mile
Personal nonmonetary costs of using motor vehicles	Motorist personal travel time and accident pain and suffering.	$2,180-3,189	17.4-25.5¢
Private-sector motor-vehicle goods and services	Vehicle ownership and operating expenses, paid travel time.	$5,020-5,659	40.2-45.3¢
Bundled Private Sector Costs	Parking subsidized by businesses.	$337-1,181	2.7-9.4¢
Public infrastructure and services	Public roads, parking subsidized by local governments.	$662-1,099	5.3-8.8¢
Monetary externalities	External accident damages, congestion.	$423-780	3.4-6.2¢
Nonmonetary externalities	Environmental damages, accident pain and suffering.	$1,305-3,145	10.4-25.2¢
Totals		*$9,927-15,053*	*$0.79-1.20*

18. Todd Litman, *Transportation Cost Analysis; Techniques, Estimates and Implications*, Victoria Transport Policy Institute (Victoria; www.vtpi.org), 1999. This report develops a framework for estimating and comparing total roadway transportation costs, including internal and external, market and nonmarket costs. It is the only cost study that is designed as a guide and reference manual for applying comprehensive costing to transport planning, and the only study that is regularly updated.

Previous cost studies are reviewed. Twenty costs are defined and discussed, and existing estimates summarized. Cost estimates are provided for 11 travel modes under urban peak, urban off-peak, and rural travel conditions. This framework is used to compare costs per passenger mile for different modes. Implications of current cost distribution on economic efficiency, economic development, equity, and land use are explored. Case studies demonstrate how cost estimates can be applied to specific planning and policy decisions. Recommendations are provided for reforming current transport decision making. This 240-page document is fully referenced. It is intended for transportation professionals, planners, economists, policy analysts and environmentalists.

Cost Estimates Summarized

The table below identifies which costs are described or estimated in each report. This shows the range of perspectives and efforts applied to transport costs.

Table A-7 **Transport Costs in Current Literature (C = Costed; D = Described)**

Study No.	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**
Cost Categories	Keeler	Cam-eron, EDF	Han-son	Mac Kenzie	Kå g-eson	KPMG	Works N.Z.	Miller & Moffet	Apo-gee, CLF	Doug Lee,	EPA, Aust.	OTA	CDTC	IBI	Mad-dison	IIEC	De-lucchi	Litman
Vehicle Costs	C				D	C		C	C			C	C	C		C	C	C
Travel Time	C				D	C			C			C	C			C	C	C
Accidents	C		D	C	C	C		C	C	C	C	C	C	C	C	C	C	C
Parking	C	C	D	C		C		C	C	C		C	C	C		C	C	C
Congestion	C	C	D	C	D	C		C	C		C	C	C	C	C	C	C	C
Facilities	C		D	C	C	C		C	C	C		C	C	C	C	C	C	C
Roadway Land	C		D	D		C		D	C	C		C	C			C	C	C
Mun. Services	C		D	C	D	C		C	C	C		C	C	C		C	C	C
Local Air Pol.	C	C	D	C	C	C	D	C	C	C	C	C	C	C	C	C	C	C
Global Air Pol.			D	C	C		D	C	C			C	C	C	C	C	C	C
Noise&Vibration	C		D	C	C	C	D	C	C	C	C	C	C		C	C	C	C
Resources/Energy			D	C		C	D	C	C	C		C	C			D	C	C
Barrier Effect			D		D		D						C		D			
Land Use/Sprawl					D	C	D	D	D				C			D	D	C
Inequity		D						D					C			D	D	C
Water			D		D	C	D	C	C	C		C	C			D	C	C
Waste Disposal							D			C		C	C			D	C	C

Freight Cost Studies

The studies below focus on freight transport costs.

Transport Concepts, *External Costs of Truck and Train*, Brotherhood of Maintenance of Way Employees (Ottawa), October 1994. Compares external costs of train and truck freight transport to justify increased truck taxes or increased subsidies for rail. Table A-8 summarizes their results.

Table A-8 **External Costs of Train Vs. Bus (1994 Canadian Cents per Tonne Kilometer)**

Cost	Intercity Truck Average	Truck Semi Trailer	Truck B-Train	Rail System Average	Rail Piggy Back	Rail Container	Rail Box Car	Rail Hopper Car
Accidents	0.40	0.40	0.40	0.06	0.06	0.06	0.06	0.06
Pollution	0.71	0.72	0.58	0.23	0.36	0.29	0.25	0.15
Congestion	0.64	0.65	0.52	-	-	-	-	-
Infrastructure	0.67	0.69	0.52	-	-	-	-	-
Cash Subsidy	0.09	-	-	0.28	0	0	0	0
Cost Subtotal	2.51	2.46	2.02	0.57	0.42	0.35	0.31	0.21
Fuel Taxes	-0.29	-0.29	-0.22	-0.06	-0.09	-0.07	-0.04	-0.04
License Fees	-0.07	-0.07	-0.07	-	-	-	-	-
Revenue Subtotal	-0.36	-0.36	-0.29	-0.06	-0.09	-0.07	-0.04	-0.04
Net External Costs	*2.15*	*2.10*	*1.73*	*0.51*	*0.33*	*0.28*	*0.27*	*0.17*

Transmode Consultants Inc., *Ontario Freight Movement Study*, National Round Table on the Environment and the Economy (Toronto), November 1995. This study focuses primarily on air pollution, particularly greenhouse gas emissions. Component 2 uses case studies to evaluate the feasibility of more efficient practices.

Committee for Study of Public Policy for Surface Freight Transport, *Paying Our Way; Estimating Marginal Social Costs of Freight Transport*, TRB (Washington DC; www.nas.edu/trb), 1996. This study uses previous analysis of marginal costs and case studies to estimate and compare marginal costs of freight transport, including internal costs to carriers, congestion, accidents, air pollution, energy consumption externalities, noise, and public facility costs. The study concludes that external costs represent an additional 7-20% cost over existing internal costs, and tend to be higher for truck and barge than for rail. The greatest external costs are associated with urban freight distribution where congestion and high population densities increase these costs. Policy applications and further research needs are discussed.

Thomas Bue Bjørner, "Environmental Benefits from Better Freight Transport Management: Freight Traffic in a VAR Model," *Transportation Research D*, Vol. 4, No. 1, January 1999, pp. 45-64. Summarizes various estimates of the external costs of freight. Concludes that these costs (air pollution, noise, accidents and congestion) are about four times higher for one truck-kilometer than for a private car. Indicates that freight transport is price sensitive.

David Forkenbrock, "External Costs of Intercity Truck Freight Transportation," *Transportation Research A*, Vol. 33, No. 7/8, Sept./Nov. 1999, pp. 505-526. Internal costs are estimated at $1.25 per vehicle-mile, or 8.42¢ per ton-mile in 1994. External costs are estimated to include accidents (0.59¢), air pollution (0.08¢), greenhouse gases (0.15¢), noise (0.04¢) and roadway costs (0.25¢). Concludes that road user charges would need to approximately triple to internalize these costs.

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Comparing Emission Reduction Strategies

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Land Use Impact Costs of Transportation

Pavement Buster's Guide

Potential TDM Strategies

Socially Optimal Transport Prices and Markets

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Thank you very much for your help.

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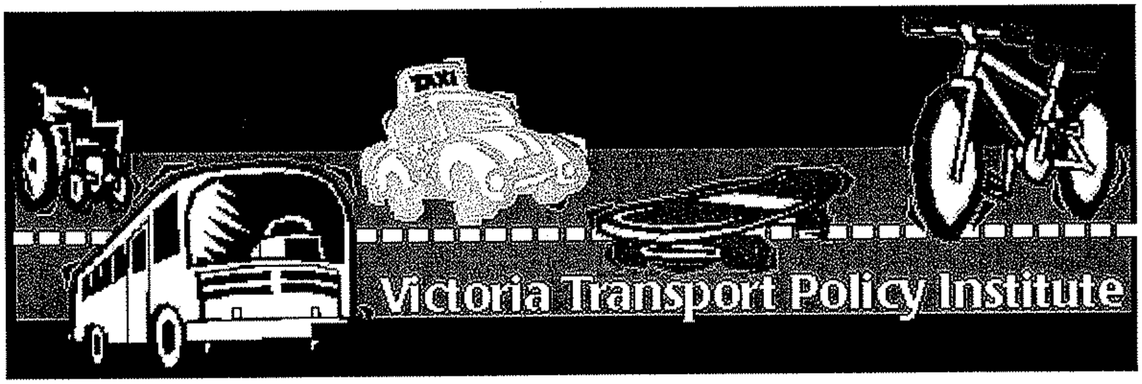

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Newest Resources (June 2004)

Managing Personal Mobility Devices (PMDs) On Nonmotorized Facilities
This paper explores the most appropriate way to manage the diverse range of Personal

Mobility Devices (PMDs) (bicycles, wheelchairs, scooters, skates, Segways) on nonmotorized facilities. PMDs are becoming increasingly common, resulting in new conflicts and opportunities. This paper examine the broader context of these issues, includes results of a recent survey of the legal status of electric powered PMDs, and develops general principles and guidelines for managing PMD use.

Appropriate Response to Rising Fuel Prices

Recent fuel price increases have renewed calls to reduce fuel taxes and increase production subsidies. But the best policy response overall is to increase taxes and do everything possible to expand travel options and improve transportation system efficiency. This short paper explains why.

Fuel Trends Spreadsheet

This spreadsheet shows annual U.S. motor vehicle fuel consumption, fuel price, tax rates, vehicle mileage and fuel efficiency from 1960 through 2002 or 2004 (depending on data availability), with graphs illustrating trends. It compares real (inflation-adjusted) fuel prices over this time period, showing that, despite recent fuel price increases, fuel costs per gallon and per vehicle-mile are low by historical standards.

Website Sections:

VTPI: Our Approach to Problem Solving

Find out more about the Victoria Transport Policy Institute's approach to solving transportation problems based on improved analysis and management.

Online TDM Encyclopedia

he *Online TDM Encyclopedia* is a unique resource for Transportation Demand Management planning and implementation. It provides detailed information on more than three-dozen specific TDM strategies, plus information on evaluation methods. It discusses travel impacts, benefits, costs, equity impacts, implementation requirements, best practices, case studies and references for each strategy. It also includes special features to help identify TDM strategies that are most effective for achieving particular objectives, including congestion reduction, safety, energy and emission reductions, and equity.

Transportation Cost and Benefit Analysis: Techniques, Estimates and Implications

This unique, 300-page document is a comprehensive study of transportation benefit and costing research, and a guidebook for applying this information for policy and planning analysis. It includes detailed reviews of various categories of transportation costs and benefits. Using the best available data, it provides monetized estimates of twenty costs for eleven travel modes under three travel conditions. Costs are categorized according to various attributes: whether they are internal or external, fixed or variable, market or nonmarket. It is one of the most comprehensive studies of transportation economic impacts ever produced, and the only one that is regularly expanded and updated. It provides extensive references, mostly available through the Internet, to allow users to obtain more information on each subject as needed. It is the only guidebook that provides costs values in a format designed to easily calculate the full costs and benefits of transportation policy and planning alternatives. It also summarizes previous transportation impact studies, describes how nonmarket impacts are estimated, discusses major findings, evaluates criticisms of transportation costing, and explores implications and applications of this research.

Evaluating Impacts and Problems

These papers explore various economic, social and environmental impacts (costs and benefits), including some that are frequently overlooked in transportation planning, and how to incorporate them into transportation decision-aking.

- What's It Worth; Lifecycle and Benefit/Cost Analysis for Evaluating Economic Value

- Transportation Cost Analysis Summary
- Evaluating Criticism of Transportation Costing
- Economic Development Impacts of Transportation Demand Management
- Efficient Vehicles Versus Efficient Transportation: Comprehensive Comparison of Fuel Efficiency Standards And Transportation Demand Management
- Measuring Transportation: Traffic, Mobility and Accessibility
- If Health Matters: Integrating Public Health Objectives in Transportation Decision-Making
- Integrating Public Health Objectives in Transportation Decision-Making
- Active Transportation Policy Issues
- Generated Traffic; Implications for Transport Planning
- Induced Travel Bibliography (by Robert Noland)
- Estimation Of Generated Traffic By New Developments: Current Practice And Possible Improvements Based On Bangkok Experience (by Shihana Sulaiha Mohamed and Kazunori Hokao)
- U.S. Fuel Trends Spreadsheet NEW
- Socioeconomics of Urban Travel: Evidence from the 2001 NHTS (By John Pucher and John Renne)
- Urban-Rural Differences in Mobility and Mode Choice: Evidence from the 2001 NHTS (By John Pucher and John Renne)
- Transport Policies in Central and Eastern Europe (By John Pucher and Ralph Buehler)
- Transportation Market Distortions – A Survey
- Comparing Transportation Emission Reduction Strategies
- How Canadian Climate Change Emission Reduction Analysis Undervalues TDM

Solutions: Innovative Strategies to Address Transport Problems

There are many ways to encourage more economically efficient transportation by increasing travel choices and encouraging consumers to choose the best option for each trip. These papers describe a wide range of transportation demand management (TDM) strategies, and discuss how to evaluate demand management in transportation planning.

- Win-Win Transportation Solutions
- Potential TDM Strategies
- Guide to Calculating TDM Benefits
- Local Politician's Guide to Urban Transportation (By Councillor Gordon Price)
- Evaluating Carsharing Benefits
- First Resort; Resort Community Transportation Demand Management
- Automobile Accidents, Tort Law, Externalities, and Insurance: An Economist's Critique (By Professor William Vickrey)
- Overcoming Obstacles Of Car Culture: Promoting An Alternative To Car Dependence Instead Of Another Travel Mode (By Michael Roth)
- UBC TREK Program Evaluation; Costs, Benefits and Equity Impacts of a University TDM Program (by Todd Litman & Gordon Lovegrove)
- The Potential for Further Changes to the Personal Taxation Regime to Encourage Modal Shift (By The Open University/WS Atkins/Napier University).
- Variable Work Hours Implementation Manual (By Oregon DEQ)

Optimal Pricing

These papers explore existing transportation market distortions, and potential market-based reforms that can help create a more economically efficient and equitable transportation system.

- Socially Optimal Transport Prices and Markets.
- Road Relief; Tax and Pricing Shifts for A Fairer, Cleaner, and Less Congested Transportation System in Washington State.
- London Congestion Pricing: Implications for Other Cities
- Evaluating the Promise and Hazards of Congestion Pricing Proposals: An Access Centered Approach (by Jonathan Levine and Yaakov Garb).
- Distance-Based Charges; A Practical Strategy for More Optimal Vehicle Pricing
- Distance-Based Vehicle Insurance
- Distance-Based Vehicle Insurance Feasibility, Costs and Benefits; Comprehensive Technical Report
- Why ICBC Should Offer Distance-Based Pricing
- Using Road Pricing Revenue: Economic Efficiency and Equity Considerations
- William Vickrey's Congestion Pricing Guidelines

Automobile Dependency and Transportation Diversity

Automobile dependency is defined as high levels of per capita automobile travel, automobile oriented land use patterns, and reduced transport alternatives. These papers explore the economic, social and environmental costs of automobile dependency, and the potential benefits to society of a more diverse and balanced transportation system.

- The Costs of Automobile Dependency and the Benefits of Transportation Diversity
- You CAN Get There From Here; Evaluating Transportation Choice
- Automobile Dependency and Economic Development (Todd Litman & Felix Laube, Ph.D.)
- Optimal Level of Automobile Dependency
- Transportation Paradise; Realm of the Nearly Perfect Automobile? (By Professor John Pucher)

Sustainable Transportation

These papers describe various definitions of sustainability and sustainable transportation, explore impacts transportation activities have on sustainability objectives, and identify ways to achieve more sustainable transportation.

- Issues In Sustainable Transportation (by Todd Litman & David Burwell)
- Mobility Management Module of the Sustainable Transport Sourcebook NEW
- Sustainable Transportation Indicators
- Transportation Cost Analysis for Sustainability
- Reinventing Transportation; Exploring the Paradigm Shift Needed to Reconcile Sustainability and Transportation Objectives
- Sustainable Transport Systems: Linkages Between Environmental Issues, Public Transport, Non-Motorised Transport and Safety (By Dinesh Mohan and Geetam Tiwari)

Land Use and Parking Management

These papers explore land use impacts of transportation facilities and activities, their economic, social and environmental costs, and strategies for reducing negative impacts. Several papers describe more economically efficient and environmentally sensitive parking management and road development policies.

- Evaluating Criticism of Smart Growth
- An Economic Evaluation of Smart Growth and TDM: Social Welfare and Equity Impacts of Efforts to Reduce Sprawl and Automobile Dependency

- Transportation Land Valuation; Evaluating Policies and Practices that Affect the Amount of Land Devoted to Transportation Facilities
- The Value of Downtown NEW
- Pavement Busters Guide: Why and How to Reduce the Amount of Land Paved for Roads and Parking Facilities
- The Trouble With Minimum Parking Requirements (by Professor Donald Shoup)
- Land Use Impact Costs of Transportation
- Parking Requirement Impacts on Housing Affordability
- Clunker Mortgages and Transportation Redlining; How the Mortgage Banking Industry Unknowingly Drains Cities and Spreads Sprawl (by Patrick Hare)
- The Asphalt Attack (by Jane Holtz Kay)

Pedestrian and Bicycle Issues

These papers explore the potential benefits of non-motorized transportation, the rights of pedestrians and cyclists to use public roads, and strategies to better accommodate and encourage non-motorized transportation.

- Who's Roads? Defining Bicyclists' and Pedestrians' Right to Use Public Roadways
- Economic Value of Walkability
- Promoting Safe Walking and Cycling to Improve Public Health: Lessons from The Netherlands and Germany (by John Pucher and Lewis Dijkstra)
- Managing Personal Mobility Devices (PMDs) On Nonmotorized Facilities NEW
- Pedestrian and Bicycle Planning; A Guide to Best Practices
- Bicycle Parking Guidelines - DRAFT, by the Association of Pedestrian and Bicycle Professionals
- End-0f-The-Trip Bicycle Facility Design Publications (Installing Secure and Convenient Bike Racks; Providing Covered Bike Parking; Bike Parking in Public Areas; Indoor Bicycle Parking; Lockers, Showers and Changing Rooms)
- Quantifying the Benefits of Non-Motorized Transport for Achieving TDM Objectives
- "Bicycling Renaissance in North America? Recent Trends and Alternative Policies to Promote Bicycling (by John Pucher, Charles Komanoff, and Paul Schimek)
- Making Walking and Cycling Safer: Lessons from Europe (by John Pucher and Lewis Dijkstra)
- Reply to "The Bikeway Controversy" by John Forester (by John Pucher)
- Traffic Calming Benefits, Costs and Equity Impacts
- My Toughest Challenge...The Clearwater Roundabout Charrette (Dan Burden)
- Link to "Wheel Life" cycling columns

Public Transit

These papers describe the benefits of public transit, the role that public transit can play in an efficient and equitable transportation system, and how to improve public transit services.

- Comprehensive Evaluation of Rail Transit Benefits NEW
- Transit Price Elasticities and Cross-Elasticities
- Evaluating Public Transit Benefits and Costs
- Appropriate Public Transit Funding
- Optimizing Public Transit Benefits
- Renaissance of Public Transit in the United States?
- Financing Transit Systems Through Value Capture: An Annotated Bibliography (Jeffery J. Smith and Thomas A. Gihring)

Transportation Equity

These papers discuss various types of equity and fairness as they apply to transportation, how to evaluate nsportation equity, and examples of equity analysis in transportation decision-making.

- Evaluating Transportation Equity
- Social Inclusion As A Transport Planning Issue in Canada

Humor

These papers describe how bridge congestion can be addressed by improving ferocity factors on lion statues, where to find the best mountain biking in the solar system, and what really goes on between man and car in the privacy of a garage.

- "Wit and Humor" chapter of the *Online TDM Encyclopedia*
- Lionine Features to Enhance Bridge Capacity (by Walter Kulash, Sandy Curran & Jay Hood)
- Those Kinky Autophiles
- Salvation by Bicycle
- Cycling Route Perfect For Heavenly Bodies

Recommendations and Reviews of Other Publications

Here are lists of recommended publications and reviews of publications by others.

- Response to Mark Delucchi's "Should We Try to Get the Prices Right?" (with Allen Greenberg)
- *Divorce Your Car* by Katie Alvord (Book Review)
- Transportation Impact Analysis Publications
- Transportation Impact Bibliographic Database
- *Street Reclaiming* by David Engwicht (Book Review)
- Transportation Paradise; Realm of the Nearly Perfect Automobile? (John Pucher's Review of the book "Driving Forces" by James Dunn)
- *Roads in a Market Economy*, by Gabriel Roth (Book Review)

Web Links

Here you will find links to many other interesting and useful website related to transportation planning, economic and environmental analysis, transportation demand management, sustainable transportation, non-motorized transport planning, and much more.

VTPI Newsletter

Click here if you want to be on the VTPI Email Newsletter mailing list. This quarterly newsletter provides information on VTPI's latest products and activities.

Our goal is to make this information widely available. You are welcome to quote and copy from VTPI documents, provided you credit the authors. Most documents are posted in HTML or PDF format. Contact VTPI at info@vtpi.org to obtain a document in other formats such as Word or RTF, for example, to more easily copy a table or graph. Just let us know how you plan to use it – we are usually glad to accommodate such requests.

Choose from the following:

VTPI: Our Approach to Problem Solving	Online TDM Encyclopedia	Transportation Cost & Benefit Analysis Guidebook	Evaluating Impacts and Problems
Solutions: Innovative Strategies to Address Transport Problems	Optimal Pricing	Automobile Dependency and Transportation Diversity	Sustainable Transportation
Land Use and Parking Management	Pedestrian and Bicycle Issues	Public Transit	Transportation Equity
Recommendations and Reviews of Other Publications	Humor	Send Comments	Internet Links

Victoria Transport Policy Institute

Efficiency - Equity - Clarity

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Phone & Fax 250-360-1560
Todd Litman, Director

Updated June 2004
Visits:

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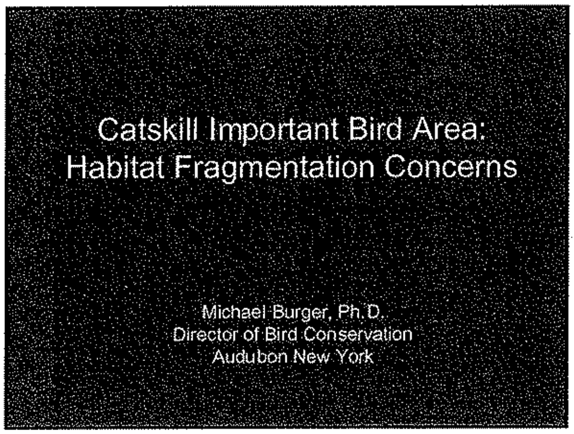

Catskill Important Bird Area: Habitat Fragmentation Concerns

Michael Burger, Ph.D.
Director of Bird Conservation
Audubon New York

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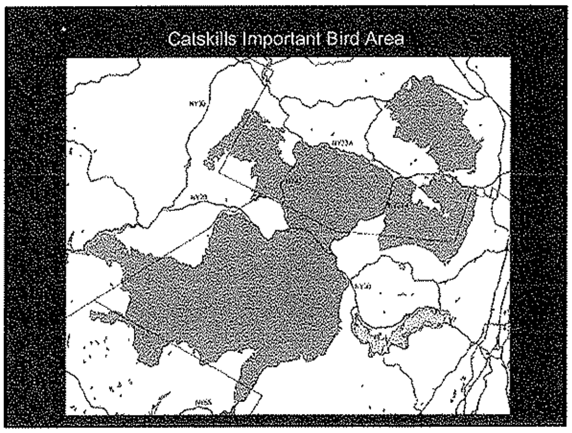

Catskills Important Bird Area

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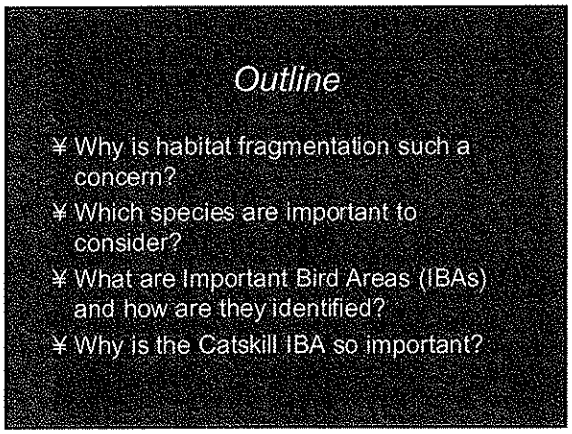
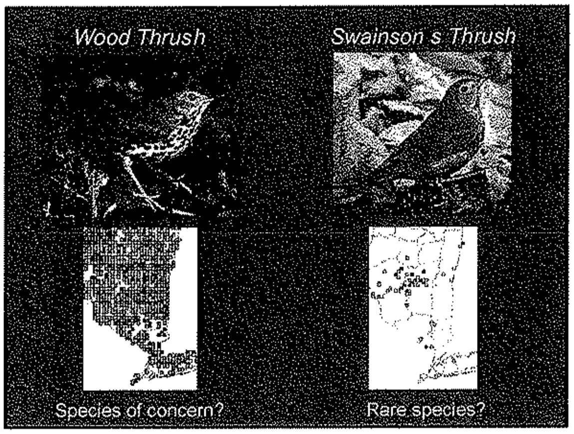


Outline

¥ Why is habitat fragmentation such a concern?
¥ Which species are important to consider?
¥ What are Important Bird Areas (IBAs) and how are they identified?
¥ Why is the Catskill IBA so important?

4



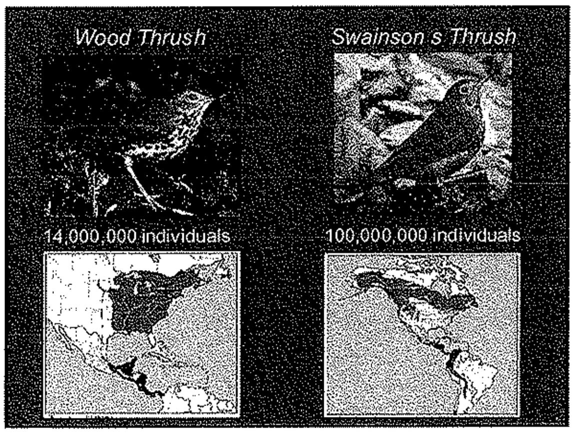
Wood Thrush

Swainson s Thrush

Species of concern?

Rare species?

5



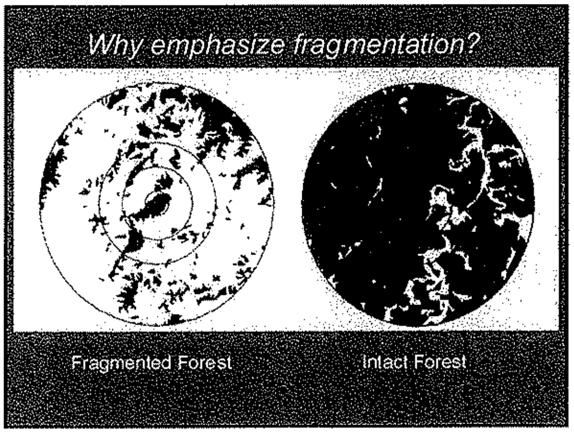
Wood Thrush

Swainson s Thrush

14,000,000 individuals

100,000,000 individuals

6

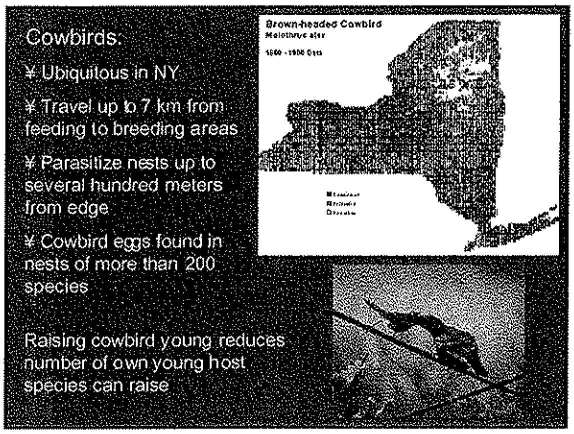


Why emphasize fragmentation?

Fragmented Forest

Intact Forest

7

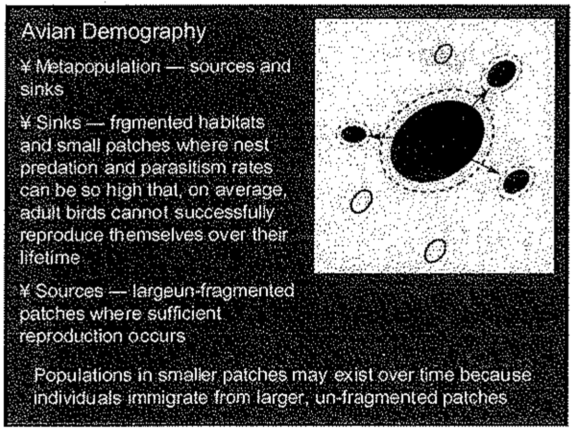


Cowbirds:

- ¥ Ubiquitous in NY
- ¥ Travel up to 7 km from feeding to breeding areas
- ¥ Parasitize nests up to several hundred meters from edge
- ¥ Cowbird eggs found in nests of more than 200 species

Raising cowbird young reduces number of own young host species can raise

8

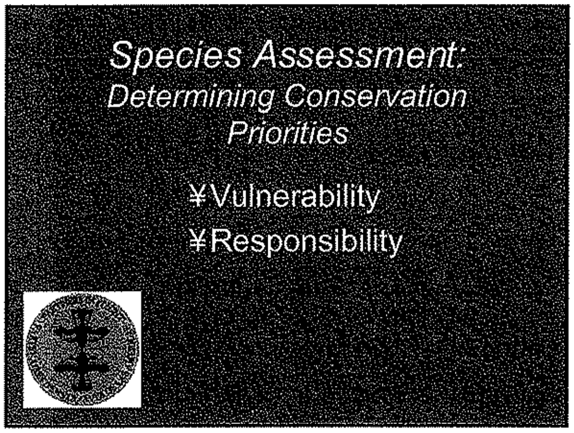


Avian Demography

- ¥ Metapopulation — sources and sinks
- ¥ Sinks — frgmented habitats and small patches where nest predation and parasitism rates can be so high that, on average, adult birds cannot successfully reproduce themselves over their lifetime
- ¥ Sources — largeun-fragmented patches where sufficient reproduction occurs

Populations in smaller patches may exist over time because individuals immigrate from larger, un-fragmented patches

9



Species Assessment:
Determining Conservation Priorities

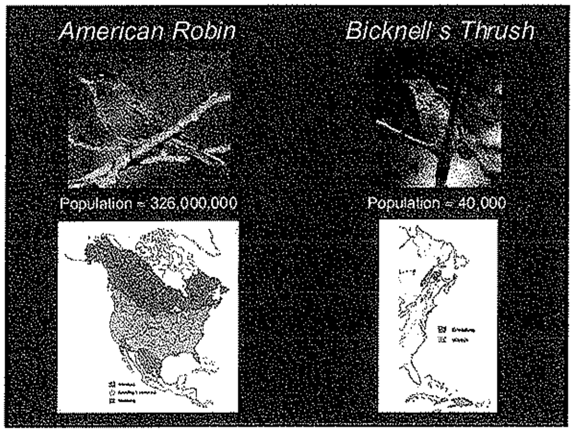
¥Vulnerability
¥Responsibility

10

Vulnerability Factors

¥Population Size
¥Size of Distribution
¥Population Trend
¥Threats

11



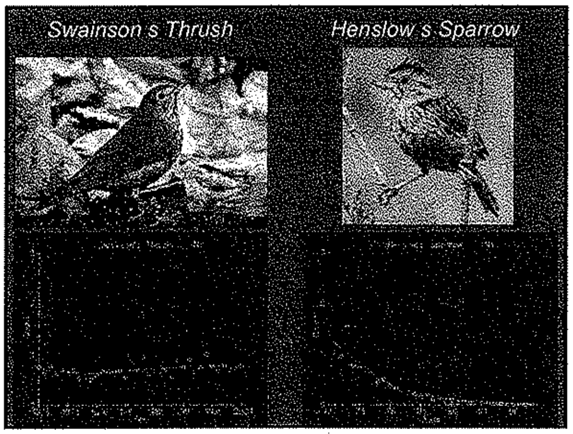
American Robin

Population ≈ 326,000,000

Bicknell s Thrush

Population ≈ 40,000

12



Swainson s Thrush

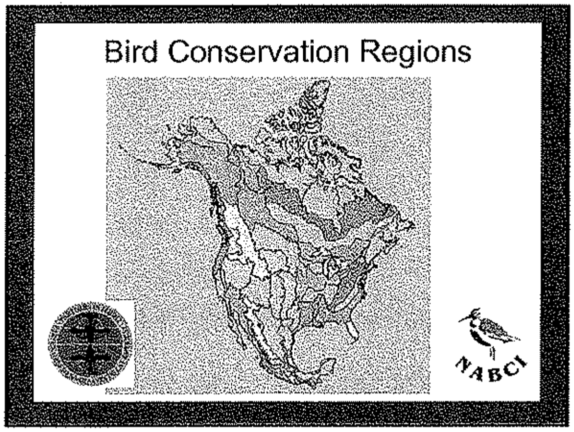
Henslow s Sparrow

13

Regional Responsibility

- ¥Relative Abundance
- ¥Percent Population

14



Bird Conservation Regions

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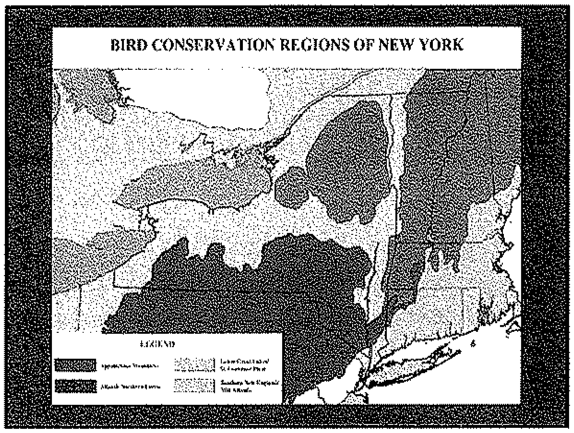

BIRD CONSERVATION REGIONS OF NEW YORK

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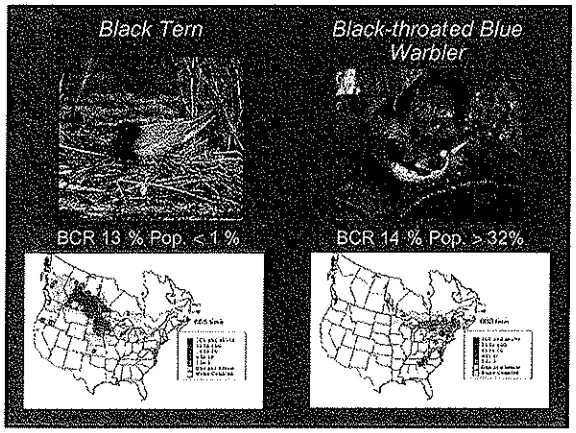


Black Tern

Black-throated Blue Warbler

BCR 13 % Pop. < 1 %

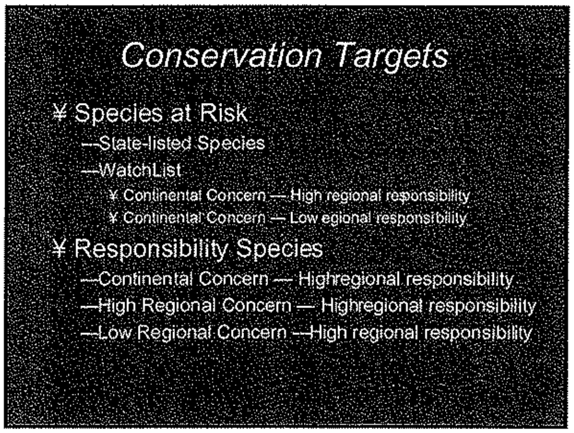
BCR 14 % Pop. > 32%

17

Priority Levels

- ¥ Continental Concern — Highregional responsibility (Bicknell s Thrush)
- ¥ Continental Concern — low regional responsibility (Olive-sided Flycatcher)
- ¥ Regional Concern — High regional responsibility (Black-throated Blue Warbler)
- ¥ Regional Concern — Lowregional responsibility (Chimney Swift)

18



Conservation Targets

- ¥ Species at Risk
  - —State-listed Species
  - —WatchList
    - ¥ Continental Concern — High regional responsibility
    - ¥ Continental Concern — Low regional responsibility
- ¥ Responsibility Species
  - —Continental Concern — Highregional responsibility
  - —High Regional Concern — Highregional responsibility
  - —Low Regional Concern —High regional responsibility

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IBA Origins

BirdLife INTERNATIONAL

¥Mid-1980s in Europe
¥Spread to the Mid-East, Africa, and Asia
¥Based on Global Criteria

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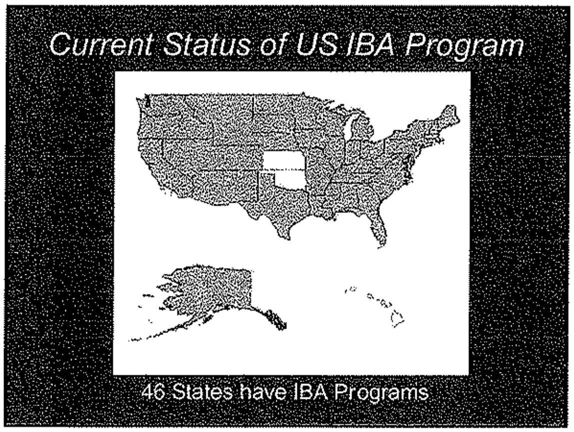
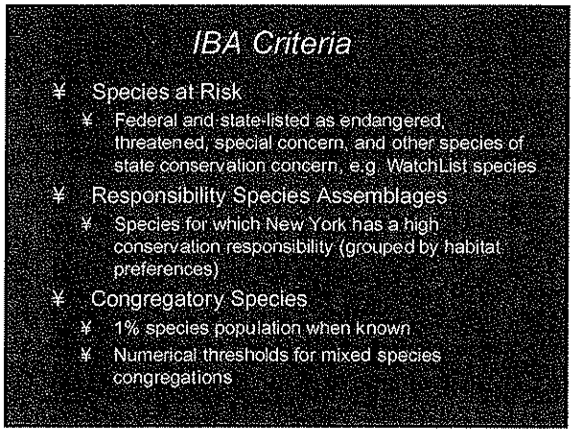


Current Status of US IBA Program

46 States have IBA Programs

21



IBA Criteria

¥ Species at Risk
  ¥ Federal and state-listed as endangered, threatened, special concern, and other species of state conservation concern, e.g. WatchList species
¥ Responsibility Species Assemblages
  ¥ Species for which New York has a high conservation responsibility (grouped by habitat preferences)
¥ Congregatory Species
  ¥ 1% species population when known
  ¥ Numerical thresholds for mixed species congregations

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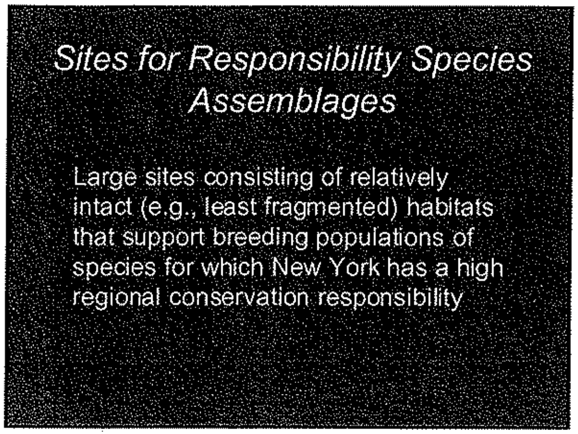

Sites for Responsibility Species Assemblages

Large sites consisting of relatively intact (e.g., least fragmented) habitats that support breeding populations of species for which New York has a high regional conservation responsibility

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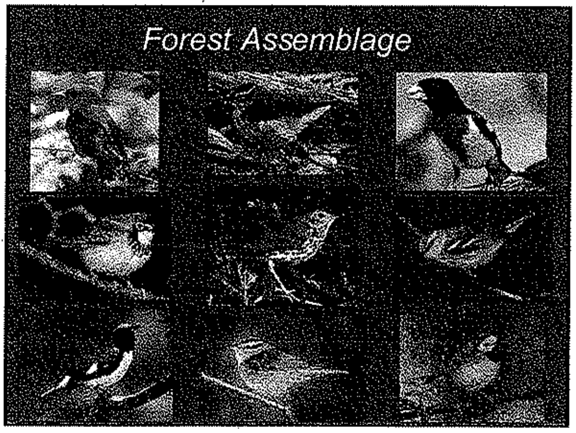
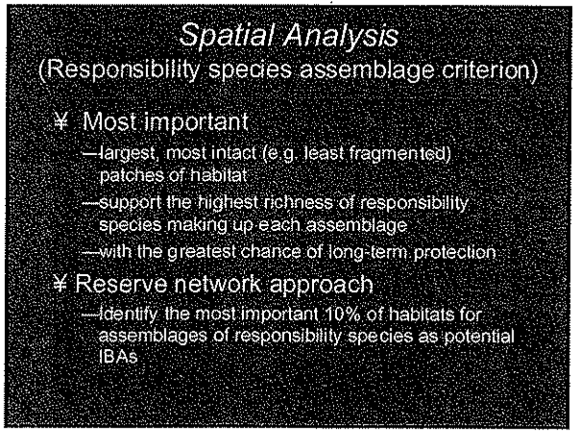


Forest Assemblage

24



Spatial Analysis

(Responsibility species assemblage criterion)

- ¥ Most important
  - —largest, most intact (e.g. least fragmented) patches of habitat
  - —support the highest richness of responsibility species making up each assemblage
  - —with the greatest chance of long-term protection
- ¥ Reserve network approach
  - —Identify the most important 10% of habitats for assemblages of responsibility species as potential IBAs

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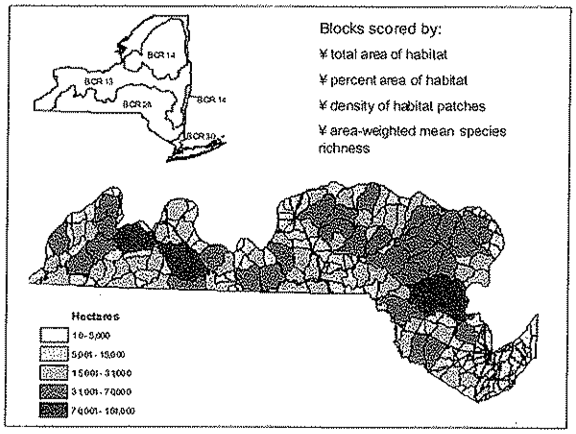
Blocks scored by:

¥ total area of habitat

¥ percent area of habitat

¥ density of habitat patches

¥ area-weighted mean species richness

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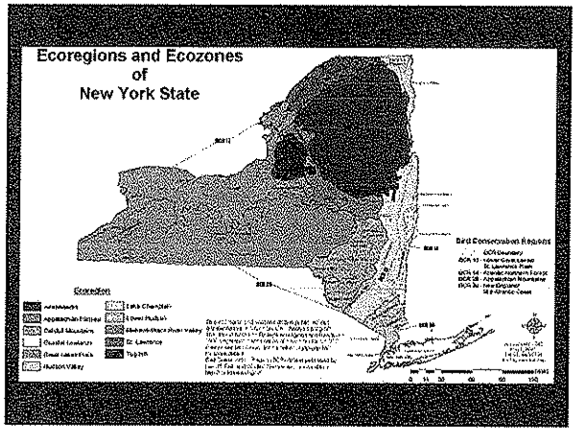
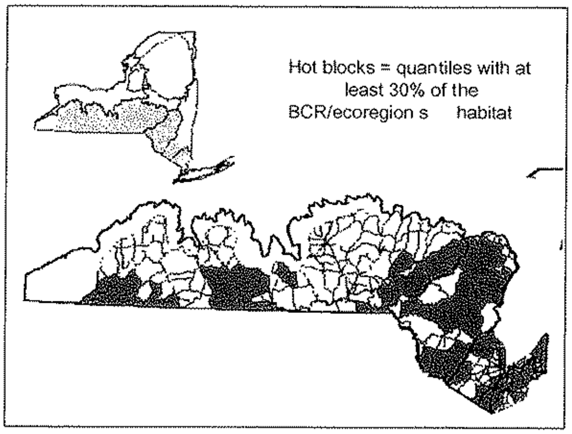
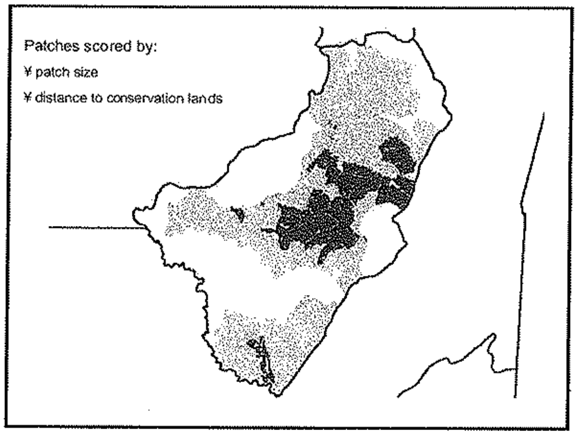

Ecoregions and Ecozones of New York State

27


Hot blocks = quantiles with at least 30% of the BCR/ecoregion s habitat

28

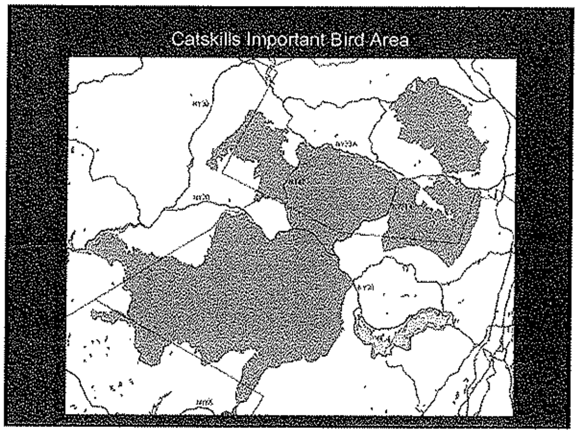


Patches scored by:

¥ patch size

¥ distance to conservation lands

29



Catskills Important Bird Area

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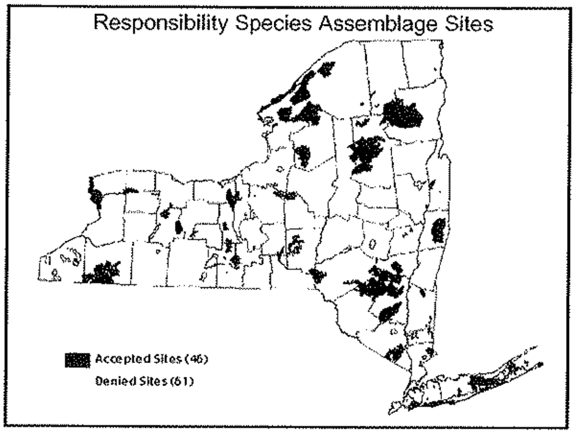

Responsibility Species Assemblage Sites

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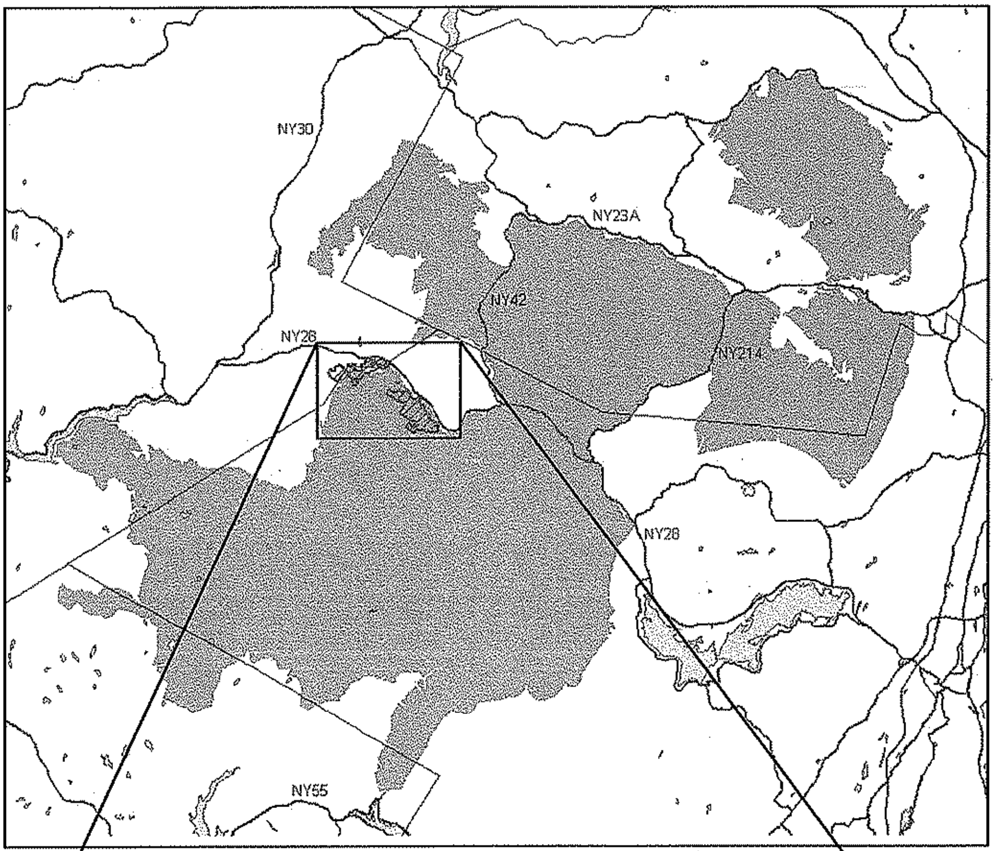
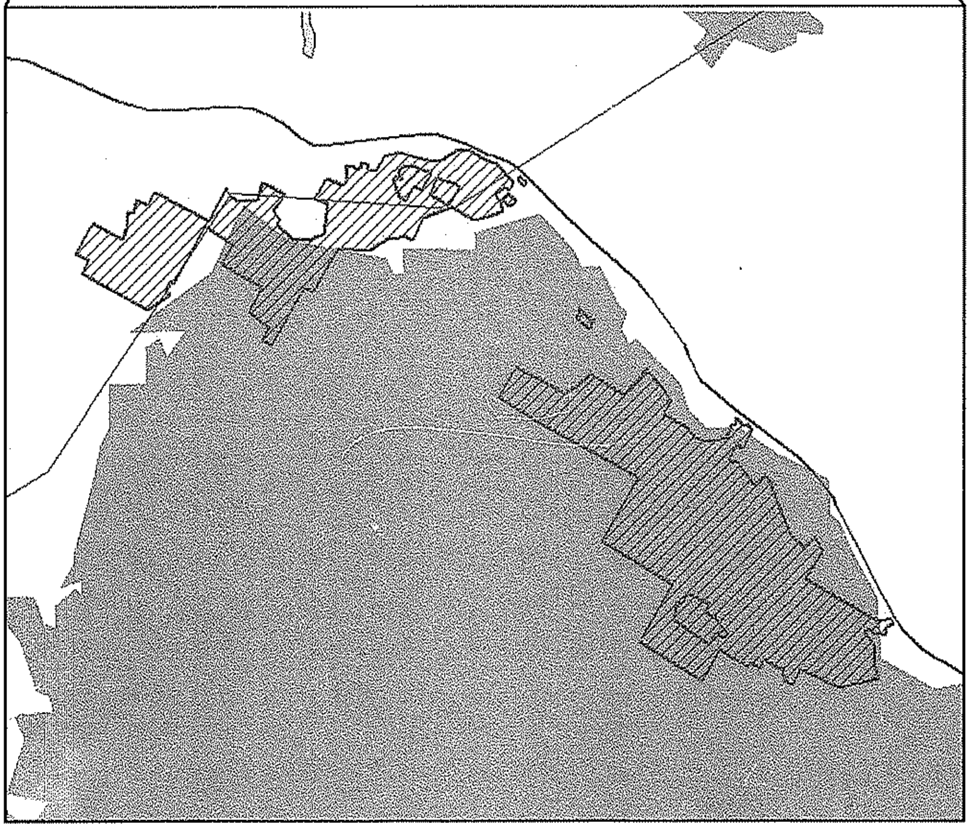
cPC 49

Catskill Important Bird Area



Crossroads site



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CORNELL LABORATORY *of* ORNITHOLOGY
159 SAPSUCKER WOODS ROAD • ITHACA, NEW YORK 14850-1999 • (607) 254-BIRD

17 June 2004

To Whom It May Concern:

In my capacity as Director of Conservation Science department at the Cornell University Laboratory of Ornithology and as a co-chair of Partners In Flight's International Science Committee, which co-authored the *North American Landbird Conservation Plan*, I have consulted with Dr. Michael Burger regarding his testimony on the significance of potential forest fragmentation impacts in the Catskill Important Bird Area. It is my professional opinion that the conclusions drawn by Dr. Burger in his presentation are correct and consistent with our scientific understanding of forest bird habitat relationships in the northeastern United States.

The *North American Landbird Conservation Plan* specifically identified habitat fragmentation as one of the leading threats to bird populations throughout North America. Many studies and conservation plans have recognized the critical importance of remaining, large forest tracts close to urbanized areas to the reproductive success of numerous bird species. I believe that the methodology Dr. Burger has illustrated to identify the most significant intact forest tracts in New York State, as part of Audubon's Important Bird Areas program, is scientifically sound.

Furthermore, the argument for preventing fragmentation of this largest section of the Catskill IBA is particularly compelling from a bird conservation perspective. This area clearly provides the largest available habitat for source populations of an entire suite of forest breeding birds, including the Wood Thrush, Scarlet Tanager, Black-throated Blue Warbler, Louisiana Waterthrush, and others.

Respectfully yours,

Kenneth V. Rosenberg, Ph.D.

• A MEMBERSHIP ORGANIZATION FOR THE STUDY, APPRECIATION, AND CONSERVATION OF BIRDS •
http://birds.cornell.edu

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Ex 51

Catskill Peaks IBA SUMMARY

Site Code	CAPE
Size of Site (acres)	313604
BCR	28
Ecoregion	Hudson Valley, Catskill Mountains

Towns and Counties: Andes (Delaware County), Middletown (Delaware County), Roxbury (Delaware County), Cairo (Greene County), Catskill (Greene County), Durham (Greene County), Halcott (Greene County), Hunter (Greene County), Jewett (Greene County), Lexington (Greene County), Prattsville (Greene County), Windham (Greene County), Neversink (Sullivan County), Rockland (Sullivan County), Denning (Ulster County), Hardenburgh (Ulster County), Olive (Ulster County), Saugerties (Ulster County), Shandaken (Ulster County), Woodstock (Ulster County)

General Description Site includes a contiguous forest tract partially contained within the Catskill Forest Preserve. The peaks support subalpine habitats that harbor a unique assemblage of breeding birds. The coniferous forests above 3500 feet are primarily composed of balsam fir (*Abies balsamea*) and red spruce (*Picea rubens*). The lower elevation hardwood forests are dominated by sugar maple (*Acer saccharum*) and beech (*Fagus grandifolia*).

Habitat Types Found at Site:

Mixed Forest	34.4%	***Grassland***	1.0%
Coniferous	7.3%	***Beach/dune***	0.0%
Deciduous	54.6%	***Open Water***	1.0%
Shrub/scrub	0.0%	***Developed***	0.1%
Wetland	1.5%		

Land Cover Types
Appalachian Oak Pine 2929.78 Acres
Clouds 58.21 Acres
Cropland 1665.22 Acres
Decidous Wetland 2972.12 Acres
Emergent marsh/Open Fen/Wet Meadow 681.57 Acres
Evergreen northern hardwood 104885.68 Acres
Evergreen plantation 501.42 Acres
Evergreen wetland 956.31 Acres
Oak 47147.09 Acre
Old field/pasture 1556.51 Acres
Open water 3302.87 Acres
Roads 275.85 Acres
Shadows 223.59 Acres

Shrub swamp 32.41 Acres
Spruce-fir 22394.86 Acre
Sub-urban residential 2.87 Acres
Sugar maple mesic 124075.79 Acres

Current IBA	Yes
Criteria Met in First Round	Congregations-Individual Species, Habitat

Catskill Peaks Responsibility Species Assemblage Data

Species Assemblage Type	Forest
Site identified through	GIS, First Round
Site located within a relatively intact landscape (hot block)	Yes
Acres of assemblage	305956
Site contains	4.72% *of this assemblage habitat type in the BCR*

Composition of Forest Habitat (based on GAP land cover classes):

Appalachian oak-pine	0.9%	***Evergreen-northern hardwood***	33.5%	***Spruce-fir***	7.1%
Deciduous wetland	0.9%	***Oak***	15.0	***Sugar maple mesic***	39.6%
Evergreen plantation	0.2%	***Pitch pine-oak***	0.0%	***Successional hardwoods***	0.0%
Evergreen wetland	0.3%				

Species	*Predicted by GAP*	*Confirmed BBA*	*Confirmed Field Survey*	*Confirmed Second Round Nomination*	*Confirmed First Round*
Black-and-white Warbler	X	X			
Black-billed Cuckoo	X	X			
Black-throated Blue Warbler	X	X			
Blue-gray Gnatcatcher	X	X			
Canada Warbler (WL)	X	X			
Cerulean Warbler (S-SC,WL)*	NA	X			
Eastern Wood-Pewee	X	X			
Hooded Warbler	--	--			
Least Flycatcher	X	X			
Louisiana Waterthrush	X	X			
Northern Flicker	X	X			
Rose-breasted Grosbeak	X	X			
Scarlet Tanager	X	X			

Sharp-shinned Hawk (S-SC)	X	X
Wood Thrush (WL)	X	X
Worm-eating Warbler (WL)*	NA	--
Yellow-throated Vireo	X	X

Catskill Peaks Species at Risk Data

Species at Risk

BBA Blocks

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Proposal Date Confirm Date Denial Date

Species	Accept/Reject	BBA 1980-1985	BBA 2000-2005	NY Natural Heritage	Other Reference 1	Other Reference 2	Reference Key
Worm-eating Warbler (WL)		0CO, 0PR, 1PO	0CO, 0PR,0PO				
American Woodcock (WL)		3CO, 1PR, 1PO	0CO, 2PR,4PO				
Blue-winged Warbler (WL)		0CO, 0PR, 2PO	0CO, 0PR,0PO				
Canada Warbler (WL)		5CO, 12PR, 10PO	2CO, 1PR,4PO				
Cerulean Warbler (S-SC,WL)		0CO, 0PR, 0PO	0CO, 0PR,2PO				
Prairie Warbler (WL)		0CO, 1PR, 2PO	0CO, 0PR,0PO				
Sharp-shinned Hawk (S-SC)		0CO, 0PR, 10PO	0CO, 1PR,7PO				
Whip-poor-will (S-SC)		0CO, 1PR, 0PO	0CO, 0PR,0PO				

Species	Accept/Reject	BBA 1980-1985	BBA 2000-2002	NY Natural Heritage	Other Reference 1	Other Reference 2	Reference Key
American Black Duck (WL)		0CO, 0PR 0PO	1CO 0PR 1PO				
Wood Thrush (WL)		8CO 10PR, 15PO	3CO 10PR 9PO				
Bicknell's Thrush (S-SC)		1CO, 5PR 5PO	2CO 1PR 5PO	1 singing male 2002 17 ind (18) 2000 5 pairs 46 ind (18) 1999 5 pairs 1994 55 pairs 140 ind (41) 1993	21 individuals recorded in 2002	30-35 pairs on Hunter Mountain in 1997	1. VINS 2002 data 2. IBA Book
Bald Eagle (S-T)		0CO, 0PR 0PO	0CO 0PR 2PO				
Cooper's Hawk (S-SC)		0CO, 0PR 3PO	0CO 0PR 5PO				
Northern Goshawk (S-SC)		0CO, 0PR 5PO	1CO 0PR 1PO				
Olive-sided Flycatcher (WL)		0CO, 5PR, 3PO	0CO 0PR 1PO				
Osprey (S-SC)		0CO, 0PR, 0PO	0CO 0PR 1PO				
Peregrine Falcon (S-E)		0CO, 0PR 0PO	1CO 0PR 0PO				

Species	Accept/Reject	BBA 1980-1985	BBA 2000-2005	NY Natural Heritage	Other Reference 1	Other Reference 2	Reference Key
Red-headed Woodpecker (S-SC,WL)		1CO, 0PR, 0PO	0CO, 0PR,0PO				
Red-shouldered Hawk (S-SC)		1CO, 0PR, 4PO	0CO, 1PR,2PO				
Willow Flycatcher (WL)		0CO, 0PR, 2PO	0CO, 0PR,0PO				

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IBA Spatial Analysis Methodology

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Audubon uses GIS to Identify Important Bird Areas in New York State

Audubon New York is a non-profit organization that conserves birds, other wildlife, and their habitats through education and advocacy, based on sound science. A major component of Audubon's efforts is the identification, protection, and proper management of Important Bird Areas.

Important Bird Areas (IBAs) represent critical habitats for the survival and conservation of birds. An IBA is a site that provides essential breeding and/or non-breeding habitat for bird species or group of species of conservation concern. In order to be designated as an IBA, a site must meet at least one of several criteria relating to its significance for threatened bird species, congregations of birds, and/or habitats important to assemblages of birds for which New York has conservation responsibility.

The IBA program began in Europe in the mid-1980s. Today, IBA programs are underway on 6 continents and in 146 countries. In 1996, New York State became the second US state to initiate an IBA program. Sites were nominated from a broad audience of interested individuals and today there are 127 IBAs recognized in New York, representing over 800,000 ha of critical nesting, breeding, and foraging habitat.

However, the original nomination process relied solely on the observations of birders and ornithologists. Though birdwatchers in New York are very knowledgeable, there are large areas of viable habitat where birders do not visit. This is evident in that many IBAs were clustered in areas of high population. Audubon conservation staff saw a critical need to reassess the IBA nomination process by incorporating a landscape analysis of bird habitat variables across New York. To address this need, in 2003 they expanded the IBA site identification process to include analysis of spatial habitat data at a landscape scale, using GIS. Jillian Liner, Audubon New York IBA Coordinator, notes that, "The use of GIS and spatial analysis has been a crucial component in identifying IBAs in an unbiased manner; it has allowed us to comprehensively assess the state to identify the most critical areas for birds." Computer equipment and GIS software were acquired by Audubon New York in 2001 through a grant from the Conservation Technology Support Program.

Audubon New York's GIS analysis targets habitat of forest, shrub, and grassland species assemblages for which New York has a high conservation responsibility. Conservation responsibility species were identified using the Partners in Flight (PIF) species assessment process and include species with a large proportion of their populations found within the North American Bird Conservation Initiative's Bird Conservation Regions (BCRs) that make up New York. The IBA program does not look to identify as an IBA every site where a responsibility species breeds, because these species tend to be fairly common. Rather, taking a reserve system approach, it sought to identify the most important 10% of habitat for each assemblage.

"Most important" habitat was defined as the largest, least fragmented patches of habitat supporting the highest richness of species comprising each assemblage, with the greatest chance of long-term protection. Habitat identification was stratified across New York's BCRs and ecoregions to capture important ecological variation and to ensure that potential IBAs were not clustered in one part of the state.

The Audubon New York staff built their analysis on land cover data, species predicted breeding habitat distributions, and stewardship lands from the New York Gap Analysis Program. Ancillary data included major and minor roads from the New York Department of Transportation. Using ArcView Spatial Analyst, they developed habitat and species richness indices at multiple scales and created spatial models to integrate these indices. Their work was accomplished on one HP Vectra computer with a 1 GHz Processor, 256MB RAM, 40GB HDD, and a 19" color monitor.

At a landscape scale, Audubon New York developed a dataset of focus areas (referred to as habitat blocks) by combining relevant land cover data and predicted bird distributions to describe the character of habitat and bird richness within lands unfragmented by major roads. For each assemblage, three habitat variables (total area of habitat, percent of habitat area, and density of habitat patches) and one species distribution variable (area-weighted mean species richness) were calculated for each habitat block. They combined these variables in a spatial model using the Spatial Analyst Map Calculator to derive an index value for each habitat block. They then ranked the resulting block dataset with the ArcView Legend Editor, using a quantile classification scheme with ten classes. The top three to five classes became focus areas for further analysis at the patch scale.

At a patch scale, Audubon New York sought to identify the areas with the greatest chance of long-term protection and demonstrated avian significance as potential IBAs. Patch variable attributes included patch size, distance to stewardship lands, and distance to existing IBAs. Within the habitat blocks identified at the landscape scale, unfragmented patches were determined by intersecting land cover data for each assemblage with all roads at a large scale. Variable attributes were then calculated for each patch. Again using the Spatial Analyst Map Calculator, a spatial model was constructed that combined these variables in order to rank patches. Patches exhibiting a high score were considered potential IBAs and targeted for ground-truthing.

Bird presence was ground-truthed by utilizing data from the New York Breeding Bird Atlas (BBA) and via field surveys. The BBA provides recent (2000-2003) data on the presence of breeding birds in 5 x 5 km squares across the state. IBAs not adequately covered or surveyed by the BBA were targeted for field surveys that were conducted by Audubon staff and qualified volunteers.

Audubon New York calculated overall accuracy, percent error commission, and percent error omission to evaluate how well the process identified potential IBA sites that support the target species. Results indicate that sites predicted to be IBAs have high potential to support habitat-species assemblages and contain quality habitat relative to other areas within the same BCR/ecoregion combination. Overall percent accuracies ranged from 67% to 100%.

Through the GIS analysis, Audubon identified 54 potential IBAs. Of these, 35 are existing IBAs, 12 are expansions of existing sites, and the remaining 19 sites are newly identified areas that may become IBAs.

The ultimate attainment of the IBA goal—creating a network of protected areas for birds—is a long-range project. Audubon is committed to working with its chapters, other conservation organizations, communities, landowners, and government officials in New York State to ensure the long-term survival of abundant bird populations. "GIS technology has allowed us to analyze critical data at a scale and breadth that will take our conservation work into the 21st century and beyond," says Dr. Mike Burger, Director of Bird Conservation for Audubon New York.

For more information, contact Jillian Liner, Audubon New York Important Bird Areas Coordinator at: 159 Sapsucker Woods Rd., Ithaca NY 14850; tel: 607-254-2437; email: jliner@audubon.org.

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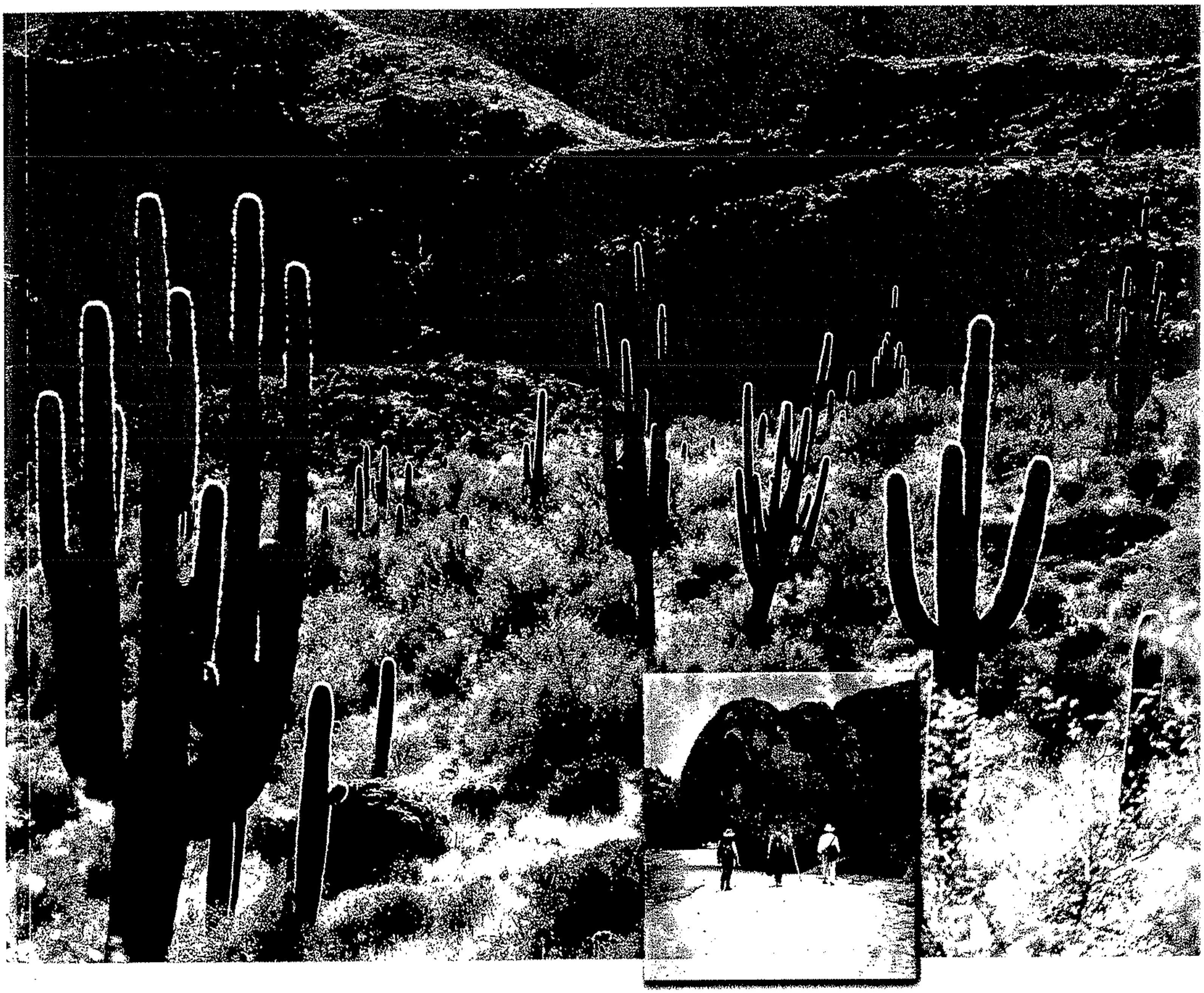
Ex. 54

Wilderness Management

Stewardship and Protection of Resources and Values

Third Edition



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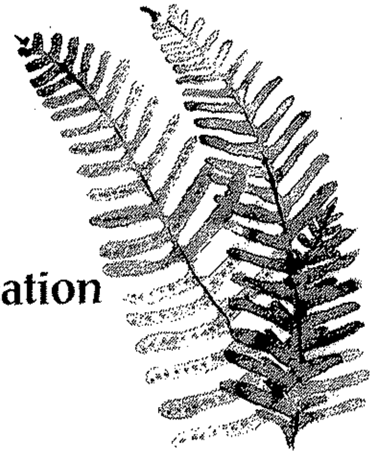


Chapter 15

Ecological Impacts of Wilderness Recreation and Their Management

by David N. Cole

Introduction

Four parallel trails gouged into a wildflower-dotted alpine meadow, denuded campsites with severe soil erosion, numerous trees battered and scarred by tethered livestock. Such recreational impacts are all too common in wilderness these days. Wilderness management to prevent and restore such impacts is a difficult challenge, and directly related to managing for quality wilderness experiences.

This chapter begins with a discussion of the significance of recreational impacts, its purpose being to bring recreation impacts into perspective with other wilderness management problems. This discussion is followed by a description of important types of recreational impacts, those caused by trampling, campfires, construction and maintenance of trails, pack animals, wildlife disturbance, and water pollution and disposal of human waste. The remainder of the chapter deals with impacts associated with campsites, trails, pack and saddle stock and alternative management responses to problems based on ecological impacts.

The examples used in this chapter come mainly from large wildernesses in the West. This reflects the author's experience, as well as the fact that less research has been published on wildernesses in the East. Some examples are taken from developed recreation areas with vehicular access. The general dearth of research on the ecological effects of wilderness recreation leaves many interpretations open to debate. Study locations are noted in the text; but caution should be used when extrapolating results from a single study to distant areas. Recent textbooks on recreation ecology provide additional information to that presented here (Hammitt and Cole 1998; Liddle 1997).

Importance of Wilderness Recreation Impacts

To evaluate the importance of recreation impacts in wilderness areas, it is important to reexamine the goals of wilderness management. The relevant phrases in the Wilderness Act state that wilderness is an area "which is protected and managed so as to preserve its natural conditions and which *generally* appears to have been affected *primarily* by the forces of nature, with the imprint of man's work *substantially* unnoticeable" (emphasis added). This implies that some recreation impacts will be tolerated, but (1) the integrity of relatively undisturbed wilderness ecosystems should not be substantially compromised and (2) the evidence of impacts should not be conspicuous. The first of these objectives is concerned with protecting wilderness ecosystems; the second, with protecting quality of the visitor's experience. Both are important.

What constitutes a substantial compromise of ecosystem integrity? There is no clear answer to this question. *I suggest that the most important impacts are those that seriously disrupt ecosystem composition, structure, and function and that are evident at large spatial scales. Impacts that alter a large proportion of a relatively rare ecosystem are particularly detrimental. Irreversible changes are unacceptable, but where impacts occur repeatedly, even easily reversible changes are important.*

The ecological impacts of recreation can be severe. The composition, structure, and function of sites that are used for recreation are often nearly completely altered. At the site scale, then, recreation impacts are as profound as any human threat to wilderness. However, these impacts are highly localized. Recreation use is highly concentrated along a few major trails and at a few popular destinations. This leaves the vast majority of most wildernesses essentially unvisited and, therefore, virtually undisturbed by recreation use. For example, even in the most heavily used part of the Eagle Cap Wilderness, Oregon, less than 2 percent of the area has been significantly altered by recreation use (Cole 1981). Marion and Leung (1997) estimate that only 0.05 percent of the backcountry at Great Smoky Mountains National Park has been directly disturbed by recreation use. At large scales, then—from the perspective of landscapes, watersheds, and regions—recreation impacts are generally not severe. At these scales, far more potent threats to the integrity of wilderness ecosystems exist. Acid rain is altering the basic ecology of lakes throughout uncommon ecosystems in certain areas. A New York state wilderness in the Adirondack Mountains provides an example of an area substantially affected by acid rain; aquatic ecosystems are most heavily impacted. In addition to external threats, such as acid rain, internal threats can also be potent. The impacts of fire suppression and livestock grazing, though less severe than recreation at the site scale, are expressed over vast wilderness acreages (Cole and Landres 1996).

Generally, then, recreation use, although causing locally severe impacts, does not substantially compromise wilderness landscapes. There are several important exceptions to this generalization, however. *The first exception is the introduction of fish, often-exotic species, into lakes and streams without fish or predator species and the subsequent removal of fish through angling.* In such cases, adding a new component to the food chain has impacted entire aquatic ecosystems. It has reduced, displaced, or eliminated competitors or prey organisms and has stimulated the invasion or expansion of predatory populations. Fish stocking has been implicated as one of the reasons for the decline in amphibian populations in the wilderness of the Sierra Nevada, for example (Knapp and Matthews 2000). Angling, although partially negating the effect of introductions, has altered the population structure of fisheries and, in extreme cases, has nearly eliminated a major consumer and link in the food chain.

Generally, fishing is allowed throughout wilderness. In a few cases, angling pressure is attenuated by "catch-and-release" regulations. Such regulations are in effect in parts of the Frank Church–River of No Return Wilderness, Idaho, and the Golden Trout Wilderness, California, for example. However, wilderness designation seldom brings such restrictions. A more common (and better) action is to discontinue the artificial stocking of fish. This will allow some areas, where reproduction is poor, to revert to a more natural state.

A second recreation impact that can be important at large spatial scales is disturbance of wildlife because of hunting or unintentional harassment. Hunting is generally allowed in wildernesses, outside of the national parks. Although long-lasting effects are difficult to document, unintentional disturbance has undoubtedly altered the distribution, population structure, and behavior of many wildlife species.

Finally, less common, but also important, is physical alteration or pollution of uncommon ecosystems or sites inhabited by rare plants or animals. Disturbance of such places can lead to the elimination of rare species or the alteration of most examples of certain ecosystem types. Pollution of lakes, disturbance of meadows by pack stock, and camping impacts along desert riparian strips are examples of such impacts that occur in certain wildernesses.

The effect of recreation impacts on visitors, in contrast, is most important when it is apparent at the site scale—the scale most relevant to human interaction with the natural environment, where people spend the most time. Consequently, recreation use—because it severely impacts ecosystems at the site scale—commonly compromises the goal of avoiding conspicuous evidence of human impact. The importance of such impacts depends on the visitor's sense of aesthetics and sensitivity to change, whether or not the change is perceived as desirable, and the magnitude of the change. Thus, trail impacts in meadows are more troublesome than impacts in forests because they are more obvious and aesthetically displeasing, even though the amount of change in meadows may be less than in forests. Felling of trees and cutting of brush may be desirable and appropriate on trails where it makes travel easier, but undesirable and inappropriate elsewhere.

Few studies of visitor perceptions of impacts show much relationship between visitor satisfaction and amount of impact. Visitors consistently report that recreation impacts—*if they occurred*—would adversely affect their wilderness experience (Roggenbuck and others 1993). However, many visitors do not notice ecological impacts that have occurred. Of those who do notice impacts, many do not perceive of these impacts as "damage"—or undesirable change. Finally, most visitors do not change their behavior or have less satisfactory experiences, even when confronted by impacts that they consider undesirable. For example, even those who dislike the heavy evidence of horse use in the Bob Marshall Wilderness are likely to continue to camp in the same places and travel the same trails and, on the whole, enjoy it. This suggests that although most wilderness visitors do not like the "idea" of recreation impacts, few visitors are bothered much by even relatively high degrees of alteration.

In dramatic contrast, site impacts are the foremost concern of many managers (Marion and others 1993). Managers are often well aware of such impacts and are charged, as managers, to effectively deal with them. They have been charged with this management responsibility despite going unnoticed by visitors, or the common indifference of visitors to the impacts that occur around them. Most

Fig. 15.1. While generally accepted in wilderness, fishing and the planting of fish in naturally barren waters can substantially alter aquatic ecosystems. Photo courtesy of the USFS.

of the discussion that follows deals more with management to avoid conspicuous evidence of human use than with management to maintain ecosystem integrity.

Recreation Activities and Associated Impacts

Now that we have discussed the importance of recreation impacts in light of wilderness management goals, we will take a more detailed look at the effects of various recreation activities on the wilderness resource.

Trampling

The old adage to "take nothing but pictures and leave nothing but footprints" is outdated. In many places, too many footprints have left an unwanted legacy. The effects of human trampling have been investigated for more than eighty years, and we now have a clear understanding of many of the general effects of trampling. These can be conveniently displayed in a conceptual model.

Trampling has three initial effects: abrasion of vegetation, abrasion of surface soil organic layers, and compaction of soils. Plants can be crushed, sheared off, bruised, and even uprooted by trampling. Although several studies have shown that very light amounts of trampling can stimulate growth (e.g., Bayfield 1971), any consistent trampling is likely to reduce the vigor and reproductive capacity of all but the most resistant plant species.

Studies have revealed a variety of physiological and morphological changes that occur when vegetation is trampled. Changes include reductions in plant height, stem length, and leaf area, as well as in number of plants that flower, number of flower heads per plant, and seed production (Liddle 1997). In Glacier National Park, Montana, Hartley (1999) found reduced carbohydrate reserves in the roots of trampled glacier lilies, presumably a response to a reduction in the ability to photosynthesize after trampling. All of these changes are manifested in reduced vigor and reproduction, leading to less plant biomass and cover. Thus, *most recreation sites exhibit a gradient in which the cover of*

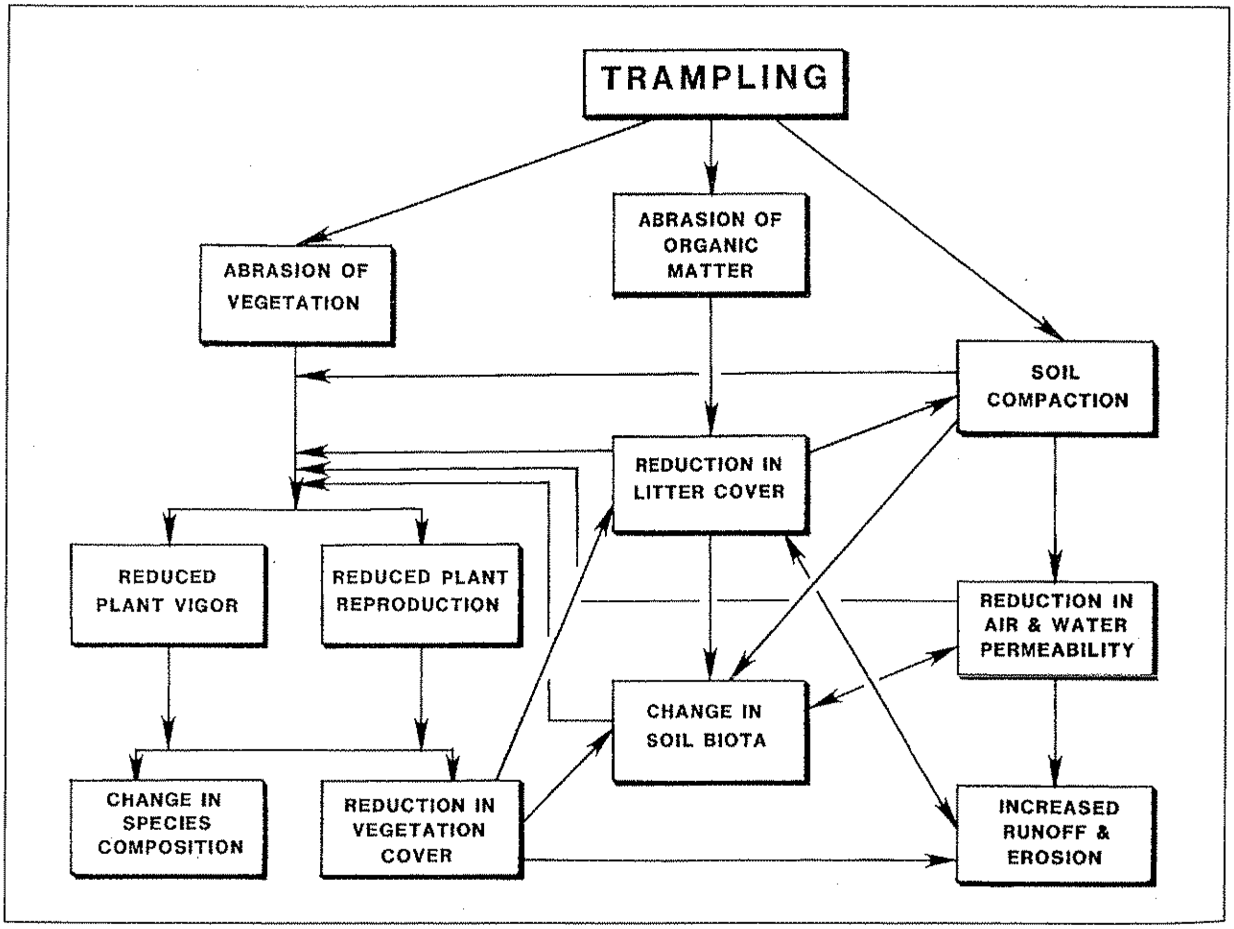


Fig. 15.2. A conceptual model of trampling effects partly based on Liddle 1979. Note the numerous reciprocal and cyclic relationships between soil and vegetational impacts.

vegetation decreases from undisturbed vegetation to places where trampling stress is concentrated and no vegetative cover survives. The sharpness of this gradient depends on both the fragility of the vegetation and whether the trampling is concentrated or dispersed. For example, the gradient from no vegetation to normal cover levels is very narrow along trails, where trampling is concentrated, particularly those trails through fragile vegetation, and quite wide on campsites, where trampling is dispersed, particularly campsites in resistant vegetation.

Plants vary in their ability to tolerate trampling. Some plants are even favored by trampling—not as a direct response to abrasion, but in response to reduced competition with other plants and favorable changes in microclimate that result from trampling. For example, trampling often increases light levels and temperature ranges—changes that favor certain species. Many, if not most, of these favored species are introduced plants that are brought into the wilderness by humans and pack stock and are not vegetation native to the site.

The vegetation that grows in areas of moderate disturbance, then, is very different in composition from undisturbed vegetation. It consists of trampling-tolerant survivors as well as either native or nonnative invading species capable of growing in the local environment and dispersing to the site. Which of these types of plants dominates is highly variable. In the Eagle Cap Wilderness, dandelion, a Eurasian weed, is the most common plant on lower elevation campsites. Apparently, it cannot tolerate conditions on campsites in subalpine forests, where the most common plants are native rushes and sedges that were originally on the site and that survive trampling, although at reduced densities (Cole 1982a). Nonnative invasive species are more problematic on low elevation recreation sites (Marion and others 1986).

The tendency for the original species on the site to decrease in density, creating more favorable conditions for new invading species, explains the observation that species richness—the number of different species occupying the site—often increases with low to moderate levels of trampling before declining to zero as trampling intensifies (Liddle 1997).

Knowledge of which species and types of plants are most tolerant of trampling can be useful in locating sites with resistant vegetation types. Morphological characteristics that generally make a plant more tolerant (Cole 1987) include the following:

1. A procumbent or trailing, rather than erect, growth form;
2. A tufted growth form;
3. Arming with thorns or prickles;
4. Stems that are flexible rather than brittle and rigid, particularly if they are woody;
5. Leaves in a basal rosette or cluster;
6. Small, thick leaves;
7. Flexible leaves that can fold under pressure; and
8. Either very large or very small structure.

Physiological characteristics that increase the tolerance of plant species include the following:

1. Ability to initiate growth from intercalary meristems, located at the base of leaves, as well as from apical meristems at the tips of stems and branches, where they are likely to be damaged;
2. Ability for perennials to initiate seasonal regrowth from buds concealed at or preferably below the soil surface;
3. The ability to reproduce vegetatively from suckers, stolons, rhizomes, or corms, as well as through seeding;
4. A rapid rate of growth; and
5. Ability to reproduce during a time when recreational use is low.

Generally, broad-leaved herbs, lichens, low shrubs, and tree seedlings have little tolerance and are quickly eliminated on recreation sites. Elimination of tree seedlings on forested recreation sites portends major, undesirable changes on these sites once the overstory dies. Established trees, because of their size, are little affected by trampling except in the few cases where studies have found reduced growth rates (Brown and others 1977), increased water stress (Settergren and Cole 1970), and damage to root systems and increased wind throw as a result of erosion (Frissell and Duncan 1965).

Cole (1995a) has shown, for groundcover plants, that the ability to resist trampling *(resistance)* decreases with erectness and that broad-leaved herbs are less resistant than grasslike plants and shrubs. Herbs growing in shade are particularly intolerant of trampling because *adaptations to shading*—possession of large, thin leaves and tall stems—make these plants vulnerable when trampled. This explains the common finding that trampling of forested sites generally results in more rapid loss of vegetation than trampling of open woodlands or meadows (Cole 1993a). Low shrubs, such as heather, are relatively resistant to trampling stress, but once damaged they recover slowly. Their *resilience* is low. Grasslike plants are most tolerant of trampling.

Although their size spares them from most trampling damage, large shrubs and trees are affected by a number of associated recreation activities. Vegetation removal during trail construction and for firewood will be discussed later. Trees may be felled for tent poles, hitch rails, or other structures, and shrubs and trees may be removed to create additional tent space. They are also subjected to *deliberate mutilation*—carved initials and ax scars. In contrast to most species, aspen usually dies from these surface injuries, suggesting that aspen groves make poor recreation sites (Hinds 1976).

Normally, less than one-half of a given volume of soil is solid matter; the rest is pore space that contains air and water. *Trampling compacts the soil—presses together the solid soil particles, filling or compressing many of the pores.* Larger pores—those that permit rapid percolation of water after precipitation and are normally occupied by air—are severely reduced by trampling (Monti and Mackintosh 1979). This can indirectly affect vegetation and soil microbiota. It can cause oxygen shortages and reduce water availability. Along with the greater difficulty plant roots have in moving through compacted soils, these changes generally reduce plant vigor and retard reproduction and establishment of seedlings.

Increases in *bulk density*—the weight of soil packed into a given volume—as high as 170 percent have been recorded on backcountry campsites in Sequoia National Park, California (Stohlgren and Parsons 1986). However, increases are more commonly 30 percent or less. A loss of 60 percent of the larger soil pores was recorded on developed campsites in Ontario (Monti and Mackintosh 1979). Compaction is generally most pronounced in the upper six inches of soil. Generally, susceptibility to compaction is least where soils are sandy or have a narrow range of particle sizes, and where trampling occurs when soils are dry (Lull 1959).

In addition to effects on aboveground vegetation, compaction will also affect soil biota. Larger organisms, such as earthworms, that help rejuvenate the soil find it more difficult to penetrate dense soils. Microbiota are likely to be adversely affected by lower oxygen concentrations. Of particular concern are adverse effects on mycorrhizal fungi, which improve nutrient uptake and water absorption in plants and may be a limiting factor in revegetating disturbed areas (Reeves and others 1979).

Perhaps of greater importance, compaction drastically reduces the rate at which water filters into the soil. Several studies have reported infiltration rates cut by more than 95 percent on developed campsites (Brown and others 1977). Water that does not filter into the soil runs off across the surface. Greater runoff increases erosion potential and decreases the supply of soil water. Although this reduced water supply is unlikely to be a problem in areas with plentiful rainfall, it is likely to increase water stress in arid environments or during dry periods of the year (Settergren and Cole 1970).

Erosion is likely to be a more common and important problem. Deeply eroded trails are unsightly and difficult to

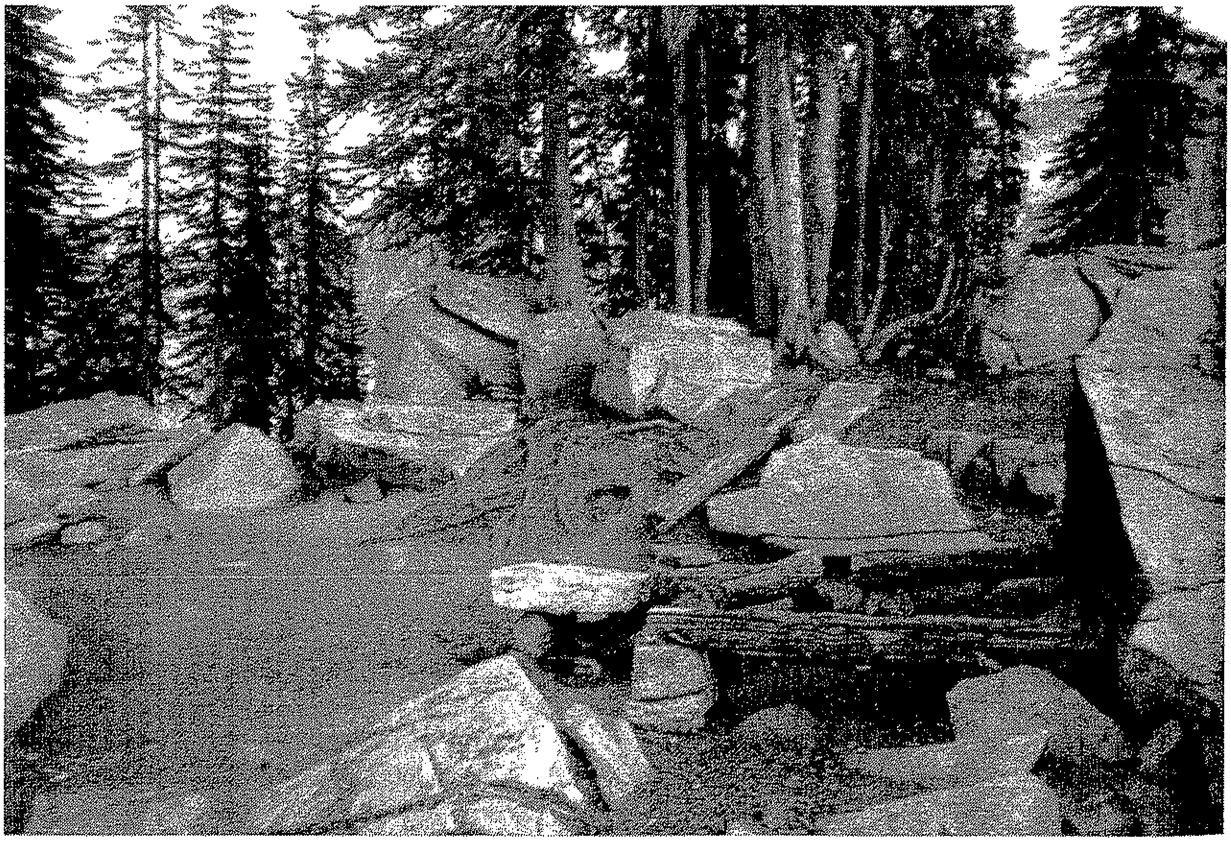


Fig. 15.3. A heavily impacted campsite in the subalpine forest of the Eagle Cap Wilderness, OR, illustrates many of the effects of trampling. Note the loss of vegetation and exposure of mineral soil and tree roots. Photo courtesy of David Cole, USFS.

use. Erosion on campsites and other sites of concentrated use, by removing the most productive soils on the site, diminishes the potential for vegetational growth on the site. Moreover, the formation of soil is such a slow process that erosion can be considered an irreversible process.

Abrasion and loss of organic matter exacerbates many of these same problems. Normally, thick organic horizons protect the mineral soil from much of the direct impact of trampling and decrease surface water runoff. Loss of these layers facilitates increased compaction and runoff. This leads to further loss of organic litter carried off by running water, completing what Manning (1979) has called the "*vicious* circle" of soil impact. On canoe-accessible campsites along the Delaware River, in Pennsylvania and New Jersey, organic soil horizons were only one-third as thick as on undisturbed sites (Marion and Cole 1996).

Loss of litter directly affects plant and animal populations, both above and below the soil surface. For example, vegetation composition is likely to shift as plants that germinate best on organic media give way to those that are more successful on bare mineral soil. Seeds of most species are unlikely to germinate on a smooth, compacted soil surface devoid of litter without a variety of microenvironments.

Soil biota are a little-studied but important component of ecosystems. Microbial communities develop in response to plant exudates and organic matter. In turn, they contribute to ecosystem functioning by metabolizing nutrients, transforming soil organic matter, producing phytohormones, and contributing to soil food webs. Soil biota are affected by many of the types of impact just described. As soils are compacted, biota requiring larger pores to live in will be eliminated. Populations will decline and shift in composition as primary energy sources—aboveground plants and soil organic matter—are eliminated. Zabinski and Gannon (1997) report substantial reductions in the functional diversity of microbial populations on a backcountry campsite in Montana.

Campfires

Collecting and burning wood in campfires results in its own unique type of impacts (fig. 15.4). As with trampling, these impacts are both *aesthetic (fire rings, blackened rocks, and charcoal) and ecological (felled trees, dead wood removal, and sterilized soils).* Ecological impacts result from both the removal of wood, either live or dead, standing or on the ground, from large areas around the campsite, and the burning of this wood in campfires (Cole and Dalle-Molle 1982).

The removal of firewood and associated trampling greatly enlarge the area affected by camping activities. In Great Smoky Mountains National Park in Tennessee and North Carolina, the area disturbed by firewood collection was typically more than nine times the size of the devegetated area around campsites. In this much larger area, the number of live and dead trees, usually the smaller size classes, was reduced, as were woody fuels. Pieces of wood one to three inches in diameter were barely one-third as abundant as on neighboring undisturbed sites (Bratton and others 1982). Around backcountry campsites in Yellowstone National Park, Taylor (1997) reports that the density of tree saplings is typically reduced until a distance of forty-five meters from the center of the campsite is reached. Because leaves, needles, and twigs—the tree components most critical to nutrient cycling—are little affected by firewood collection, removing downed wood need not adversely affect long-term site productivity. The major source of damage is likely to be the elimination of large (more than three-inch diameter) woody debris. Decaying wood of this size plays an important role in the ecosystem that has only recently been appreciated (Maser and others 1988). It has an unusually high water-holding capacity, accumulates nitrogen, phosphorus, and sometimes calcium and magnesium, and is an important site for nitrogen-fixing microorganisms. It is the preferred substrate for seedling establishment and subsequent growth of certain species. Of particular importance, *ectomycorrhizal fungi*—organisms that develop a symbiotic association with the roots of most higher plants, improving the plant's ability to extract water, nitrogen, and phosphate from less fertile soils—are also concentrated in decayed wood. Consequently, although collection of smaller pieces of wood is unlikely to cause adverse impacts, elimination of large woody debris is likely to reduce site productivity, particularly on droughty and infertile soils.

Loss of large woody debris is likely to adversely affect the populations of invertebrates, small mammals, and birds that use the wood as a food source or living place (Bull and others 1997). It eliminates sites protected from trampling where

Fig. 15.4. The impacts of campfires have both aesthetic and ecological consequences. Photo courtesy of Robert Lucas, USFS.

seedlings can regenerate and removes natural dams that decrease the potential for soil erosion. *Clearly, loss of large woody debris due to firewood collection is a serious impact where a sizable area is affected; recovery rates, moreover, are likely to be lengthy. Collection of wood that can be broken by hand is likely to have little effect.*

A wood campfire severely affects the area burned. Fenn and others (1976) found that a single intense campfire burned 90 percent of the organic matter in the upper inch of soil. *Fires cause pronounced changes in soil chemistry.* Reported fire effects include the loss of nitrogen, sulfur, and phosphorus, increases in pH and many cations, and reductions in the moisture-holding capacity, infiltration rates, and microbiotic populations of soil. Overall, these changes constitute a sterilization of the soil, likely to render the site less hospitable for the growth of vegetation and likely to require at least ten to fifteen years to recover, particularly if the site has been used for some time (Cole and Dalle-Molle 1982). Such impacts are particularly pronounced where fires have been built in several places on a single campsite.

Other problems result from carelessness with campfires. Escaped campfires have burned thousands of acres. More common is the destruction of small vegetational coppices by creeping root fires. This has been a serious problem in subalpine tree clumps in the mountains of the Southwest. Here, such clumps are considered beautiful, are valued highly as campsites, and regenerate very slowly, if at all.

Although more research will be necessary before we understand the importance of firewood collection and burning, the preceding review suggests some effective means of minimizing impact. *With firewood collection, the key is not disturbing woody debris larger than about three inches in diameter.* The firewood-collection problem can be minimized by teaching visitors to collect only wood they can break by hand. In fact, if campers would leave their axes and saws at home many impacts—loss of large woody debris, scarring, and felling of trees—would be eliminated. It may also be necessary to prohibit or discourage campfires, or to promote the use of small stoves in areas where wood production is low. If use in such areas is high, firewood will quickly disappear, tempting visitors to use the larger pieces. In fact, campfires should probably be discouraged or prohibited wherever use is very high—regardless of site productivity—to avoid adverse impacts. As of 1991, about one-half of National Park Service backcountry areas prohibited campfires, at least in some places (Marion and others 1993). This prohibition was most common in areas with little firewood—arid, arctic, and alpine regions. Many areas prohibit fires in zones of low productivity, such as the whitebark pine forest, at high elevations in the Sierra Nevada. Such a prohibition at high elevations would also reduce the destruction of tree coppices by escaped campfires.

Minimizing campfire impacts is more complex, involving *a choice between either confining impacts to a small total area of concentrated use or dispersing and covering up evidence of use.* Generally, in heavily used areas, campers should be encouraged to use established fire rings so that only a small amount of ground is severely altered. This requires leaving a fire ring at well-used sites, encouraging campers to use these sites, and keeping them clean and attractive. In areas that are infrequently used, it might be better to persuade visitors to use undamaged sites, to build small, less damaging fires, and to camouflage the site when they leave to discourage repeated use of the site and, through the addition of organic matter, initiate recovery of the site. In this case, campers must be willing to select undisturbed sites and be able to leave the site looking undisturbed. *The worst situation is allowing fire rings to move around a site, continually being rebuilt after being removed by rangers or earlier campers, and allowing many fire sites to proliferate at popular destinations.* Unfortunately, this situation is all too common. Further discussion of the pros and cons of dispersal and concentration can be found in the section on campsite management in this chapter and in Cole and Dalle-Molle (1982).

Trail Construction and Maintenance

The construction and maintenance of trails have pronounced effects on vegetation and soil. Although these impacts are usually deliberate and considered necessary to provide recreation opportunities and to manage visitor traffic, their impacts, as with all others, should be kept to a minimum.

The major impacts of trail construction and maintenance stem from the opening up of tree and brush canopies, the building of a barren, compacted trail tread that may alter drainage patterns, and the creation of a variety of new habitats in the process. Forest Service standards for maximum clearing widths and heights range from 4 by 8 feet on hiker trails to 8 by 10 feet on trails for stock. This clearance increases light intensity considerably and reduces competition for species that can survive along the trail. These changes can alter the composition of vegetation substantially (Hall and Kuss 1989). Composition along trails also shifts in response to increased trampling and grazing, increased nitrogen from manure and urine, and increased moisture, the result of having fewer trees to intercept precipitation, fewer plants to transpire, and more watershed along the sides of the compacted trail tread. Trail corridors can contribute to the rate of spread of exotic plant species, as has been reported for Glacier National Park, Montana (Tyser and Worley 1992) and Rocky Mountain National Park, Colorado (Benninger-Truax and others 1992).

The creation of a bare compacted trail tread and a narrow zone of disturbed vegetation on either side is a dramatic change but is usually accepted by visitors. The dramatic changes are confined to a zone usually no more than 8 feet wide, although in meadows compositional changes have been noted more than 20 feet from the center of the trail (Cole 1979; Foin and others 1977). Probably more disturbing are sites, usually in wet soil areas, where the disturbed, barren tread widens, greatly exceeding the recommended tread width of 24 inches. This change is caused by use—not construction—although poor location and design during construction may have initiated or contributed to the problem.

Trail construction can also create new habitat by other means. Examples include creation or elimination of rock faces where trails traverse rock outcrops; creation of debris slopes where boulders are pushed down slope to build the trail; creation of flat, soil-covered surfaces where trails traverse steep talus slopes; and creation of wet soil areas where trails impede normal drainages. Again, these changes do not affect large areas and are generally considered to be acceptable; however, they should be recognized as undesirable and kept to a minimum.

Perhaps the two most serious trail impacts are disruptions of drainage systems and aesthetic problems resulting from obtrusive design or construction of trails. Unfortunately, the solution to one of these problems is likely to aggravate the other. That is, designs to solve drainage problems may be perceived as over engineering, whereas lack of engineering may lead to drainage problems. This trade-off is discussed in more detail in the trail-management section of this chapter. The solution demands a careful balance—enough engineering to avoid disturbing drainage while remaining sensitive to building trails that blend into the natural environment. In each situation, those who construct trails will have to evaluate which is more "natural" and appropriate—a high-standard trail that avoids off-trail disturbance or a low-standard trail that risks the possibility of more resource damage and a less comfortable walking surface.

Grazing of Pack Stock for Recreation Visits

Pack and riding stock trample vegetation and soil along trails and on campsites, as hikers do, leading to the changes noted in

Fig. 15.5. Where trail construction and use is likely to disrupt drainages and degenerate into quagmires, bridging is often required. Although critical to avoiding resource damage, such structures should be kept to the minimum possible. Photo courtesy of David Cole, USFS.

the section on trampling impact. Differences between stock and hiker impact are summarized in the section of this chapter on pack-stock management. Here we outline changes occurring on areas grazed by recreational pack stock—meadows and grasslands that are generally unaffected by hikers.

Grazing areas are affected primarily by trampling and grazing (defoliation), although defecation may also cause minor changes. Grazing, by removing leaves, disrupts the ability of plants to manufacture food. Excessive and repetitive defoliation depletes food reserves, reducing plant vigor and reproductive capacity. Numerous studies have illustrated that grazing can reduce current growth; stem, leaf, and seed stalk heights; reproductive activity; basal and foliar cover; and root growth (see McClaran and Cole 1993). Loss of vigor, in turn, makes vegetation more susceptible to trampling damage, particularly penetration of the vegetative mat by stock hooves, and results in a reduction in vegetative cover.

Trampling causes changes in vegetation and soil conditions, as described earlier. Of particular concern in grazing areas is disturbance of wet meadows. Wet soils, thick organic deposits, and vegetation mats are all susceptible to deformation and disintegration when trampled. Heavy trampling of such sites can lead to a surface of broken sod and hummocks, increased erosion, and even lowering of water tables. In Kings Canyon National Park, California, disturbance by recreational stock, superimposed on the earlier effects of sheep and cattle grazing, led to accelerated rill, channel, and gully erosion of meadows. Gullies up to fourteen feet deep lowered water tables and dried out meadows, promoting invasion of lodgepole pine, before being stabilized through improved meadow management and grazing programs (DeBenedetti and Parsons 1979).

Plants differ in their susceptibility to grazing, much as they differ in susceptibility to trampling. Those capable of growing from buds close to or under the ground are more likely to survive close grazing than those with buds located where they can be removed by grazing. Of even more importance, plants are preferentially grazed so that the least palatable species are most likely to survive grazing. Olson-Rutz and others (1996a,b) report short-term effects of a pack-stock grazing experiment, including preferential grazing of grasses, decreasing vegetal cover, and reduced subsequent-year production of grass and forb stems. All of these selective forces, along with the introduction of exotic species in manure, coats, hooves, and supplemental feed, contribute to pronounced changes in species composition and reductions in forage. In the Eagle Cap Wilderness, montane valley-bottom meadows

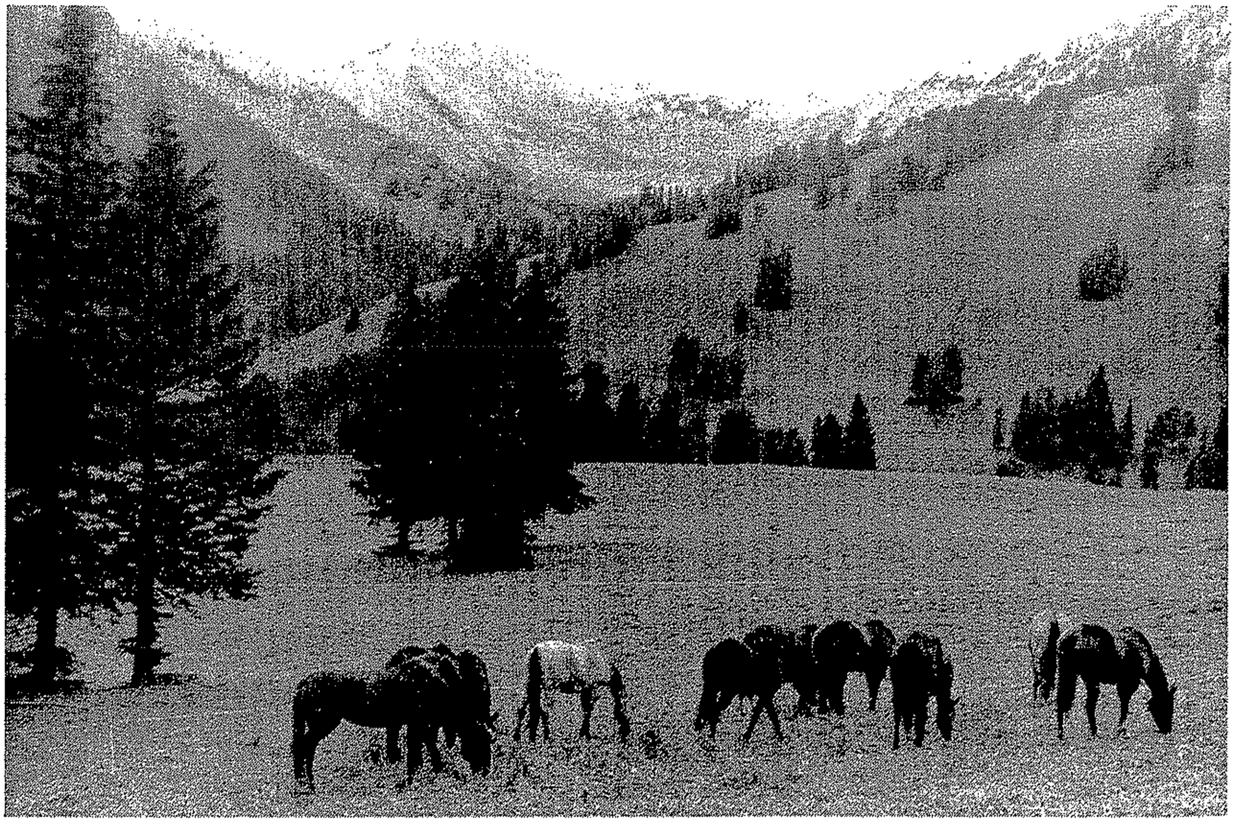


Fig. 15.6. Grazing by pack and saddle stock has altered vegetation and soil conditions over large proportions of many wilderness areas. Photo courtesy of the USFS.

grazed by stock had only about two-thirds the vegetational cover of nearby ungrazed meadows. The grazed meadows were dominated by forbs and had a sizable component of annual and exotic species, whereas the ungrazed meadows were dominated by native grasses and sedges (Cole 1981).

Because it reduces available forage, stock grazing may adversely affect wildlife populations that use the same forage resource. For such competition to occur, there must be overlap in the diets of the stock and wildlife species, and they must be using the same meadows. Of the important ungulates in wilderness areas, competition with elk is most likely. Elk and horses have similar diets (Hansen and Clark 1977), and elk commonly use popular grazing areas as winter range. Unpublished range studies in the Bob Marshall Wilderness found that recreation-stock grazing has caused deterioration of forage areas that are used by elk in winter. Competition with bighorn sheep and mountain goats is also possible, but winter range of these species is probably less accessible to livestock.

Wildlife Disturbance

Recreation activities can impact wildlife in four different ways (Knight and Cole 1995a). Animals can be indirectly affected through *habitat modification* or through *pollution* (particularly through leaving trash). They can be directly affected through *exploitation—hunting, fishing, trapping, or collecting.* Finally, wildlife can be *directly disturbed*—either intentionally or unintentionally. We know most about the short-term responses of individuals to disturbance—nest abandonment, elevated heart rates, or flight. We know little about how entire populations or communities of animals are affected or about long-lasting effects (see also chap. 12).

Firewood collection can affect small mammal and bird populations by altering food sources and living places and eliminating protected sites (Cole and Landres 1995). Similar modifications of habitat are also likely to affect reptile and amphibian populations. Organic trash around campsites also attracts animals, ranging from invertebrates to small rodents, certain birds, and large mammals, such as bears. Blakesley and Reese (1988), for example, found seven bird species to be positively associated with campgrounds and seven species to be negatively associated.

Although habitat modification and improper disposal of trash are the major source of impact for smaller wildlife species, most of these changes are highly localized and, with the exception of the attraction of "pest" species to campsites, not evident to most users. Change becomes more important only where a species' entire habitat is disturbed or where the "pest" is a bear. Improper food storage and disposal has frequently been implicated as a causal factor in a chain of events that ultimately ends in the death of bears. Consequently, appropriate food-storage procedures and/or devices have been implemented in many backcountry areas.

Perhaps of more widespread importance to the achievement of wilderness management goals are the impacts resulting from stocking fish, angling, hunting, and unintentionally harassing wildlife. As noted earlier, hunting outside of national parks and angling are legal, accepted practices that are likely to continue in wilderness, despite their considerable alteration of natural conditions (Anderson 1995). Fish stocking, which has been shown to adversely affect amphibian populations (Knapp and Matthews 2000), occurred in more than 40 percent of all wildernesses according to a survey conducted in 1980 (Washburne and Cole 1983), but this practice has been discontinued in some wildernesses.

Although poorly understood, unintentional harassment, particularly of birds and large mammals, has undoubtedly altered the distribution, structure, and behavior of animal populations (Knight and Cole 1995a). Where harassment affects an entire population (as is likely to be the case with grizzly bear or hunted, localized populations of bighorn sheep and mountain goat) or affects most of a species' habitat, this disturbance is probably much more disruptive to wilderness ecosystems than many of the impacts we have been discussing, such as effects of trampling on trails and campsites.

Harassment of wildlife by recreationists or other wilderness users produces excitement or stress in animals. This may lead to panic, exertion, disruption of essential functions such as breeding or nesting, displacement to other areas, and sometimes death. Animals that are healthy and have ample food and places to escape to are more capable of withstanding harassment than animals that are underfed, highly parasitized, experiencing severe weather, giving birth or nesting, or lacking secure areas for escape. Damage to animals—in terms of increased energy expenditures or radical changes in behavior or distribution—also increases as disturbance becomes more frequent and more unpredictable (Knight and Cole 1995b).

Generalizing about harassment is made more difficult by the considerable variability between and within species. Effects on wolves, which are relatively intolerant of disturbance, are much more serious than effects on coyotes. Similarly, effects on eagles, which may not return to feeding sites for several hours after disturbance (Stalmaster and Newman 1978), are more serious than effects on jays. Within species, prior experience with humans strongly tempers responses. Some individuals can learn to tolerate at least predictable disturbances (Knight and Temple 1995). Differences between hunted and nonhunted populations can also be profound, because hunted animals have experienced a need to escape. Individuals giving birth or with young are more readily disturbed than others.

Disturbance of several subspecies of bighorn sheep has been widely studied, primarily in California and Canada (MacArthur and others 1982). Although a number of studies have implicated harassment as a cause of declining sheep populations, most recent work suggests that sheep can habituate to human intrusion. One Canadian study monitored heart rates and behavioral responses to disturbance. Although largely unaffected by foot traffic approaching from a road below, sheep responded dramatically to the presence of dogs and foot traffic approaching from upslope (an unexpected action that blocks their preferred escape route). The authors conclude that disturbance by visitors can be minimized by confining use to established trail systems and discouraging people from taking dogs (MacArthur and others 1982).

Several trends may greatly increase wildlife disturbance. First is the popularity of attempting to disperse visitors from popular parts of the wilderness to less visited places. Such dispersal occurs when use levels are limited in popular places, forcing visitors to seek out less popular places. It can also result from educational messages asking visitors to avoid popular places or to seek out places where opportunities for solitude are greater. Where increased dispersal occurs, the frequency of wildlife harassment may increase and the size of secure areas where harassed animals can escape may decrease. Any attempt to alter visitor-use distributions should consider the consequences to wildlife.

The second trend is toward increased off-season use. Cross-country skiing, in particular, can stress populations at a time of year when they are least able to tolerate it. Cassirer and others (1992) documented disturbance of elk by cross-country skiers in Yellowstone National Park. Ferguson and Keith (1982) have documented a tendency for elk and moose to move away from trails being used by skiers. Importantly, they found that a single skier usually caused the animals to flee; the passage of additional skiers was irrelevant. Possibly, a few large parties will likely cause less disturbance than many widely dispersed small parties. Although little is known about the consequences of such disturbance to reproduction or survival, we do know that flight increases the necessary caloric intake of these animals. Some ungulates adapt to winter conditions by decreasing activity to conserve energy (Moen 1976). Disturbance interferes with this adaptation and may increase food demand beyond the supply provided by winter range. Clearly, the severity of such an effect would vary from year to year and from place to place; only through increased monitoring of wildlife populations in relation to disturbance will we be able to measure impacts. Nevertheless, many managers are currently educating winter users about the threats posed by harassment and the need to avoid animals.

Fig. 15.7. Use of wilderness during winter is increasing in popularity. Such use can stress wildlife populations at a time when they have little tolerance of increased stress. Photo courtesy of the USFS.

Other important problems occur when use is concentrated on limited critical habitat. Use does not need to coincide with the presence of animals. For example, summer grazing by pack stock reduces available food sources on critical elk winter range. Recreation use around desert waterholes and salt licks can cause more substantial problems than one would expect from the same amount of total use. Managers should identify habitat critical to wildlife at various seasons and develop plans for minimizing disturbance.

Three general approaches to *minimizing problems with wildlife disturbance* can be identified. Of foremost importance in wilderness is *management of people.* Access can be limited, as where overnight use is prohibited or where sensitive places are closed to all visitation—actions that currently are almost entirely confined to FWS and NPS wildernesses. Alternatively, access can be restricted at certain critical times of the year, such as feeding times, nesting times for birds, and postnatal periods for mammals. There is considerable potential to educate users about avoiding wildlife conflict. One of the primary principles of the leave-no-trace educational program is "Respect Wildlife."

The other potential management strategies involve modification of wildlife behavior and habitats. *Behavioral modification*—habituation to predictable, harmless human activity—is useful where hunting is not allowed. For example, aversive training of "problem" bears has been tried. This can be used to influence reactions to human disturbance, although the appropriateness of such an approach must be questioned (Whittaker and Knight 1998). Finally, *habitats can be modified* to change population distributions or to mitigate disturbance, although the appropriateness of such actions in wilderness must be questioned.

Water Pollution and Disposal of Human Waste

Most management concerns with water pollution have centered on the potential for transmission of disease by organisms present in water. Many different organisms are capable of causing illness in humans (Cilimburg and others 2000). *Three prominent sources of water contamination are (1) visitors, their dogs, and pack stock; (2) domestic livestock; and (3) wildlife.* Even where animal contamination is absent, bacteria and other pathogens can be found in the soil, forest floor, and stream sediment (Silsbee and Larson 1982). Therefore, even so-called pristine areas receiving almost no recreation use can harbor organisms that are harmful to humans.

Water quality studies in mountainous wilderness in the West have generally found very low levels of bacterial contamination, even in areas of concentrated use. For example, at Rae Lakes, one of the most popular alpine lake basins in Kings Canyon National Park, coliform bacteria counts were usually low enough to allow drinking (Silverman and Erman 1979). Along the Colorado River, in Grand Canyon National Park, Arizona, water was unfit for drinking but coliform levels were generally low except when major tributary streams were in flood (Brickler and others 1983). Here the primary source of contamination appeared to be domestic livestock or wildlife. Springs and streams in Great Smoky Mountains National Park exceeded maximum permissible levels of coliform bacteria, but contamination did not appear related to recreation use (Silsbee and Larson 1982).

Even where contamination is not evident, transmission of disease does occur. Most common is giardiasis, an intestinal disease caused by the protozoan, *Giardia.* Although it is not clear whether contamination is spreading or whether the disease is being more frequently and accurately diagnosed, it is clear that surface waters in many wildernesses are contaminated with *Giardia* (Cilimburg and others 2000). As with bacterial contamination, most (but not all) experts believe that humans, domestic animals, and wildlife all act as hosts capable of spreading the organism. Beaver have most frequently been implicated as the major source of *Giardia* contamination.

Where level of contamination has been related to amount of recreational use, it is not clear whether areas receiving more recreation use present higher health hazards than lightly used areas do (Cilimburg and others 2000). In fact, one study of used and unused watersheds in Montana found less contamination in the watershed open to recreation use and a decrease in contamination after the closed watershed was opened to use (Stuart and others 1971). The authors concluded that the primary source of contamination was wildlife and wildlife populations and, therefore, contamination was reduced by recreation use. In an unpublished study in the Anaconda Pintler Wilderness, Montana, elevated bacterial counts were most often found just downstream from trail crossings used by horses and pack animals. In the Eagle Cap Wilderness, contamination levels were higher in streams, particularly at mid-elevations in meadows, than in lakes; and coliform counts generally peaked along with runoff after a storm (McDowell 1979).

All this suggests that management of recreation use is likely to do little to reduce health hazards. The most important management action is informing visitors about the prevalence of contamination and the need to treat water. In Great Smoky Mountains National Park, the NPS removed more than 100 spigot pipes at backcountry springs, to erase the impression that such water was safe to drink. Instead, through trail signs, brochures, and direct visitor contact (Silsbee and Larson 1982) visitors are advised to treat water. Treatment is particularly important when using turbid water after a storm; water should be taken above rather than below trail crossings.

Proper control of waste, from both humans and recreational stock, is also important, although this will not eliminate health hazards. Toilets may be appropriate at sites that receive heavy, consistent use throughout the season. However, knowledge is insufficient to provide specific guidance about when toilets are or are not necessary. Where provided, toilets must be sensitively located by managers, because their presence—especially when accompanied by a direction sign saying toilet—is a reminder of civilization and may not be consistent with the spirit of wilderness.

Where soil is available and use levels are not too high, disposal of human waste in individual "cat-holes" is recommended. Even this practice poses problems, however. Research in Montana's Bridger Range has shown that significant numbers of intestinal pathogens in feces survived an entire year of burial (Temple and others 1982). Statements that nature will take care of wastes "in a few days" are misleading and may promote careless disposal. This research shows that the possibility of disease transmission persists for a considerable time. Moreover, depth of burial (two to eight inches) made no difference in survival of pathogens; neither did it matter whether disposal occurred at high or low elevations, in forest or in meadow. This emphasizes the need to promote burial at sufficient depth and far enough away from campsites and water bodies to minimize the chance of direct contact by other users. Although education campaigns in proper human waste disposal are common, greater emphasis on the potential hazard and the need for careful disposal seems necessary. Pack and riding animals should be kept away from surface water as much as possible, and they should never be confined where manure is likely to contaminate water sources.

Other types of water pollution appear to be more prevalent and more subject to management control. In the Kings Canyon National Park study, where the health hazard was minimal (Silverman and Erman 1979), recreation use was associated with a number of changes in the basic ecology of lakes. The most heavily used lakes had less nitrate and more iron, and more aquatic plants than other lakes (Taylor and Erman 1979). The authors suggest that recreation use—through erosion of trails and campsites, improper waste disposal, destruction of vegetation, and campfires—may cause an increase in trace elements, such as iron, the absence of which formerly limited plant growth. Stimulated plant growth results in increased nitrogen uptake and, therefore, decreased nitrate levels. Insects, aquatic worms, and small clams were more abundant on the bottom of more heavily used lakes (Taylor and Erman 1980). At a lake in a semiwilderness area in Canada, Dickman and Dorais (1977) found unusually high phosphorus levels and increases in phytoplankton that they attributed to increased erosion of phosphorus-rich substrate, triggered by human trampling.

Although we do not know how common lake eutrophication has become, its effects are felt throughout the food chain. Moreover, such changes are long lasting. In the Kings Canyon National Park study mentioned earlier, changes were still prevalent at Bullfrog Lake, a formerly heavily used lake, sixteen years after it had been closed to camping and grazing. Such changes are very important because they are likely to affect the entire lake ecosystem. This can be a serious problem in wilderness areas with a small number of heavily used lakes. In this situation, recreation use can dramatically alter the structure and functioning of many representatives of that type of ecosystem. This would clearly constitute a serious failure to achieve the wilderness management goal of preserving natural conditions. This suggests that aquatic ecosystems may be the wilderness ecosystems most prone to important disruption by recreation use.

Managing Campsite Impacts

In virtually all wilderness areas, the most common and profound impacts of recreation are those associated with campsites and trails. In many areas, the management of pack stock is also an important issue.

Campsite Impacts

Most visitors spend more time at their campsite than anywhere else in wilderness. Unfortunately, this focuses impacts on the very places where visitors spend most of their time (Cole 1991a). Although natural conditions are desirable, some amount of impact can actually make a campsite more habitable. Some

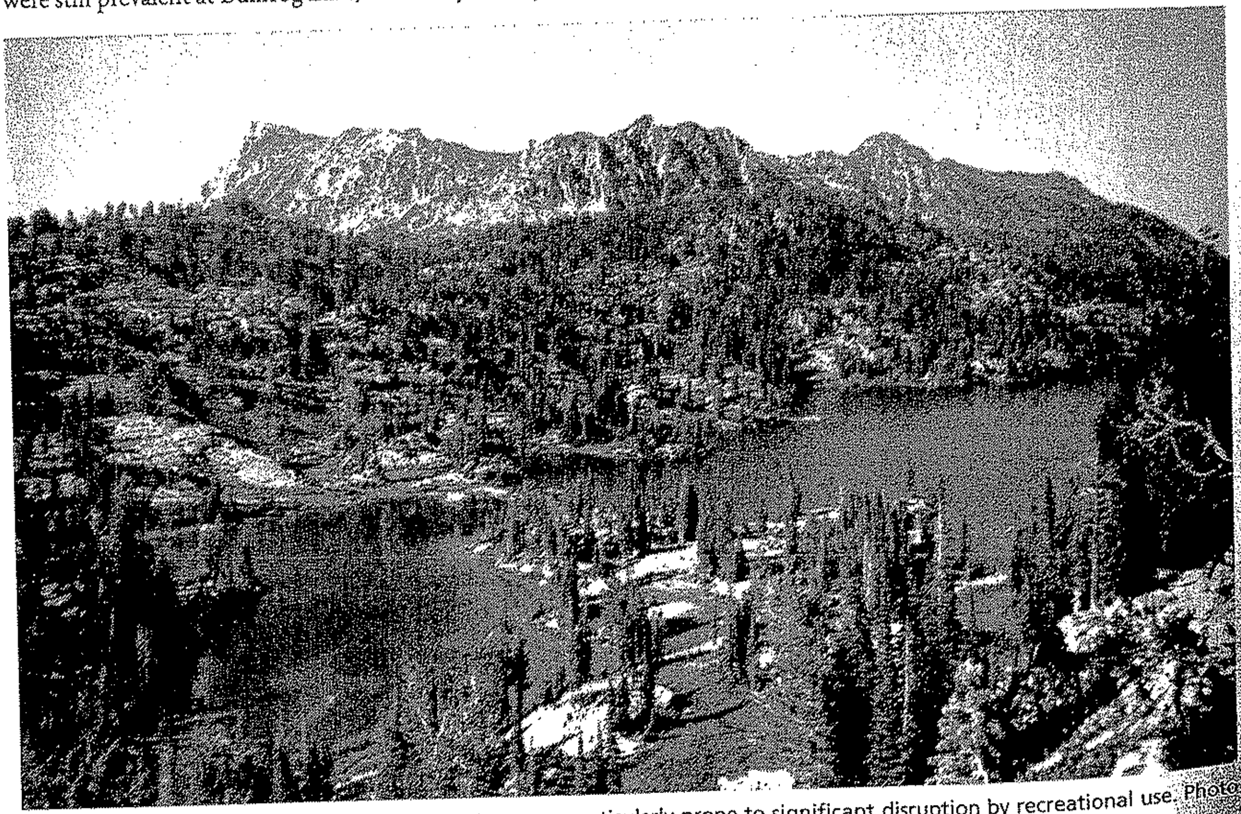


Fig. 15.8. In many wildernesses, aquatic ecosystems are particularly prone to significant disruption by recreational use. Photo courtesy of David Cole, USFS.

Fig. 15.10. Many visitors are exposed to Leave-No-Trace messages primarily at trailhead bulletin boards. It can be difficult to capture much attention in such locations. Photo courtesy of David Cole, USFS.

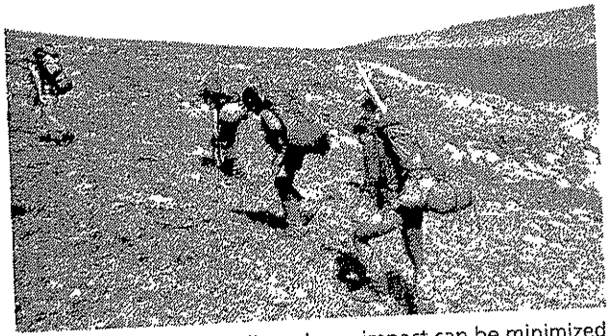


Fig. 15.9. In remote, trailless places, impact can be minimized if hikers spread out and disperse their impact. Photo courtesy of David Cole, USFS.

clearing of brush and trees, for example, provides better tent sites, causing many visitors to select sites with some vegetation loss. Problems arise when damage to campsites becomes extreme or where sites proliferate over entire destination areas, providing constant reminders of the large numbers of people using the area.

Vegetation Change

Many studies have examined changes in vegetation on wilderness campsites. In most cases, trees are mechanically damaged and the reproduction is suppressed, and there is profound damage to ground plant cover. Generally, there is little evidence that vigor of large trees is reduced, and aside from outright felling of trees and girdling because of tethering stock, tree mortality is uncommon. An exception to this generalization was documented in the BWCAW, Minnesota, where severe erosion of shallow soil around tree roots has caused high mortality (Marion and Merriam 1985). Ground-level vegetation is more profoundly affected. Plant cover is reduced, usually to bare ground in the central part of the campsite, and plant-species composition changes. Species diversity is usually reduced, and exotic plants often become an important component of the flora (Marion and others 1986).

To illustrate the magnitude of campsite changes, I ask you to consider the median change on twenty-two campsites located in subalpine forests in the Eagle Cap Wilderness (Cole 1982a). On the median campsite, more than 2,000 square feet had been obviously disturbed by camping. Almost 90 percent of the ground cover had been lost on the site—as inferred by comparing campsite conditions to those of an undisturbed control site close by. One-half of the site, the central area around the fire ring, was entirely devoid of vegetation. The surviving vegetation was very different in plant-species composition from undisturbed vegetation. Two species, a huckleberry and a heather, contributed almost 40 percent of the cover on undisturbed sites but only 6 percent of the surviving cover on campsites. In contrast, a sedge and a rush that contributed only 8 percent of the cover on undisturbed sites contributed almost 30 percent of the cover on the campsites. Overall, low shrubs and mosses were greatly reduced in cover. Grasses and grasslike plants, although losing some coverage, were less drastically affected, so they became the most abundant type of plant on the campsites.

Essentially all of the trees growing on these sites, 96 percent, had been damaged. Although much of the damage was minor, consisting of broken lower branches and nails driven into the trunk, one-fourth of the trees bore trunk scars from chopping and another one-fourth had been felled. About one-third of the trees had exposed roots, usually a result of tying stock to tree trunks. About 90 percent of the tree seedlings had been eliminated by trampling, which does not bode well for perpetuating forested campsites. Along with the felling of most of the saplings on the site, death of seedlings suggests that overstory trees will not be replaced when they die.

Typical levels of campsite impact vary greatly between different wilderness areas, as well as between campsites within the same area. For example, in the Bob Marshall Wilderness, Montana, campsites are typically much larger (mean of about 3,000 ft^2) than in the Eagle Cap, whereas in Grand Canyon National Park, they are much smaller (mean of about 500 ft^2) (Cole and Hall 1992). Mean campsite size varied between 500 ft^2 and 800 ft^2 in four wilderness areas in the south-central United States and was about 1,000 ft^2 at Great Smoky Mountains National Park (Marion and Leung 1997).

Changes in Soil Condition

The changes in soil condition most frequently noted are loss of the organic litter horizon, exposure of bare mineral soil, and compaction of the soil. Various measures of compaction are used, the two most common being bulk density and resistance to penetration. A few studies have also documented decreases in water infiltration rates and changes in organic matter content and soil chemistry.

On the Eagle Cap campsites, the depth of the organic horizons was cut in half (Cole 1982a). In some places, all organic litter was lost. Exposure of bare mineral soil was 1 percent on control plots compared to 31 percent on campsites. Although some of the surface organic matter pulverized by trampling is probably removed by erosion, some evidently moves downward and accumulates in the uppermost mineral horizons because soil organic matter content increased 20 percent on campsites. Similar studies have found both increases and decreases in organic matter on campsites. Loss of vegetation cover and changes in the organic content of soils will have a profound influence on the biota that live in soil. Zabinski and Gannon (1997) report evidence for a dramatic reduction in the functional diversity of the soil microbial population on campsites. Such a change is likely to represent a barrier to any attempts to revegetate disturbed campsites.

Bulk density increased 15 percent and infiltration rates were reduced by about one-third on the Eagle Cap sites. These relatively small changes may result from the sandy, granitic substrate of these campsites, which makes them relatively resistant to compaction. In similar studies, infiltration rates were reduced by two-thirds in the Bob Marshall Wilderness (Cole 1983a) and three-fourths in Grand Canyon National Park (Cole 1986). Finally, several changes in soil chemistry were found. Values of pH increased, soils became less acidic, and there were sizable increases in the concentrations of magnesium, calcium, and sodium. These chemical changes probably reflect input from campfire ashes, excess food, soap, and other substances scattered about the site.

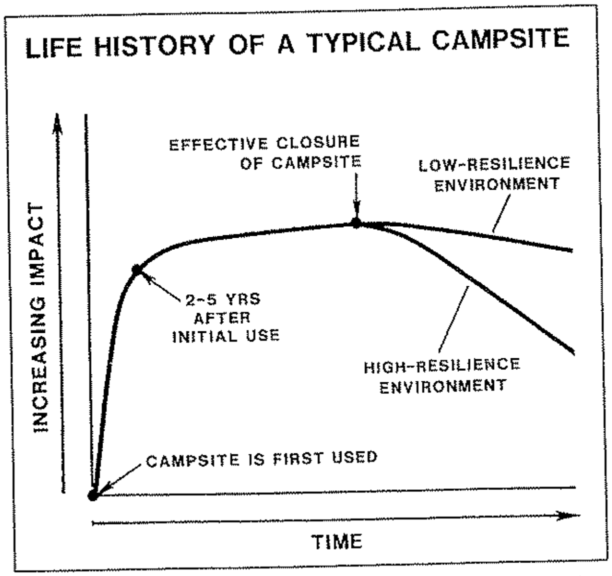


Fig. 15.11. The life history of a typical campsite, illustrating periods of rapid deterioration, relative stability, and slow recovery.

To summarize, almost every parameter examined on the Eagle Cap campsites had been substantially altered by camping. We conclude that "natural conditions" are not being preserved on these wilderness campsites because these are typical sites—not worst cases or atypical examples.

Despite their severity, campsite impacts are highly concentrated. For the Eagle Cap Wilderness as a whole, less than 0.2 percent of the area has been affected by camping (Cole 1981). Marion and Leung (1997) estimate that less than 0.01 percent of Great Smoky Mountains National Park has been affected by camping. In most places, only occasional campsites are encountered. However, large numbers of campsites are concentrated in a few popular destination areas. For example, camping has impacted at least 144 sites at one popular lake in the Eagle Cap (Cole 1993b). Over one-half of these sites lost more than 25 percent of their vegetation, and most were in sight of the trail. Although this represents little threat to the ecological integrity of the Eagle Cap Wilderness, it does provide conspicuous evidence of human use. Not only is there scant opportunity to camp on an undisturbed site, but pronounced campsite impacts are found on almost every potential campsite area.

Temporal Patterns of Impact

Studies of individual campsites show that they have a typical "life history" moving successively through a "development phase," "dynamic equilibrium phase," and then "recovery phase."

Impact usually occurs rapidly in the development phase, when a previously unused site is first used as a campsite. On newly established canoe campsites at Delaware Water Gap, for example, most of the impact that occurred over the six years following campsite opening occurred during the first year of use (Marion and Cole 1996). Impact did continue to increase each year for the first three years, but at a decelerating rate. Actual rates of deterioration during the "development" phase vary between kinds of impact and with amount of use and environmental durability. Loss of vegetation occurs rapidly, while exposure and compaction of mineral soil occurs more slowly. Deterioration occurs more rapidly as amount of use increases and as site durability decreases.

The "development" phase is followed by a more stable phase of "dynamic equilibrium," where site impacts remain stable with a steady level of use. Where amount and type of use is relatively constant, seasonal and year-to-year fluctuations, dictated largely by climatic variation, may exceed change for many kinds of impact. For example, on long-established campsites in the Eagle Cap Wilderness, mean vegetation cover was 15 percent in 1979, 12 percent in 1984 and 19 percent in 1990 (Cole and Hall 1992). Vegetation cover on these sites might be expected to fluctuate between 10 and 20 percent indefinitely, as long as use characteristics are relatively stable. Devegetated area and soil compaction are impacts that tend to be stable on established campsites. Other impacts tend to deteriorate more steadily because recovery processes are so slow. For example, mineral soil exposure on Eagle Cap campsites increased from 33 percent in 1979 to 41 percent in 1984 and 44 percent in 1990 (Cole and Hall 1992). In these western coniferous forests, the accumulation of new litter cannot keep pace with the rate of litter loss from campsite use. In eastern forests, however, the amount of mineral soil might be more stable because litter production is greater. Tree damage, in particular, tends to be cumulative, worsening over time because recovery is slow or does not occur.

Once a campsite is effectively closed, a "recovery" phase begins, with the rate of recovery highly variable and always slower than was site deterioration. Recovery rates vary between kinds of impact and environments, as well as with amount of previous impact. After fifteen years without use, litter accumulation and soil penetration resistance on subalpine campsites in Kings Canyon National Park had returned to predisturbance levels, but tree mutilations and vegetation loss were still evident (Parsons 1979). Hartley (1999) reports residual effects thirty years after vegetation trampling experiments were conducted at Logan Pass in Glacier National Park, Montana. In contrast, most visual evidence of camping on closed riparian campsites at Delaware Water Gap disappeared within six years (Marion and Cole 1996).

Given the same environmental setting, more highly impacted sites will require longer periods to recover. When different environments are compared, however, it is difficult to predict how long recovery will take merely based on how the site is impacted. Some of the environments that are most readily disturbed by camping (such as lush herbaceous vegetation in riparian zones) are capable of relatively rapid recovery once camping stops. There is some evidence that differences in recovery rates, between different environments, may exceed differences in deterioration rates.

Temporal patterns at larger spatial scales are especially important. There is a tendency for impacts to proliferate and spread across the landscape where the distribution of recreation use is not tightly controlled. For example, in two drainages in the Eagle Cap Wilderness, the number of campsites increased from 336 in 1975 to 748 in 1990 (Cole 1993b). *Site proliferation occurs because sites deteriorate rapidly and recover slowly. As use shifts across the landscape, new campsites appear more rapidly then old campsites disappear.*

Factors that Influence Amount of Impact

To better understand how to minimize camping impacts, it is important to understand why some sites are more seriously damaged than others. Total impact is a product of both the intensity of impact at any one place and the areal extent of impacted places. *The major factors that influence how much change occurs on an individual site are (1) the amount and frequency of use the site receives, (2) the type and behavior of its users, and (3) the environmental conditions and durability of the site.* Season of use would be a fourth important factor, except that in most places, campsites are seldom used outside of the main-use season. *The areal extent of impact is primarily a result of the spatial distribution of recreation use.*

Amount of Use

The usual assumption has been that the amount of use a site receives is most important in determining its impact, but numerous studies suggest that this assumption is misleading. In the Eagle Cap (Cole 1982a), for example, even campsites used no more than a few nights per year (light-use sites) have been severely altered (table 15.1). Most overstory trees have been damaged, most seedlings have been eliminated, most of the vegetation has been lost, soil has been compacted, and soil chemistry has been changed. Sites used an estimated five to ten times more frequently, about one night per week during the main-use season (moderate-use sites), differed in the following ways: the disturbed area was usually much larger, as was the devegetated area; exposure of tree roots was pronounced; organic horizons were thinner; and changes in undergrowth species (indicated by the floristic dissimilarity value) were more extreme. Compared with these sites, the only major difference on the most heavily used sites—those used several nights per week—was that organic horizons were even thinner. In an experimental study, one night of camping on previously unused sites caused significant vegetation loss in all four vegetation types studied (Cole 1995b). Four nights of camping caused less than twice the impact of one night.

These and similar results from across the country suggest *there is a general relationship between use and impact similar to that in figure 15.12. Only when comparing sites receiving very low levels of use do differences in amount of use make any sizable difference in amount of impact.*

Type and Behavior of Site Users

Certain types of impact on campsites are determined almost entirely by the behavior of campers, for example, damage to trees, "pollution" of the site with campfire ashes, charcoal, food, and so on. Not all parties build campfires or damage trees. A campsite could be heavily used and not suffer tree damage or

Table 15.1. Relationship between selected campsite impact parameters and the amount of use a site receives.

Impact parameter		Light-use sites ($N = 6$)	Moderate-use sites ($N = 6$)	Heavy-use sites ($N = 10$)	Kendall's tau ($\alpha = 0.05$)
		Median			
Camp area	(m^2)	48	224	205	NS
Devegetated area	(m^2)	19	122	93	0.30
Trees with exposed roots	(%)	3	33	39	0.41
Damaged trees	(%)	74	85	97	NS
Seedling loss	(%)	73	92	89	NS
Surviving vegetation cover	(%)	9	6	4	-0.41
Decrease in depth of organic horizons	(%)	3	21	68	0.36
Floristic dissimilarity	(%)	31	60	64	0.33
pH increase	(%)	3	5	11	NS
Decrease in infiltration rates	(%)	8	57	12	NS
Increase in soil organic matter	(%)	19	26	20	NS
Increase in bulk density	(%)	16	11	16	NS

Source: Cole 1982a.

changes in soil chemistry caused by building campfires or discarding wastes. Other types of impact are little affected by behavior. Even campers who carefully practice low-impact use techniques will still trample vegetation and compact soil.

Three other characteristics of user groups also influence campsite impact—size of the party, length of stay, and whether or not they use pack stock. The effect of party size on campsite impact has never been formally studied. One can assume that large parties will increase the disturbed area of individual campsites. Thus, campsite area and size of the devegetated area would be much larger than on sites used by small parties. However, there is little reason to believe that party size should affect any other characteristic of established campsites. On undisturbed sites, however, large parties will cause impact more rapidly than small parties. It is considerably more difficult for a large party to cause minimal impact when visiting relatively undisturbed places.

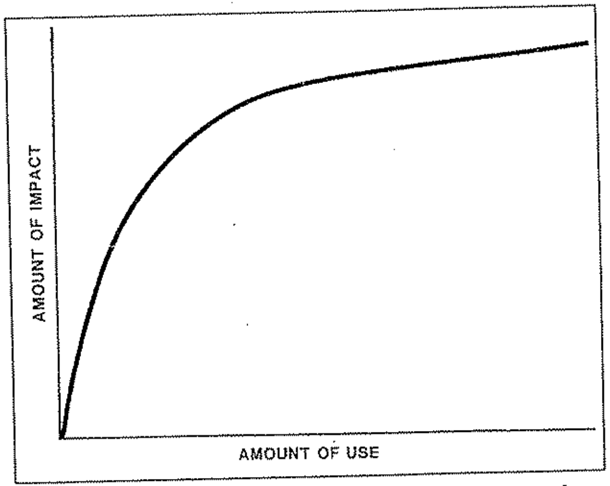


Fig. 15.12. Generalized relationship between amount of use and amount of impact. Only at low-use levels are site impacts likely to reflect different amounts of use.

Campsites used for long periods of time by the same party tend to be more heavily impacted than other sites. Two factors seem to be at work here. First, use patterns on the site are repeated day after day, leading to severe disturbance of certain parts of the site. For example, places where tents are set up and used for a week or more are likely to be highly altered. Long lengths of stay can be highly damaging on previously unused sites, whereas length of stay may be of little importance on a site where impact levels are already high. The second factor—and this applies even to well-impacted sites—is the natural tendency for people to "improve" and "develop" their campsite the longer they stay.

A final behavioral factor, *the spatial distribution of visitors, also influences the areal extent of impact.* Cole (1992) shows that the factor that most influences amount of campsite impact is the degree to which activities are spatially concentrated. Campsite impacts in the backcountry of Grand Canyon National Park are relatively low—campsites are extremely small—because the rough terrain forces campers to confine their activities to small flat spots, free of rocks and thorny vegetation (Cole 1986). Marion (1995) documents the effects of management actions taken to increase the concentration of use at two spatial scales on canoe campsites at Delaware Water Gap over a five-year period. Intersite concentration of use was increased by reducing the number of designated sites 25 percent. Managers increased the intrasite concentration of use by installing fire grates on each site. This centralized activities more than in previous years when visitors built fires on many different parts of the site. As a result, mean campsite area decreased more than 30 percent. The effect of these combined actions was to reduce the aggregate area of campsite disturbance 50 percent—from 2.8 ha in 1986 to 1.4 ha in 1991. Although these actions increased the intensity of use on individual campsites, there was no resultant increase in intensity of impact on individual sites (Marion and Cole 1996).

The effect of pack stock is discussed in more detail later. *Parties with pack stock disturb a larger area than hikers because the campsite includes an area where stock are confined.* Such camps often show more soil disturbance, a result of trampling by heavy, shod animals, and more tree damage, a result of tying horses to trees for extended periods (Cole 1983a).

Environmental Conditions and Durability of the Site

The final factor determining intensity of impact is environmental conditions and the durability of the campsite. Trail condition provides a useful illustration of the importance of location. It is common to find badly eroded or wet sections of trail alternating with better-drained sections that are in good shape, despite the fact that the very same number and type of people are using both good and bad trail segments. Environmental differences such as steepness of slope, soil texture, and moisture content account for most of these differences in condition. *Similarly, on campsites, environmental conditions including soil characteristics, depth of surface organic horizons, and vegetation type can greatly influence site durability, or the amount of impact it will exhibit in response to use.*

A number of studies have examined, through experimentation, the effects of increasing amounts of trampling on different types of vegetation. Trampling disturbance, particularly loss of vegetation, varies widely between vegetation types. In experimental trampling studies, Cole (1993a) found that as few as twenty hikers can destroy 50 percent of the vegetation cover in some vegetation types; in other vegetation types, 50 percent vegetation cover is lost after 600 hikers have crossed the area. This suggests that campsites in some vegetation types could absorb more than thirty times as much use as campsites in other types, with no more vegetation damage. Clearly, where people camp is critical in determining loss of vegetation.

Environmental influences on campsite susceptibility to impacts are complex, and our understanding is still rudimentary. Any environmental setting may be susceptible to one type of impact and resistant to another. There may be little relationship between a site's resistance, its ability to tolerate use without changing, and its resilience, its ability to recover from changes that do occur. Characteristics of durable campsites include (1) either lack of ground-cover vegetation or presence of tolerant vegetation (grasslike plants are most tolerant—short woody plants are least tolerant), (2) an open rather than closed tree canopy, (3) thick organic soil horizons, and (4) a relatively flat but well-drained site.

It is commonly believed that sites located close to lakes and streams are more fragile than sites away from water bodies. When examined in the Eagle Cap Wilderness, this did not prove to be the case (Cole 1982a). Campsites close to lakes were no more highly impacted than sites located away from lakes.

Management Strategies and Techniques to Control Impacts

Each of the factors that influence amount of impact offers a strategy for reducing site impacts. For example, four primary strategies for minimizing impacts involve *(1) limiting amount of use on campsites, (2) changing type of use and behavior in such a way that per capita impact is reduced, (3) shifting use to more durable sites or hardening sites and providing facilities to actively increase site resistance, and (4) containment of impacts—recognizing situations where impacts are inevitable and can best be minimized by limiting their areal spread.* A fifth strategy—site cleanup and rehabilitation—treats symptoms rather than causes (table 15.2). These strategies can be implemented by various techniques or actions. Effective campsite-management programs call for an evaluation of objectives, problems, and all potential solutions before selecting a series of coordinated actions, often using several different strategies. Further information on alternative management options can be found in Cole and others (1987) and Anderson and others (1998). Leave-No-Trace education—one of the most important management techniques—is discussed in chapter 16.

Limiting Amount of Use

Currently, overnight use is limited in most of the forty-four NPS wildernesses (Marion and others 1993), as well as in about twenty USFS wildernesses, two BLM wildernesses, and one FWS wilderness. This is little different from the situation in 1980, when overnight use was limited in sixteen classified and fifteen potential wildernesses (Washburne and Cole 1983). Managing campsite impact is just one of many reasons for limiting use. *Because the relationship between amount of use and amount of impact is that a little use causes most of the impact, this* *suggests that limiting use, by itself, is likely to do very little to improve the condition of well-established campsites. In most cases, unless all visitation is curtailed on a site, there is little chance for recovery.* The only exception to this rule is where use levels are kept very low and dispersal is practiced (see next technique).

In places where use levels are high—the usual case where rationing has been implemented—use limits are likely to be more effective in limiting the *number* of campsites than the *severity* of impacts on individual sites. *To limit the number of campsites, however, it is necessary to simultaneously employ the containment strategy (discussion follows) and get campers to use existing or designated sites, rather than make new sites.* In general, then, use limits are likely to be effective only when supporting containment or when they maintain extremely low use levels. Use limits can, however, be effective in dealing with other management problems, particularly crowding.

Dispersal of Use

Since use dispersal has been found to disperse campsite impacts as well as use, it is a much less common management strategy today than it was in the past. In 1980, managers were attempting to disperse use in 50 percent of all wildernesses and potential areas to be added to the wilderness system (Washburne and Cole 1983). Goals ranged from shifting use to less frequently visited areas, to discouraging camping on impacted campsites. Any dispersal of use will affect the number, distribution, and condition of campsites and recent research has shown that dispersal is more likely to increase than to decrease impact.

As in the case of use limitation, *use dispersal is unlikely to improve the condition of individual sites unless use levels are very low.* Studies in wilderness areas in the West suggest that even a night or two of use per year usually inflicts persistent damage. We also know that only a slight increase in use will significantly alter previously unused or seldom-used sites. In the Eagle Cap, even the lightly used sites away from trails had typically lost more than 70 percent of their vegetation. Therefore, increased use of little-used areas or sites will increase both the number of impacted sites and their level of impact. The more than 220 campsites around Mirror and Moccasin Lakes in the Eagle Cap (where the average number of parties probably does not exceed ten per night) is partially a result of a management decision, made in the late 1970s and early 1980s, to remove existing rock fire rings and to request visitors not to camp on heavily used sites (Cole 1982b). *At such popular destinations, directing use away from heavily used sites actually spreads campsite damage. Encouraging more use of less popular parts of the wilderness will also increase campsite impacts in these places, with little compensatory improvement in the condition of popular locations.* More recently, Eagle Cap managers have stopped removing all fire rings, in places where campfires are allowed, and no longer encourage visitors to avoid heavily used campsites.

Dispersal could improve campsite conditions in lightly used remote parts of wildernesses, if visitors can be encouraged to spread out and camp on undisturbed sites. In this vast majority of wilderness acreage, dispersal can help perpetuate the "ideal" wilderness situation where no sites become heavily impacted. However, if use increases, it may be necessary to impose limits. Ironically, use limits may be more effective in low-use situations than in the high-use places they are most commonly applied. The dispersal strategy must be supported with an intensive educational program wherein campers are taught minimum-impact camping techniques and how to select apparently unimpacted and resistant sites. Indeed, concentrating use and impact in popular places and dispersing use and impact elsewhere is one of the most critical leave-no-trace messages. This allows sites to fully recover before being used again; otherwise sites will deteriorate, and dispersal will merely spread lasting impacts. Because of this possibility, the monitoring of campsites and their condition is particularly important to a dispersal program.

Temporary Campsite Closures

Rest-rotation systems—where certain heavily impacted sites are temporarily closed to allow recovery before being used again—are likely to be effective only if required recovery periods are short in relation to periods of use and deterioration. This is seldom the case, however. Recovery almost always is slower than deterioration. The effectiveness of a temporary campsite closure program was monitored around Big Creek Lake in

Table 15.2. Factors that influence impact on campsites. Each factor defines a strategy and set of specific techniques (of which only one example is provided here) for managing impacts.

Factor	Strategy	Technique (example)
Amount/frequency of use	Reduce use	Institute quotas
Type/behavior of use	Change type/behavior of use	Party size limits
Environmental/site conditions	Increase site resistance	Bridge unavoidable bogs along trails
Use distribution	Contain use	Camping in designated sites only

the Selway-Bitterroot Wilderness, Montana, where seven out of fifteen campsites were closed to allow recovery. Eight years after closure, vegetation on closed sites was still only one-third as extensive as that on controls, and mineral soil exposure was 25 percent, compared with only 0.1 percent on controls (Cole and Ranz 1983). The most profound change since initiation of the closures was the creation of seven new campsites, close to the closed sites, on which conditions have rapidly deteriorated. Within eight years of their creation, loss of vegetation and soil exposure were as high on new sites as on long-established sites. The likely effect of a rest-rotation system, then, is an increase in the number and area of impacted sites without substantial improvement in the condition of sites in use.

Limitations on Length-of-Stay

Limits on length-of-stay have been placed both on the maximum number of nights allowed in the wilderness and at individual campsites. The imposition of areawide length-of-stay limits is unlikely to have any effect on site impacts. The major benefit of such a regulation is to allow more people to use an area in which total use is limited. Length-of-stay limits for campsites are likely to do little to improve campsite conditions in popular parts of wildernesses or on popular campsites because new parties are likely to occupy sites shortly after they are vacated. Such a limit will help prevent "homesteading," although this is more a social than an ecological problem. It can also prevent serious deterioration of sites that had not been heavily impacted previously and avoid the tendency for sites used for long periods to become developed or improved. However, in these cases *the common fourteen-day limit is too long. To avoid damaging little-used areas, sites should never be used more than a night or two in succession.*

Reducing length of stay to a minimum, and by sleeping and eating in different places, users can reduce per capita impact in little-disturbed areas. Using this technique, a party traveling through the wilderness will prepare and eat supper in one location, clean up, and travel farther to a good bed site. In the morning, the party gets up and moves on to a good breakfast site. A typical camp is never established. *Generally, the most valuable use of length-of-stay limits is minimizing time spent at little-used sites.* This goal is most effectively accomplished through education, particularly when such limits are not imposed on heavily used sites.

Party Size Limits

Party size limits apply to a majority of wildernesses where the number of people per party is limited, the limits ranging from six to sixty persons, the most common being ten (Monz and others 2000). *As noted earlier, larger parties are likely to disturb larger areas, but in the most highly disturbed part of the campsite, severity of impact is unlikely to be much greater than with small parties.* Establishing lower party-size limits could reduce the size of campsites and devegetated zones; however, such an action might result in the need for more campsites. *To be effective in maintaining small campsites, limits probably should be ten or fewer and users should be educated to not spread out on campsites.* Excessively large sites may require partial revegetation and some means of keeping visitors off the periphery. The BWCAW, Minnesota, limits party size, teaches minimum impact camping, monitors all campsites, and where site expansion is occurring places rocks and logs to keep people off the periphery (Marion and Sober 1987).

Party-size limits are of most value in lightly used parts of wilderness where dispersal is being practiced. Rate of impact tends to increase with party size, so a small party will find it much easier to leave little trace of their visit than a large party. Again, limits must be quite low and might be most effectively implemented as part of a program to foster appropriate use of places off the beaten track. *Impacts of larger groups can be reduced if party members will spread out during travel and break up into small dispersed camping units.*

Encouraging Use of Resistant Sites

Because certain sites are much more durable than others, encouraging use of resistant sites can minimize impacts by directing use either to resistant sites or away from fragile sites. This can be done through regulation or through education. Camping in meadows is often discouraged or prohibited. Such campsites—both when occupied and after use—are much more obvious and aesthetically displeasing than sites set back in forests. Most research suggests, however, that grassland and meadow vegetation, particularly if it is dry, is much more resistant to damage than the forest undergrowth (Cole 1993a). Therefore, in lightly used areas, where the dispersal strategy is being practiced, visitors should be encouraged to camp on meadows and grasslands. Here, encounters with other parties are unlikely, and it is most important to minimize trampling damage. In heavily used areas, where even resistant vegetation will be lost, one should encourage camping in forested areas with thick organic horizons, so impacts and other campers will be screened by trees.

Setbacks from Water

One of the most common management actions is to discourage camping close to streams and lakes. Such setbacks have social and ecological justifications as well as repercussions. Three conditions that might make lakeshores particularly vulnerable are (1) moist soil with great potential for vegetation damage and soil compaction, (2) steeply sloping shores prone to erosion, and (3) potential for water pollution. Soil moisture and slope steepness do not necessarily decrease with distance from water, however. Flat rock outcrops close to shores are undoubtedly much more tolerant of use than moist or sloping sites a considerable distance from the lake. Most water quality studies suggest that even in high-use areas pollution from human sources does not present a significant health problem (Silverman and Erman 1979). However, in at least one case, heavy use appears to have altered benthic plant populations and the concentration of certain ions (Taylor and Erman 1979). More monitoring is necessary to determine whether this is a common problem. Around heavily used lakes, particularly in areas where lakes are rare, setbacks may be justified as a means of reducing pollution.

Another justification for setbacks from water is the tendency of visitors to develop trails from campsites to the lake or stream. Social reasons—maintenance of public access and the aesthetic qualities of the lakeshore or streamside, plus reducing the visibility of campers—may also justify setbacks. This action will keep visitors from camping where they most like to camp. Moreover, Christensen and Cole (2000) note that visitors report social justifications for lakeshore setbacks are less persuasive than ecological justifications. Setbacks will increase the area altered by camping, at least for the short term, because visitors will develop a second set of campsites away from the lake. Moreover, a setback will often eliminate most of the potential places to camp near water.

Setbacks should be instituted because they will solve a specific problem. Often much could be accomplished by persuading visitors to prevent water pollution; this would avoid imposition of rigid setbacks. Elsewhere, setbacks may be necessary only in a few heavily used places. Many wildernesses are adopting more flexible setback policies than in the past. This may involve a rigid minimum setback of, say, 50 feet, with the suggestion that camps be at least 100 feet back if the terrain permits. Where setbacks are established, the old sites closer to water should be actively rehabilitated.

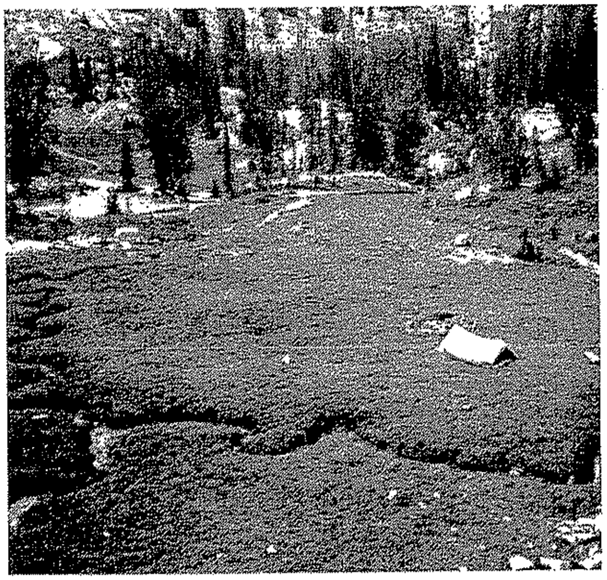


Fig. 15.13. Dry meadows make durable campsites, provided stays are short and campfires are not built here. Photo courtesy of David Cole, USFS.

Site Hardening and Facilities

True site hardening, wherein a site's durability is increased through manipulation, such as planting hardy grasses, is almost nonexistent in wilderness. More common is the provision of facilities that absorb or concentrate impact: fireplaces, tent pads, shelters, stock-holding facilities, toilets, and trash cans. Building facilities is a controversial action. *We support the installation of such facilities to protect resources or for visitor safety, but not for visitor comfort and convenience.* Trails are an example of an almost universally accepted facility that serves to absorb and concentrate impact. The most common other facilities in wilderness are toilets, shelters, constructed fireplaces, tables, and a drinkable water supply.

Facilities should be the exception rather than the rule—a means of dealing with concentrated use, particularly by novice users, in a few places in the wilderness. In Great Smoky Mountains National Park, for example, shelters receive 37 percent of the backcountry use, but because they concentrate impact, they account for only 10 percent of the disturbed area on campsites in the park (Marion and Leung 1997). Although shelters may seem inappropriate to many in wilderness, they are effective in reducing resource impact. We feel that wilderness should offer a range of recreational opportunities, including a few places that must accommodate heavy, localized use. The provision of facilities may help prevent excessive deterioration of these places, while their judicious use preserves quality experiences for those who choose to visit such popular locations.

The facilities that can be most readily defended as necessary are constructed fireplaces, stock facilities, and toilets. Stock facilities are discussed in the section on pack-stock management. Fireplaces are most appropriate in areas of high fire hazard, for example, some wildernesses in southern California and the Southwest. However, in a number of other places they are used to confine campfire damage and to designate an acceptable campsite. Generally, this is necessary if visitors will otherwise build new fire rings or disturb new sites.

Toilets are an undesirable, but sometimes appropriate facility, particularly where use is so high that the likelihood increases of visitors digging up previously buried fecal material. Much can be accomplished by teaching people to defecate far from high-use camps. However, in some situations, toilets become a necessity. The most common toilet is a wooden box a few feet high. In some areas, however, outhouses are enclosed, and in some wildernesses, composting toilets have been installed.

Containment of Impacts

Containing use is a well-developed principle of site management outside of wilderness and, though many consider it inappropriate in wilderness—labeling it the "sacrifice site" concept—it is already being consciously and unconsciously applied within wilderness. The label "sacrifice site" is an unfair one, because it implies that managers have the option of not "sacrificing" sites. This is only possible if recreation use is very low or not allowed. Given that recreation use will be allowed, the choices are between having relatively large or relatively small numbers of impacted ("sacrificed") sites. *The containment strategy is an attempt to keep the number of impacted sites relatively small. For example, a trail contains and concentrates use.* Exhorting visitors to stay on trails, and not to shortcut switchbacks, are examples of appropriate containment. *Applied to campsites, the same "containment concept" would encourage use of existing sites to avoid rapid deterioration of new sites.* Currently a number of wildernesses, particularly those managed by the NPS, allow camping only on designated sites, at least in certain parts of the wilderness. Others encourage the use of existing campsites.

Most sites deteriorate substantially even when used only a few nights per year. Therefore, at a heavily used destination area, the choice is between a few deteriorated sites—the result of containment—or many deteriorated sites—the result of dispersal. Containment is a better strategy for minimizing impacts, unless management is willing to reduce use to extremely low levels and actively rehabilitate deteriorated sites. Generally, this is neither practical nor desirable. Wilderness can and should accommodate a range of opportunities; having a few popular locations with a handful of well-impacted campsites seems appropriate as long as the vast majority of the area remains largely undisturbed.

Although this conclusion may be disturbing to those who want pristine wilderness, we find it a sensible compromise that allows generous opportunities for recreational use. The finding that heavily used sites show little more impact than sites used a few times per year has its positive side; concentrating use on a few sites will not result in ever-increasing deterioration, provided that sites are well located and inappropriate visitor behavior is discouraged. Moreover, as long as most people want to visit popular areas and use the most heavily impacted sites—site containment will allow natural conditions to be preserved throughout most of the wilderness; opportunities for solitude will be preserved for those who seek it; and the need to manipulate visitor distributions and behavior, which results in loss of freedom, will be minimized.

Containment can be accomplished either through regulation—by allowing camping only on designated sites—or through education—by encouraging the use of existing campsites. Sites can be either clustered or dispersed. Although easier to administer and patrol, we feel that clustered sites are usually undesirable because they reduce campsite solitude and exacerbate problems such as bear encounters, waste disposal, and depletion of firewood supplies. Where use is so high that unacceptably large numbers of campsites are required, use limits may have to be established.

Where use limits are established, managers often set up a reservation and fixed itinerary system, too. Visitors are required to stay at sites they reserve before entry. With such a system, the number of sites necessary to accommodate a given number of parties is minimized because the need for overflow sites is eliminated. Reservations and a fixed itinerary greatly reduce freedom and spontaneity, however, and are among the most unpopular actions taken in wilderness (Lucas 1980). *Compliance with fixed-itinerary systems is often low, defeating their efficiency* (Stewart 1989). Such regulations should be applied only if absolutely necessary. Visitor freedom can be maintained by limiting use at trailheads and then allowing free movement within the area. Based on historic use patterns, trailhead quotas can be set to keep use levels in destination areas within acceptable limits most of the time (Parsons and others 1981).

Containment need not—and usually should not—be practiced throughout an entire wilderness. For example, in many wildernesses managed by the NPS, the wilderness is divided into a number of use areas or zones. In the most heavily used areas, camping is allowed only at designated sites. Elsewhere, visitors can camp wherever they choose. Both dispersal and containment can be practiced in the same wilderness area. Visitors who are properly equipped, skilled, and sensitized to low-impact use can be dispersed, while those who are novices or poorly equipped for low-impact use can be contained on designated sites.

Once a containment strategy is established, with or without use limits, the existing number of campsites can be reduced. This requires keeping people off closed sites and actively rehabilitating them. Usually, closed sites are identified through signing or a string enclosure. Open sites can also be signed, but a less obtrusive tactic might be leaving fire rings only on open sites. It is important to leave open sites where people want to camp and to have a few more sites open than the maximum number of parties anticipated at any time. *Spildie and others (2000) evaluated the effectiveness of a containment strategy in a subalpine lake basin in the Selway-Bitterroot Wilderness, Idaho.* Actions taken included closing certain campsites to all use, requiring groups with stock to camp in one of nine designated stock sites in the lake basin, and restoring closed sites and portions of sites still available for use. *In just five years, disturbed area decreased 37 percent and bare area decreased 43 percent.* They project that, in a few decades, disturbed and bare area can be reduced to just 36 percent and 24 percent, respectively, of what it had been before imposition of the containment program.

Monitoring Campsite Conditions

Effective campsite management requires detailed information about the location and condition of campsites and trends over time. Sites should be inventoried to identify locations and problems that need attention, and to plan the types of corrective management actions that will be required. If done carefully, the inventory can provide a baseline for identifying trends in campsite number and condition and possibly relating changing conditions to changes in visitor traffic and management actions. Finally, the inventory and monitoring system can be a critical part of the limits of acceptable change (LAC) planning process (Stankey and others 1985). Ideally, an inventory would include sites that visitors might use if they were aware of them. Knowledge of potential sites would be useful in implementing a dispersal system or establishing new campsites if poorly located ones were closed.

Considerable progress has been made recently in the implementation of programs. Several decades ago, very few wildernesses had any monitoring data. In a recent survey of wildernesses, we found that *campsites are being monitored in a portion of 50 percent of all wildernesses.* A variety of different campsite monitoring techniques has been developed. (Refer to Cole 1989b and Marion 1991 for further detail on available monitoring techniques.) These techniques vary in the quantity and quality of the information produced, as well as in cost. Techniques that produce precise, reliable information on a number of separate impact parameters require more time and cost more than those that produce either relatively little information or less precise information.

One common monitoring method uses photographs. Photographs can be compared from year to year, but one must record date, time of day, the precise location of the photopoint, distance and direction to subject, height of the camera above the ground, camera make and model, focal length of the lens, filter, and film type. These conditions should be replicated to as great an extent as possible when subsequent photographs are taken (Brewer and Berrier 1984). From experience, *photographs have not proven to be reliable substitutes for field measurements* or estimates of parameters, such as vegetation cover or tree damage. Patches of sunlight and shade often make interpretation of ground cover difficult, and it is seldom possible to distinguish features beyond the closest trees. *Nevertheless, as supplementary documentation, photos are indispensable.* They can help identify the site for future measurements, record campsite features not measured in the field, and provide a visual supplement to collected data.

Where it can be afforded, the best monitoring data comes from careful measurements in the field, using techniques similar to those employed in campsite impact research studies (for example, Cole 1982a and Marion and Cole 1996). However, such techniques often require spending several hours measuring each campsite. Because it is important to collect monitoring data on all campsites—to permit assessments of change in the number and distribution of campsites over time—such techniques are prohibitive except in wildernesses with small numbers of campsites. Most wildernesses have so many sites—Kings Canyon and Sequoia National Parks had more than 7,400 sites—and funding levels are so low that a system using visual estimates will be most practical.

Frissell (1978) developed a condition-class estimate system in which each campsite is located and assigned a condition class rating between one and five based on the following criteria:

1. Ground cover flattened but not permanently injured. Minimal physical change except for possibly a simple rock fireplace.
2. Ground vegetation worn away around the fireplace or center of activity.
3. Ground vegetation lost on most of the site but humus and litter still present in all but a few areas.
4. Bare mineral soil widespread. Tree roots exposed on the surface.
5. Soil erosion obvious. Trees reduced in vigor or dead.

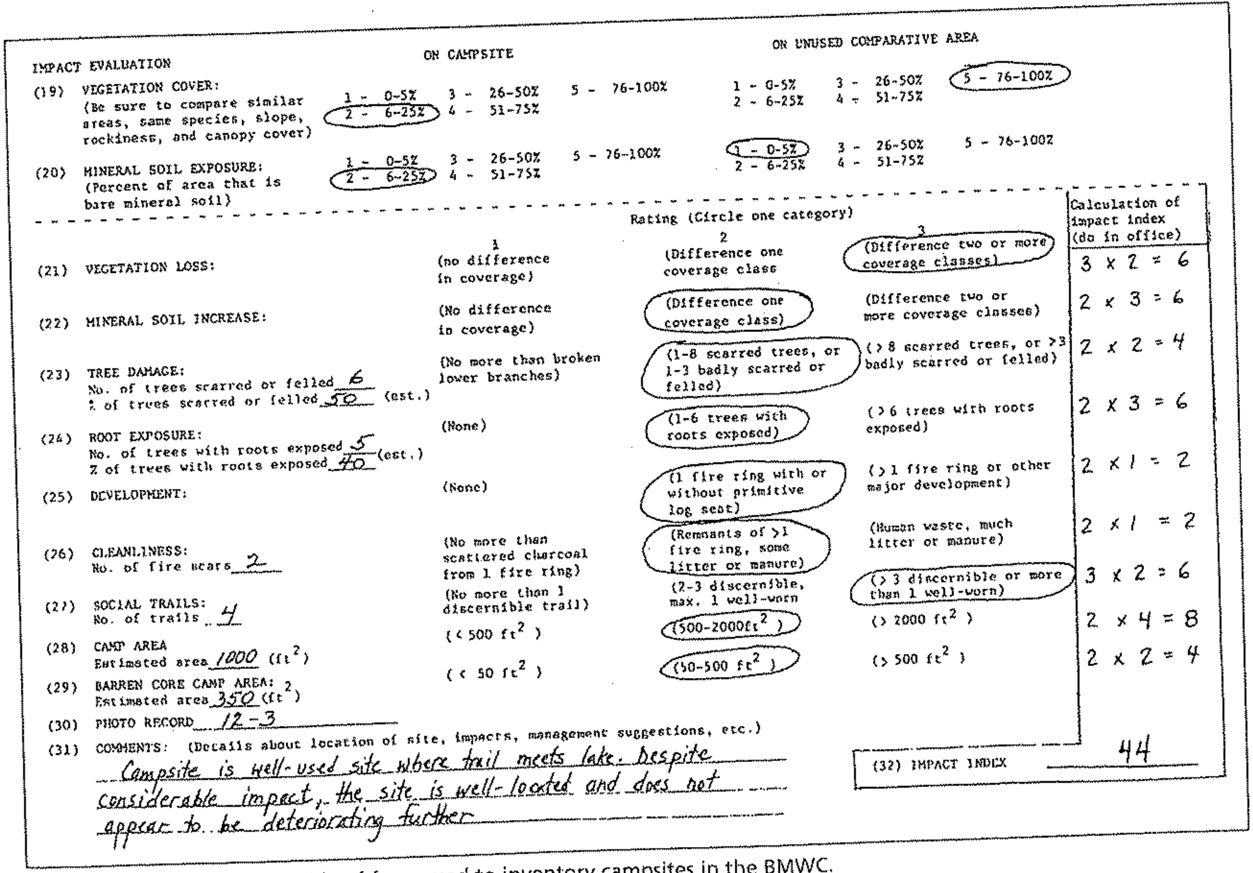
Condition-class systems are inexpensive and produce quite reliable, precise information. Their primary drawbacks are that they are not very sensitive, and the amount of information produced is limited. This system is most helpful in showing the location of campsites, which campsites are most heavily impacted, and how the distribution of sites changes over time. It reveals nothing about which types of impact are most serious, and by the time campsite conditions have changed enough to be reflected in a changed condition class rating, a profound amount of change will have occurred.

A slightly more time-consuming technique, first developed in Sequoia and Kings Canyon National Parks (Parsons and MacLeod 1980) involves quick estimates of a number of different impact parameters. Figure 15.14 shows one side of a form, based on this system, used to inventory all campsites in the

Bob Marshall, Great Bear, and Scapegoat Wildernesses in Montana. With training, this form can be completed in five to ten minutes. Modifications of this system are currently being applied in many other USFS wildernesses.

Nine impact parameters are used to evaluate campsite condition:

1. Loss of vegetation is expressed as the difference in vegetation cover between the campsite and its undisturbed surroundings. A vegetation-cover class (percent cover of vegetation) is identified for both the campsite and an undisturbed comparative area. This undisturbed comparative area should be as similar as possible to the campsite in slope, canopy cover, and the composition of plants growing in protected places. The vegetation loss rating is based on the difference between these cover classes.
2. Mineral soil increase is a similar comparison between the campsite and an unused comparative area. In this case, areas of mineral soil, devoid of vegetation and organic litter, are compared.
3. The number of trees that have been damaged (trunk scars, nails, stumps, and so on) is noted and used to rate tree damage. Large scars and felled trees are especially significant.
4. The number of trees with pronounced root exposure is noted.
5. The presence or absence of such facilities as fire rings, log or stone seats, and more elaborate structures is used to rate level of development.
6. The presence and amount of charcoal, blackened logs, other campfire evidence, litter, toilet paper, human waste, and horse manure is used to rate level of cleanliness.
7. The number of informal trails providing access to water sources, the main trail, or adjacent campsites is noted. Well-worn trails are considered to be more significant than faint, barely discernible trails.
8. The total area of the campsite, including satellite tent areas and stock-holding areas, is paced off or tape measured.
9. The area devoid of vegetation, centered around the fire ring, is estimated.
10. In addition to measuring many of these parameters, each is rated on a scale of one to three. *These ratings can simply be summed to arrive at the impact index or* they can be multiplied by weighting factors reflecting the perceived relative importance of each parameter. These weights are the second column of numbers in the calculation box. In this case, the impact index becomes



IMPACT EVALUATION

	ON CAMPSITE	ON UNUSED COMPARATIVE AREA
(19) VEGETATION COVER: (Be sure to compare similar areas, same species, slope, rockiness, and canopy cover)	1 - 0-5% [✓ 2 - 6-25%] 3 - 26-50% 4 - 51-75% 5 - 76-100%	1 - 0-5% 2 - 6-25% 3 - 26-50% 4 - 51-75% [✓ 5 - 76-100%]
(20) MINERAL SOIL EXPOSURE: (Percent of area that is bare mineral soil)	1 - 0-5% [✓ 2 - 6-25%] 3 - 26-50% 4 - 51-75% 5 - 76-100%	[✓ 1 - 0-5%] 2 - 6-25% 3 - 26-50% 4 - 51-75% 5 - 76-100%

Rating (Circle one category)

	1	2	3	Calculation of impact index (do in office)
(21) VEGETATION LOSS:	(no difference in coverage)	(Difference one coverage class	[✓ (Difference two or more coverage classes)]	3 x 2 = 6
(22) MINERAL SOIL INCREASE:	(No difference in coverage)	[✓ (Difference one coverage class)]	(Difference two or more coverage classes)	2 x 3 = 6
(23) TREE DAMAGE: No. of trees scarred or felled 6 % of trees scarred or felled 50 (est.)	(No more than broken lower branches)	[✓ (1-8 scarred trees, or 1-3 badly scarred or felled)]	(>8 scarred trees, or >3 badly scarred or felled)	2 x 2 = 4
(24) ROOT EXPOSURE: No. of trees with roots exposed 5 (est.) % of trees with roots exposed 40	(None)	[✓ (1-6 trees with roots exposed)]	(>6 trees with roots exposed)	2 x 3 = 6
(25) DEVELOPMENT:	(None)	[✓ (1 fire ring with or without primitive log seat)]	(>1 fire ring or other major development)	2 x 1 = 2
(26) CLEANLINESS: No. of fire scars 2	(No more than scattered charcoal from 1 fire ring)	[✓ (Remnants of >1 fire ring, some litter or manure)]	(Human waste, much litter or manure)	2 x 1 = 2
(27) SOCIAL TRAILS: No. of trails 4	(No more than 1 discernible trail)	(2-3 discernible, max. 1 well-worn	[✓ (>3 discernible or more than 1 well-worn)]	3 x 2 = 6
(28) CAMP AREA Estimated area 1000 (ft^2)	(<500 ft^2)	[✓ (500-2000ft^2)]	(>2000 ft^2)	2 x 4 = 8
(29) BARREN CORE CAMP AREA: Estimated area 350 (ft^2)	(<50 ft^2)	[✓ (50-500 ft^2)]	(>500 ft^2)	2 x 2 = 4

(30) PHOTO RECORD 12-3

(31) COMMENTS: (Details about location of site, impacts, management suggestions, etc.)
Campsite is well-used site where trail meets lake. Despite considerable impact, the site is well-located and does not appear to be deteriorating further

(32) IMPACT INDEX 44

Fig. 15.14. Completed back side of form used to inventory campsites in the BMWC.

the sum of the weighted ratings (the product of rating times weight). Although not strictly appropriate mathematically, such a procedure provides a useful relative index of impact.

Both the impact index and the individual parameter ratings can be mapped. Fig. 15.15 shows the location and overall condition (impact index) of campsites in a portion of the Bob Marshall Wilderness. Such a map is valuable for identifying problem areas and specific types of problems. This makes it much easier to tailor a campsite-management plan to the area. Obviously, different management strategies are necessary for Upper Holland Lake, with many highly impacted sites; Koessler Lake, with only one site, but a highly impacted one; and George Lake, with many sites, none of which are highly impacted.

Such a system provides considerable information at relatively low cost; however, the information is not very precise. It is not uncommon, for example, for different evaluators to give the same campsite very different ratings for individual parameters. We have found, however, that overall index ratings do not vary greatly between different evaluators. This suggests that the primary limitation to these techniques is in drawing conclusions about changes over time—for separate types of impact, such as amount of vegetation loss—on individual campsites.

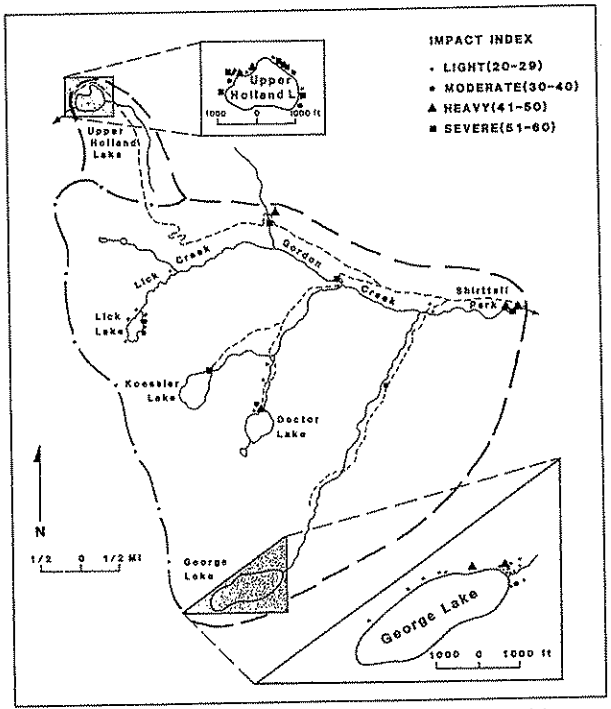


Fig. 15.15. This map of a portion of the Bob Marshall Wilderness displays the location and overall condition (impact index) of each campsite. This provides a graphic overview of campsite conditions at one point in time.

Marion (1991) developed a technique that is a compromise (in both cost and precision) between research-level techniques and the rapid assessments used in the Bob Marshall Wilderness. Certain parameters—such as campsite area—are measured carefully, while other parameters are visually estimated. After using this technique in a number of parks in the eastern United States, Marion reports that it takes two trained evaluators about thirty minutes to monitor a campsite. Another compromise approach is to inventory all campsites using a condition-class rating and then to carefully monitor a sample of campsites to identify subtle trends.

Regardless of the technique employed, the wilderness should be reinventoried periodically, perhaps every five years. This will show whether the number of sites is increasing or decreasing and whether conditions on individual sites are improving or deteriorating. If standards have been established for campsite condition, the ratings can be related to specific standards to determine where and what type of management is needed. By relating documentation of existing conditions (through monitoring) to specific objectives (standards) and then carefully choosing solutions from the array of possible management strategies described earlier, campsite management should become more effective and efficient.

Campsite Restoration

As we noted, *temporary closures as part of a campsite rest-rotation system are unlikely to succeed.* However, campsites may be *permanently* closed to enforce setbacks from lakes, to close poorly located sites, or to reduce the number of sites in places where containment is being tried. Closed campsites are common in wilderness. In many cases, closed sites are simply left alone. Increasingly, however, managers are realizing that they need to assist the recovery process because recovery rates are so slow. Most restoration programs are run by highly committed but untrained volunteers. Experimentation, documentation, and communication of what does and does not work are usually lacking. Barriers to restoration success are challenging and poorly understood. Moreover, suitable techniques and materials can be highly area- and site-specific. For all of these reasons, success and the ability to generalize about site rehabilitation has been limited.

Five Steps for Site-Restoration Plans

The likelihood of restoration success can be increased through careful planning. Common problems that can be avoided through careful planning include destruction of restoration work because the cause of the problem was not adequately dealt with; failure of plantings due to inadequate site preparation and plant selection; loss of plantings due to inadequate long-term maintenance of the site; and an inability to learn from successes and failures due to insufficient monitoring. Although there are many appropriate formats for a restoration plan, all are likely to contain the following five steps.

1. *Establish Restoration Goals and Objectives. Goals define the intended result of the project*—for example, whether to return the site to its predisturbance condition or to simply reduce current levels of impact. *Objectives provide specific measurable targets.* It is critical to simultaneously consider goals for both the site and the larger landscape in which the site occurs. For example, in addition to restoring the lakeshore, what are the goals for the entire lake basin? Goals might be to confine camping impacts to places more than 200 feet from lakes or to confine them to other existing campsites. *Without statements of goals for larger areas, restoration programs may do little more than displace impacts to other places in the wilderness.*
2. *Conduct a Situational Analysis. Describe and analyze the site and its context, answering the following questions:* (a) what is the nature and extent of the problem, (b) what caused the problem, (c) what ecological and visitor-use characteristics constrain the restoration effort, and (d) what are the ecological and visitor-use characteristics of a fully successful project? It is helpful to place the problem in a historical context. Is the problem recent or has it existed for decades? Is it relatively stable or getting worse? Does the problem result from visitor use, natural events, management actions or some combination of these? Evaluate the difficulty of restoring the site. Sites can be difficult to restore because they are harsh, unproductive or have short growing seasons. They can also be difficult because the needs and desires of visitors in the area are such that visitors cannot easily be kept off the site.
3. *Design the Site. Lay out the physical and ecological characteristics of the site-to-be,* including accommodations for visitor use and management. The design should prescribe the desired topographic configuration and drainage, as well as spatial arrangements of vegetation and substrate—usually in an attempt to emulate characteristics of the natural site. When designing vegetation planting, both vertical and horizontal structure should be considered.
4. *Develop Implementation Procedures. Describe the procedures necessary to achieve the site design.* Procedures to be specified, discussed in more detail later, include (a) site stabilization, (b) site preparation, (c) propagation or collection of vegetation or propagules, (d) planting procedures, (e) maintenance procedures, and (f) visitor management.
5. *Develop Monitoring Procedures. "Monitoring provides the means to quantify and verify success in achieving the objectives of the plan, and offers insight into reasons for success or failure"* (Nuzzo and Howell 1990, p. 207). A monitoring program should (a) define the area to be monitored, (b) decide which parameters should be monitored, (c) prescribe techniques for each parameter, (d) define a sampling/monitoring plan, and (e) include records of planting, maintenance, and management programs. Be sure to note when monitoring should be done, by whom and how it will be used.

Guidelines to Implementing Site-Restoration Plans

As noted before, experience with wilderness campsite restoration is not well documented, and generalizations are difficult. However, a few guidelines related to steps in the process of implementing a restoration design can be suggested.

Visitor Management

The first step in any rehabilitation program is to effectively close the site to all use. Even day use, where horses are tied to trees or people inadvertently walk across the site, can frustrate a rehabilitation attempt. This is one of the real problems with rehabilitating closed sites close to lakes. Even if people do not camp there, they may use the site for picnicking or walk across it to go fishing or swimming. The most effective approach to closure consists of helping people understand the reasons for closures and letting them know about other desirable places to camp. It is best to get this information to visitors before they enter the area so they can adjust travel plans. In a number of cases, rope or string between stakes or trees has been honored. A sign declaring the site closed, the reason for the closure, and the location of alternative open sites in the vicinity promotes compliance. Use of the site can also be discouraged by partially burying large rocks and logs (iceberging) or planting dead trees and shrubs (vertical mulching).

Site Stabilization and Preparation

Once closed, the site should be cleaned up, eliminating fire rings, charcoal, excess firewood, and trash. Erosion is usually not a serious problem on campsites; however, if erosion is occurring it must be dealt with, usually through drainage manipulation. Then the soil needs to be prepared. Compacted soil should be cultivated (scarified) to a depth of about four inches to facilitate seed germination, root and plant growth and water infiltration. Clods need to be broken up, leaving a crumb texture. Long-established campsites usually have soils lacking in organic matter and a healthy soil biota. Scarification may have little effect if organic matter is not either incorporated into the soil or spread on top of the soil. Peat moss or raw organic matter can be mixed with the scarified soil. This may not be desirable in grasslands because grasses generally prefer more neutral soils. In a recent study on subalpine campsites in the Eagle Cap Wilderness, revegetation success was increased by adding compost to soils (Cole and Spildie 2000). Other types of organic fertilizers—which largely increase the organic content of soil, while slowly adding low levels of limiting nutrients—are also available, but have not been evaluated on wilderness campsites. Inorganic fertilizers can be added at this stage, but they have seldom improved revegetational success (Beardsley and Wagar 1971) and they tend to favor exotic species.

Propagation, Collection, and Planting

Under some favorable circumstances, natural revegetation may occur without much assistance within a short period of time, but elsewhere may require decades or centuries (Parsons 1979; Willard and Marr 1971). In the West, at least, natural revegetation is likely to be most rapid at lower elevations, on more productive soils, and in areas that receive plenty of light and moisture. In slow recovery places, revegetation can be facilitated by transplanting whole plants or plant cuttings, or by seeding.

Transplanting, a technique used frequently and successfully, is time consuming and can disturb adjacent areas from which plants are removed. Consequently, in a number of areas, plants grown in nurseries, from seed, cuttings, or root divisions obtained close to the restoration site, are transported to the backcountry for transplanting (Rochefort and Gibbons 1992). *Transplanting is more successful than seeding in certain environments.* Transplants can provide an early seed source, "nurse" plants that shelter and facilitate the germination and survival of seedlings and may be the only effective way to get late successional plants established on sites. Experience in the Pacific Northwest suggests the following procedure for transplanting:

1. Select plant species adapted to grow on the site. Species that naturally colonize disturbed sites are good choices, as are plants that reproduce vegetatively. Choose relatively short plants with healthy looking foliage.
2. Water both the plants to be transplanted and the area to be transplanted one day before transplanting.
3. Place the plant upright in a hole slightly larger than the root ball. Make certain that roots are not doubled over on themselves. Fill in the excess space with organic matter and soil. When tamped down firmly, the top of the root ball should be slightly below the ground to facilitate watering and to reduce the risk of damage from frost heaving.

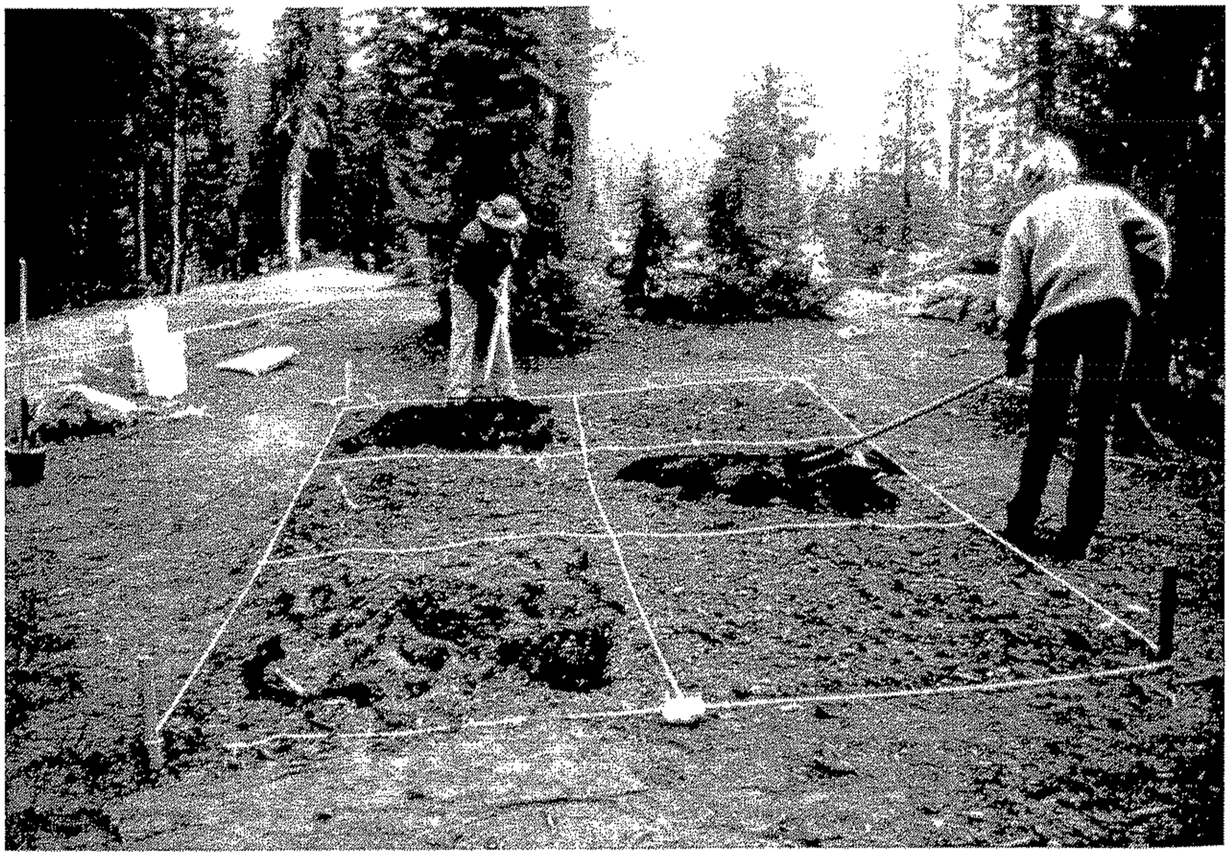


Fig. 15.16. Amending the soils of damaged campsites can speed recovery of the site when it is closed to use. Experiments with different soil amendments are being conducted on this campsite in the Eagle Cap Wilderness, OR. Photo courtesy of David Spildie, USFS.

4. Water thoroughly. If it is warm or dry, it may be necessary to water the plants daily or to shade them. Where this is not feasible, survival rates can be increased by pruning some flowers, leaves, and branch tips and by providing large root balls.
5. Add a one-inch layer of mulch over the transplanted area and around the base of the transplants. Mulch can be leaves, pebbles, commercial mulch, decaying wood, grass, or any other material that insulates yet allows free movement of air and moisture. Lightweight mulches may have to be anchored by limbs, stones, or similar objects.

Seeding is less complicated. Again, seed should be gathered close to the restoration site (to maintain genetic integrity) from plants adapted to the site. In some cases, nonnative species have been used because seed is more readily available, and it was thought that such plants would be replaced by native species. In Mount Rainier National Park, for example, red fescue, a nonnative species, was planted as a cover crop to reduce erosion, soil temperatures, and frost action, and to increase the organic matter in disturbed areas. In four years, native plants did not invade red fescue sites; bare areas that were not planted with red fescue showed better revegetation (Van Horn 1979). *To us, seeding with nonindigenous plants is an unacceptable alteration of natural conditions in wilderness—the finding that it is frequently unsuccessful confirms this belief.*

When seeding, it is important to become familiar with special germination requirements, such as scarification or stratification, of the species used. Seeds should either be scattered over the prepared soil and covered with one-half inch of soil or dropped into holes one-half inch deep. Soil should be tamped, mulched, and watered.

Site Maintenance

It may be necessary to water plantings for years, if conditions are droughty. It will also be necessary to maintain ropes and signs that keep visitors off sites.

Even with all this effort, restoration is likely to require long time periods. Transplants on road cuts in the alpine zone of Rocky Mountain National Park were surviving after forty years, but they had not spread significantly (Stevens 1979). Three years after being planted, only 19 percent of transplants on closed subalpine campsites in Yosemite National Park were alive and total vegetation cover had increased only 1 percent (Moritsch and Muir 1993). *Clearly, it is much better to avoid damage than to try to fix it after it occurs.*

Site rehabilitation is an appropriate means for correcting past abuses, but it should be used judiciously. In addition to being costly, it interjects horticulture and landscaping into the wilderness. *As a general principle, we believe rehabilitation should be used to restore wilderness campsites that could then be protected through a new management program. Rehabilitation should not be used to bandage sore spots where no other change in management is implemented.*

Managing Trail Impacts

Impacts on and along trails result from the trampling of hikers and pack stock and the effects of trail construction and maintenance. As discussed in more detail earlier in this chapter, *these impacts include loss of vegetation and shifts in plant-species composition, exposure of bare mineral soil, soil compaction, and changes in microhabitats, including changes in drainage.*

Where trail construction is carefully planned, most of these changes are of little concern; although pronounced, most changes are localized and deliberate. Most wilderness trails were originally constructed to provide administrative access, particularly for firefighters, but currently are maintained primarily for recreational purposes. Most trail impacts only warrant concern when they provide obtrusive evidence of human use, become difficult to use, or require large amounts of money and labor to maintain. Although trail problems are usually highly localized, maintaining and relocating trails usually costs more than any other aspect of wilderness management.

Three Common Problems: Erosion, Muddiness, Impromptu Trails

The most common problems with trails are (1) excessive erosion, (2) muddy stretches in areas of water-saturated soils, and (3) development of impromptu trails, either adjacent to existing trails or in areas where no trails were planned. The first two problems make the trail difficult to use; all three suggest either "overuse" or improper use to visitors (table 15.3). Two other problems result from attempts to correct the first three problems: excessive engineering and the proliferation of open and closed trails where trails have been frequently relocated. Both of these situations provide abundant evidence of human use and manipulation of the resource—evidence that cannot be eliminated but should be kept to a minimum.

Erosion

Although erosion can be significant on parts of a trail system, studies of trails in the Selway-Bitterroot Wilderness, Montana, and Guadalupe National Park, Texas, showed that little erosion is occurring over entire trail systems (Cole 1991b; Tinsley and Fish 1985). Material eroded from trail "banks" or the tread itself is usually deposited elsewhere on the trail. *Soil is lost from the trail system only where water drains off the trail,* and much of that can be compensated for by sediment washed onto the trail from above by overland flow. Although trail troughs often change—either deepening through erosion or being filled in through deposition—trail systems as a whole usually exhibit a relatively steady state.

What is critical, however, are those stretches where erosion is pronounced. Severe erosion does occur and it can make a trail difficult to use, either because it is too deep and narrow or because exposed roots and rocks make footing difficult. This tempts people to leave the trail and make a new trail. Deeply rutted trails also exacerbate their own erosion problems by more effectively channeling water.

Although trampling of vegetation can cause limited amounts of erosion, the primary effect of trampling is to make a trail susceptible to erosion by loosening up the soil (DeLuca and others 1998), reducing infiltration rates, and removing vegetation. *Running water is the principal agent of erosion.* Streams, snowmelt water, and water from springs all cause erosion when channeled down the trail. In some places, rainfall can also be intense enough to erode trails. For this reason, the main factors that determine degree of erosion damage are trail grade, orientation, and drainage—factors that affect the channelization and erosive force of water in the trail—and soil texture, the primary factor determining how readily the soil is detached and carried away. Leung and Marion (1996) provide a useful review of what is known about the influence of environmental factors on trail degradation.

Amount and type of use are generally less important to causing erosion than trail location and design features. Studies in the northern Rocky Mountains concluded that trails were not substantially deeper where use levels were higher (Cole 1991b; Dale and Weaver 1974). This is not to say that 1,000 hikers per day would not cause more erosion than only one hiker per day. Rather, it means that beyond a low threshold of use—a substantial amount of use is required to eliminate vegetation and render the trail vulnerable to water erosion—location and design are more important determinants of erosion than amount of use. Therefore, to prevent erosion, use levels would have to be so low that bare trails do not form. Virtually eliminating use to avoid trail problems is inefficient—not to mention unpopular with the public—given that trails can be designed to accommodate heavy use.

It has been suggested that type of footwear is an important determinant of amount of damage. Bainbridge (1974) wrote, "Indications are that Vibram lug soles may be 50 to 100 times more destructive than tennis shoes or flat soles but the conclusive research has not been completed" (p. 10). Studies indicate, however, that lug soles are not substantially more destructive than other types of footwear. Kuss (1983), for example, found no significant difference in the volume of soil eroded from a stretch of trail after being trampled by lug-soled and corrugated rubber-soled boots. This lack of difference was found despite increases in soil yield, after 600 and 2,400 trampling passes, amounting to 1.4 and 1.7 times the yield of undisturbed trail, respectively.

Whether trail use is by hikers or by parties with pack and saddle stock is an important indicator of potential erosion problems. A small bearing surface carrying heavy weight, a horse's hoof can generate pressures of up to 1,500 pounds per square inch (Bainbridge 1974). These pressures, along with sharp shoes, cause stock to break up, not compact the trail surface. Detached soil is more easily eroded and makes trails dustier when dry and muddier when wet. In a recent experimental study, DeLuca and others (1998) found that horse traffic resulted in much higher sediment yields (an indicator of erosion potential) from established trails than either hikers or llamas. Hooves also tend to punch holes through meadow turf and disrupt wet soils. Use of stock on frequently used, properly located, and well-maintained trails is unlikely to aggravate problems. However, *on little-used trails that are steep, pass through wet meadows, and are seldom maintained, stock use can be much more damaging than hiker use. Limiting stock use in such areas could reduce trail problems.*

Table 15.3. Common trail-impact problems and strategies and techniques for mitigating each problem.

Problem	Strategy	Technique (example)
Erosion	Improve location and/or design	Build water bars
Muddiness	Improve location and/or design	Route trails around boggy areas
Multiple trails	Improve location	Relocate trails
Shortcutting switchbacks	Change user behavior	Convince visitors to stay on existing trails
Informal trail systems	Reduce use	Reduce use quotas

For most trails, the most effective solution to erosion problems lies in locating the trail where it is resistant to erosion and, where this is not possible, designing it to minimize erosion. Studies have found that erosion is most severe where trails are located in soils of homogeneous texture and that lack rocks. Erosion-prone soils consist primarily of sand, silt, or clay, rather than a combination of these different particle sizes; fine sand and silt soils are particularly prone to erosion (Bryan 1977). Such soils are frequently encountered in glacial deposits, particularly in valley bottoms and enclosed basins. Meadows also often have homogeneous, fine-textured soils. Meadow soils can also be highly organic, and organic soils are particularly prone to deterioration (Stewart and Cameron 1992). Steep slopes and places where drainage or snowmelt run down the trail are prone to erosion. Streambanks, with steep slopes, abundant moisture, and, in many places, fine-textured soils, can frequently experience excessive erosion.

For these reasons, *in the mountainous West, erosion problems are frequently avoided by locating trails on ridges, talus slopes, and bedrock, away from alluvial plains and the glacial deposits of valley bottoms* (Summer 1980). South- and west-facing slopes are often preferred locations because snow melts earlier there. *Where trails receive regular use, trails are best located in forests outside of meadows.* Although the vegetation in meadows is relatively resistant (Cole 1993a), regular trail traffic use will eliminate even resistant vegetation and expose soils that are highly prone to erosion.

Several trail-design features can help minimize erosion by getting water off the trail. It is important to avoid steep grades by locating trails on side hills and by providing switchbacks where necessary. To divert water off the tread, trails are usually out sloped and often incorporate dips and rises (often called a rolling grade) rather than long, continuous down slope stretches. Water bars—logs, boards, timbers, or rocks installed across a trail, usually on an angle and sloping out—are common means of directing water off the tread and minimizing erosion. Water bars must be spaced closely enough so that water cannot build up excessive speed and erosive power. They must be securely anchored and large enough to keep water from running around or over them, forming destructive little waterfalls; and they must be maintained frequently because they cease to function when dislodged or buried in the sediment deposited behind them. Finally, all of these techniques need to be part of the original trail design; once a deep trough has eroded, none of these techniques will be effective. Proudman and Rajala (1981), Birkby (1996), and Hesselbarth and Vachowski (1996) provide good how-to instructions on these techniques.

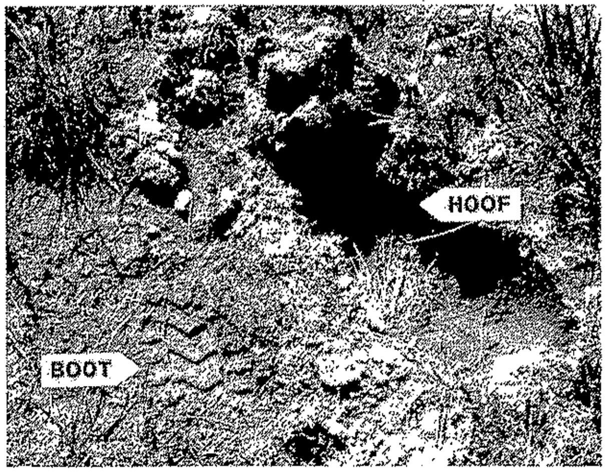


Fig. 15.17. The effect of a horse's hoof is very different from the effect of a hiker's boot. Hikers tend to compact the soil; horses can punch holes in the soil, leaving soil detached and easily eroded. Photo courtesy of David Cole, USFS.

It is also necessary to keep water from flowing onto the trail. The most common devices used are cross ditches (rock- or log-armored ditches crossing the trail), culverts (wood, metal, or fiberglass drainages buried underneath the trail), and parallel ditches (depressions that carry water adjacent to but lower than the trail tread). All of these devices must be carefully placed and maintained or they can aggravate problems and appear unnatural.

Erosion of stream banks can be minimized by locating stream crossings where banks are low, gentle, and stable. Where this is not possible, angling the trail across rather than directly up the bank and incorporating drainage devices can help minimize damage.

Muddiness

Muddy stretches are particularly disturbing to recreationists; and both hikers and pack stock balk at walking through muddy, wet areas. *In an attempt to avoid muddy sections, hikers and stock may travel parallel to the trail and enlarge the muddy area until it can be hundreds of yards long and unnecessarily wide.* These muddy areas usually result from trampling while soils are water-saturated. Again, amount and type of use are of little importance because it takes only a little trampling to do most of the damage; however, damage is much more rapid with stock use than with hiker use (Stanley and others 1979). Muddiness can be a season-long problem in places where the water table is always close to the surface, or it can be temporary, occurring during snowmelt or when heavy rains fall on trails that have been churned to dust. *The solution to trail muddiness is to either locate trails on dry soils or shield the wet soils from trampling through trail engineering. Relocation is preferred, if a better location exists.*

Snowfields that do not melt until late in the season should be identified, and trails should be located away from meltwater channels. Identifying areas where the water table is close to the surface is more difficult. By noting the plant species and plant communities that grow in places along existing trails where muddiness is a problem, one can identify reliable vegetation indicators of potential problems. In the Selway-Bitterroot Wilderness, for example, more than two-thirds of the muddiness problems in one trail system were found in one vegetation type, which, along with vigorous growth of four individual species, can be used to identify sites to avoid (Cole 1983b).

Where trails must be built through water-saturated soils and it is not possible to improve the drainage, some sort of bridging is necessary to shield the vulnerable soil from trampling. Stepping stones sometimes provide a simple solution. A common type of bridging—*corduroy*—consists of three or more logs laid on the ground as stringers and bound together with wire or nails. It is notorious for not lasting long and should only be a temporary measure (Hesselbarth and Vachowski 1996). More permanent solutions include *puncheon*, a deck or flooring placed on stringers to elevate the trail, and *turnpiking*, an elevated trail of earth or gravel fill supported either by logs or flat rocks. Turnpikes may or may not be ditched on either side or may use culverts to facilitate drainage. Although such a trail is a permanent improvement and shows a "substantially noticeable imprint of man's work," huge muddy areas are also noticeable and undesirable. Therefore, *it is our opinion that trail engineering in wilderness is appropriate where necessary to cope with mud as long as (1) relocation is not feasible, (2) the design fits the environment, and (3) the practice is not carried to the extreme where every small wet place is bridged.*

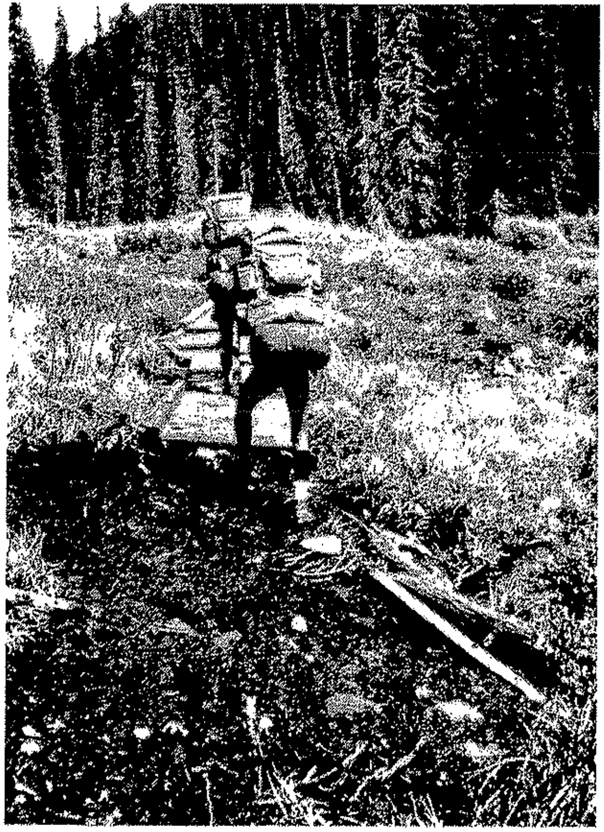


Fig. 15.18. Trails through areas of water-saturated soils develop into ever-larger bogs. In many cases the only solution is to bridge the area. It is best to bridge the entire bog, rather than just part of it—the problem with this trail. Photo courtesy of the USFS.

Impromptu Trails

The three most common types of undesirable impromptu trails are: (a) multiple, parallel, or braided trails; (b) shortcuts on switchbacks; and (c) informal trail systems that traverse popular trailless areas or that fan out across popular destination areas. Each of these situations is the result of a unique set of circumstances; consequently, very different management approaches are required for each. The one element they have in common is that they are caused by people leaving the existing trail system—out of either dissatisfaction with the trail itself or a desire to go someplace else. Therefore, understanding visitor behavior and possibly accommodating their desires, as well as informing them of the damage they are doing, are common means of dealing with these three situations.

Multiple trails are common in areas that are poorly drained or have homogeneous fine-grained textures, and in open areas, such as meadows, where it is easier for visitors to spread out. Trails in such places present difficult footing due to their slippery, muddy surface or their being deep and narrow. In either case, hikers and horses walk beside the trail, forming a new one. Other than educating people to stay on existing trails, the best solution to multiple trails is trail relocation. Over the past few decades, there has been a strong trend to get trails out of meadows into adjacent forested areas. However, trails abandoned in meadows usually need to be actively rehabilitated or they may continue to erode and may take centuries to recover.

In some places, such as Yosemite National Park, it has been very difficult to get people to stop using trails in the meadows or along other preferred routes. In these cases, engineering solutions such as turnpiking have been employed to overcome the problems that encouraged users to form multiple trails. Although engineering may be preferable to doing nothing, we feel it should be a last option. Widening the trail trough can be a means of making it easier for visitors to stay on the trail tread. Armoring the trailside with rock—by making it uncomfortable to leave the tread—can also be helpful.

Shortcutting switchbacks is a common problem that is usually dealt with by trying to change visitor behavior and through trail design. Whether through education or regulation, visitors are asked not to shortcut switchbacks. In some places signs have been erected along the trail; this is an undesirable intrusion and should not be used unless absolutely necessary. Designs that can effectively reduce shortcutting include screening one switchback from another, building barriers of rock or vegetation, avoiding the use of numerous short switchbacks, and using wide turns.

Informal trail systems indicate too much use of an area intended to be kept trailless. They are difficult to control. In popular destination areas, managers should consider developing an "official" trail system based on existing use patterns and encouraging its use. This strategy should control the size of the informal trail network and keep trails out of fragile environments. When laying out an official trail it is critical to provide access to the places visitors seek to go. If this is not done, the informal system will continue to be used, frustrating this management strategy.

Informal trails can also be controlled by reducing use, closing and rehabilitating trails, and persuading visitors to spread out. This is probably only realistic in remote, lightly used parts of the wilderness, where management objectives are to keep the area trailless. Once trails begin to develop, use must be reduced or an official trail should be designated. Although it may seem inappropriate to reduce use in lightly used places—particularly if use is not limited in much more heavily used destination areas—this may be the only means of meeting the objective of avoiding trails. Several actions can be taken at an early stage to make such an action less likely. Users of such areas should be educated about the need to travel in small parties, to spread out rather than follow in each other's footsteps, and to avoid using incipient trails. Of particular importance, management should not attempt to disperse use from heavily used destination areas to these lightly used areas unless they are willing to accept trails in these places.

As much of the preceding discussion concludes, next to proper trail location, engineering—surfacing, bridging, ditching, and so on—is the most effective means of avoiding trail problems. Problems that cannot be reduced or avoided by trail relocation will generally require an engineering solution. Although engineering is an appropriate means of providing for use without excessive resource damage, it is counter to the wilderness ideal, and therefore, should be kept to a minimum.

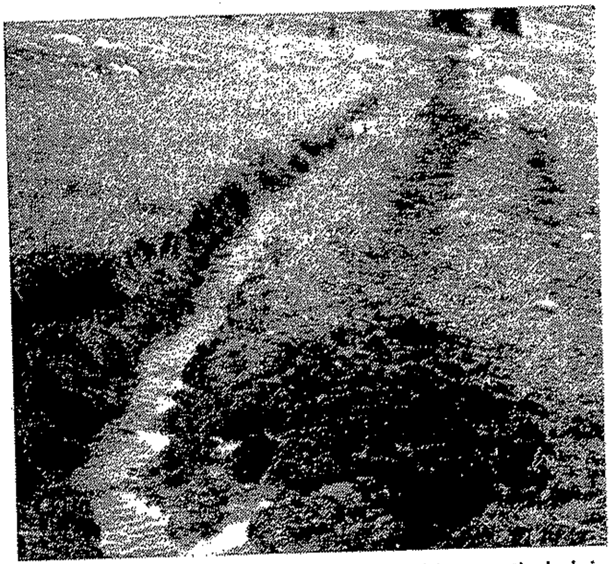


Fig. 15.19. Multiple trailing is a common problem, particularly in meadows. Such trails tend to form where the trail tread is difficult to use (note the water flowing down the main tread of this trail). The most common solution has been to relocate trails in the forest or at the edge of the meadow where soils are drier and less erodible. Photo courtesy of Randel Washburne, USFS.

Excessive relocation should be avoided because frequent relocation can produce a maze of closed trails. Managers must exercise restraint when relocating trails. This problem can be reduced by actively rehabilitating trails. A good rule of thumb, however, is not to relocate a trail unless (1) the new section is in a more resistant environment or is better designed, and (2) hikers can be kept off the old section of trail (Proudman and Rajala 1981). Unless both these conditions are met, relocation will only compound problems by disturbing new sites.

Monitoring Trail Conditions

Monitoring of trails can be used to ascertain trends in trail condition, where and how to locate and design trails, whether trail-management programs are working, and where and how trails need to be fixed.

For assessing trends in condition, rapid survey techniques are quick and easy and usually provide adequate precision. One approach is to sample conditions along trails at a systematic specified distance, such as every 100 meters. Using such an approach on a trail system in Montana, Cole (1991b) showed that mean trail width (the zone disturbed by trampling) increased from 100 cm to 125 cm between 1980 and 1989; however, bare width (the zone without any vegetation) and trail depth did not change significantly. Such data can also be used to assess the portion of a trail that exceeds certain depth or width standards or that contains certain "detracting features" (such as root exposure or muddiness). Recently, Leung and Marion (1999a) assessed the influence of sampling interval on the accuracy of estimates of the lineal extent of "detracting features" on trails at Great Smoky Mountain National Park. They report that a sampling interval of less than 100 meters is best, although an interval of 100 meters to 500 meters is probably acceptable.

They advocate using a sampling approach to assess the lineal extent of problems but advise against using a sampling approach to estimate the frequency of occurrence of problems.

Frequency of problems—and also lineal extent—is most accurately and usefully assessed with a census of the trail system. The first step here is to define exactly what is or is not considered a problem. As trails are walked, the number and length of problems are recorded and their location is mapped. Such information is useful to not only assess trend, but also in budgeting for trail maintenance and in allocating resources to certain trail segments. In a recent application of this approach at Great Smoky Mountains National Park, Leung and Marion (1999b) were able to show that (a) soil erosion and wet soil were the most extensive problems; (b) water bars were more effective than drainage dips in diverting water off trails; and (c) although serious impact problems were fairly well distributed through the park, trails with wet muddy treads were concentrated in places with high horse use.

An extension of the census—focused exclusively on decisions regarding where and what trail work is needed—is the prescriptive work log (Williams and Marion 1992). As the trails are hiked, problems are noted. Assessors note the distance along the trail of each problem, describe the problem, and attempt to prescribe the maintenance work needed to fix the problem.

For assessing the effectiveness of management programs or maintenance techniques on specific trail segments, the expense of more detailed replicable measurements may be justified. Typically, these techniques provide accurate measures of trail cross-sectional area at fixed locations that can be precisely relocated. Increases in trail cross-sectional area indicate erosion has occurred. Cole (1991b) used this technique to show that though there was no net trail erosion over an eleven-year period, one poorly located section of trail exhibited a two ft^2 increase in cross-sectional area. Warner and Kvaerner (1998) describe a photographic technique that can provide accurate estimates of trail erosion,

As mentioned earlier, it can be quite useful to census problem trail segments and look for associations between deterioration problems and environmental indicators such as vegetation type. These indicators, once identified, can be used to guide trail location and relocation and to indicate where engineering and maintenance are necessary. Although such a survey involves an initial outlay of funds, the investment will be recovered quickly in reduced trail relocation, maintenance, and rehabilitation costs.

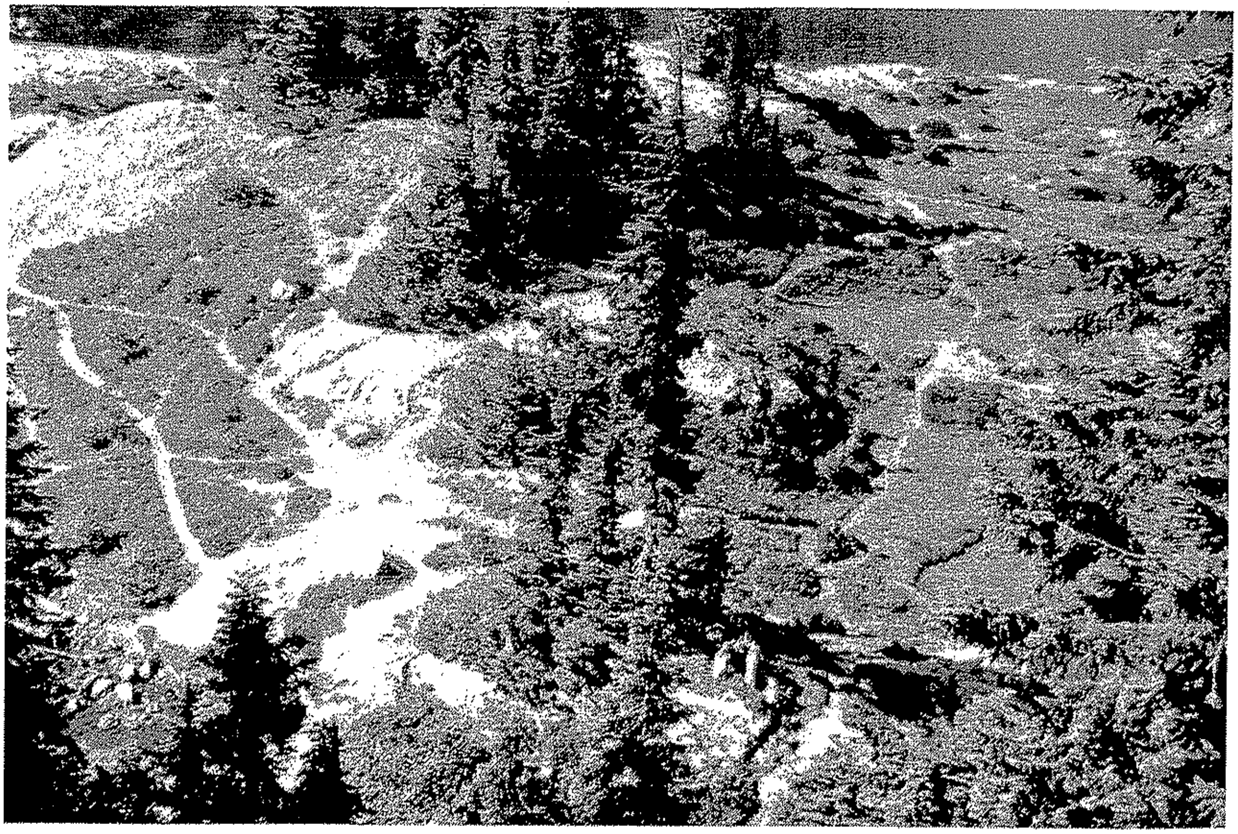


Fig. 15.20. Informal trail networks at popular destination areas can be unsightly. Managers often try to confine use and impacts to certain trails, while closing and restoring other trails. Photo courtesy of Alan Watson, USFS.

Trail Rehabilitation

Much of the information about rehabilitating campsites also applies to trails, particularly the techniques available for reestablishing vegetation and the need to eliminate all use. The major difference is the need, in many places, to stop erosion and to replace the soil lost by erosion. It also may be more difficult to keep people from using the trail if it leads where they want to go.

One must first provide a desirable alternative route to minimize use of a trail. This may require observation of use patterns and visitor behavior, and even some questioning of users about their itinerary and what alternative routes might be acceptable. Once the alternative has been provided, one should try to deemphasize the old trail. Careful selection of a starting point for the relocation can make it easier to hide the old trail. If it cannot be hidden, block it with logs, rocks, or brush. Finally, if this does not work it will be necessary to erect signs such as "Please stay on the trail to prevent damage."

Avoiding further trail erosion starts with looking for the erosion source. Sometimes runoff has been directed down the trail, and it must be diverted elsewhere. Ditches and water bars across the trail can be used to keep water off the trail. Where trails are deeply eroded, it may be necessary to place rock or log check dams in the trail to reduce water velocity and to allow backfilling of sediment (Rochefort and Gibbons 1992). Material used to fill in trail troughs—other than what is deposited behind check dams—must be judiciously selected. Where the trail follows the contour, it is often possible to move material deposited below the trail, because of construction, back into the tread. Other good sources of material include soil from streambeds and rock from talus slopes or other trail work. It is best not to remove too much material from any single place and to make certain the source area is blended into its surroundings and hidden from view. Regardless of where the material comes from, revegetation will be most effective if the trough is filled to grade with soil.

One of the few documented tests of rehabilitating multiple trails was tried along a section of trail in Tuolumne Meadows in Yosemite National Park (Palmer 1979). Of twenty techniques tried, the most successful one involved cutting off the sod ridges between the multiple trails at the level of the trail tread and stacking it in the shade. The soil beneath both the trails and the ridges was dug up to eliminate compaction, and sand was added to bring the trail up to the level of the surrounding meadow. Finally, the sod was divided into transplant plugs and planted. Although this technique will work only in certain environments, it is well suited to multiple trails in meadows—a very common problem in many areas. Eagen and others (2000) report on the continued success of this basic technique in Tuolumne Meadows.

Managing Pack and Saddlestock

Although the backpacking "boom" of the late 1960s and 1970s relegated pack and saddle stock to a minority use in all but a few wildernesses, *stock use (both riding and pack animals) is still an accepted tradition in the NWPS.* This is in contrast to some other nations, such as Australia, where use of stock in wilderness is not allowed. As of 1990, stock use occurred in about one-half of all wilderness areas (McClaran and Cole 1993). It is only explicitly prohibited in 14 percent of wilderness areas. *About one of every nine parties entering wilderness in 1990 traveled with stock, and about one-third of all nonadministrative use of stock is commercial, as opposed to private.* In 1980, although pack stock accompanied more than 2 percent of parties in only seventy-two wildernesses, and more than 50 percent of parties in only six areas, pack-stock impacts were reported to be a problem in seventy-six wildernesses (Washburne and Cole 1983).

Despite the prevalence of such problems, the published literature on pack-stock impacts and their management is sparse. Certain impacts are similar to those caused by hikers and can be managed similarly; others are qualitatively different and require very different sorts of management techniques.

Types of Stock Impact

Generally the impact of stock on trails is similar to that caused by hikers except that it is more pronounced. Weaver and Dale

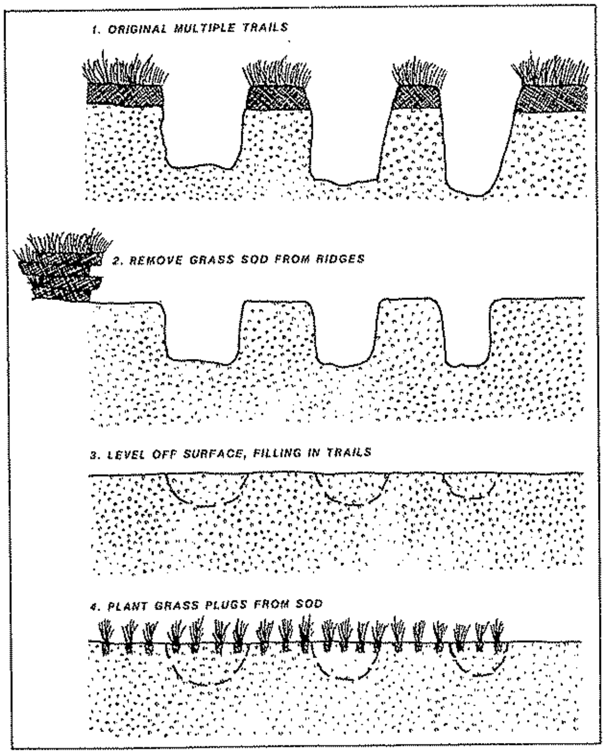


Fig. 15.21. Multiple trails have been revegetated by removing sod, leveling the soil surface, and transplanting sod plugs.

(1978) examined the effects of controlled amounts of use by horses and hikers on trail width and depth, percentage of bare ground, and soil compaction (bulk density). Trails produced by 1,000 horse passes were 2 to 3 times as wide and 1.5 to 7 times as deep as trails produced by 1,000 hiker passes. Compaction increased about 1.5 to 2 times as rapidly on horse trails as on hiker trails. Finally, one-half of the vegetation was lost after 1,000 hiker and 600 horse passes on a grassland, and after 300 hiker and only 50 horse passes in a forest. *In a more recent experimental trampling study in Montana, Cole and Spildie (1998) report that just 25 horse passes cause more loss of vegetation cover than 150 passes by hikers or llamas.* In a Tasmanian shrubland, Whinam and Chilcott (1999) report that broken plant material, as a percentage of plant biomass, was 0.1 percent after trampling by hikers, compared to 39.2 percent after trampling by horses. These experimental results suggest that *the creation of multiple trails and new trails in trailless areas will occur much more rapidly with stock use than with hiker use. The trails created will also be wider, deeper, more compacted, and less vegetated.*

The effect of stock on existing trails, which can differ from their effect on undisturbed sites, was examined experimentally in Great Smoky Mountains National Park (Whittaker 1978). Again, horse use caused more pronounced increases in trail width, trail depth, and litter loss than hiker use. In Montana, horse traffic on existing trails resulted in more than double the sediment yield caused by a comparable amount of hiker traffic (DeLuca and others 1998). Although hiker use generally tends to increase soil compaction on the trail, horse use loosens the soil, making it more susceptible to erosion (fig. 15.15). McQuaid-Cook (1978) comments that this tendency for shod hooves to loosen soil leads to more pronounced incision of equestrian trails. *Trail widening is accentuated by the tendency for stock to walk on the down slope side of the trail.* This breaks down the outer edge of the trail so that new soil must be brought in to rebuild the trail. The result is a wide trail, a much wider area of disturbance, and an ongoing trail maintenance problem (Whitson 1974).

Equestrian trails require considerably more maintenance than hiking trails. They must be "brushed out" to a greater height and width. Fallen trees must be quickly removed or detour trails will rapidly develop. Stock often break or dislodge drainage devices such as water bars. Stock disturbance of muddy trail sections can be particularly severe and can be corrected only with some type of bridging more elaborate than that required for foot travel.

At campsites, the magnitude of impact caused by stock parties as opposed to hiking parties is even more pronounced than on trails. Moreover, stock parties cause a number of impact types that other parties do not. Unfortunately, very little data on differences between these two types of use are available. Unpublished data from Dr. Sidney Frissell's work in the early 1970s, in what is now the Lee Metcalf Wilderness, indicate that campsites used by stock parties were, on the average, ten times as large and had seven times as much exposed mineral soil as sites used primarily by backpackers.

A more complete picture of differences in amount of impact between stock and backpacker campsites comes from

Table 15.4. Differences in amount of impact between sites used primarily by backpackers and sites used primarily by parties with stock, Bob Marshall Wilderness, MT.

	Backpacker sites	Stock sites
	Median	
Disturbed area (m^2)	76	456
Area devoid of vegetation (m^2)	3	13
Number of damaged trees	5	56
Number of felled trees	0	8
Number of trees with exposed roots	1	25
Seedling loss (%)	100	100
Ground-cover vegetation loss (%)	26	33
Relative cover of exotic plants (%)	5	43
Increase in mineral soil exposure (%)	4.6	9.3
Depth of organic horizons (cm)	2.2	1.2
Penetration resistance (kg/cm^2)	2.6	4.0
Infiltration rate (cm/min)	1.0	0.1

Source: Cole 1983a.

a comparison of six sites of each type in the Bob Marshall Wilderness (Cole 1983a). When compared to backpacker sites, stock sites are much larger, have many more damaged trees, have been more extensively invaded by exotic species, and have experienced much more profound soil disturbance (table 15.4).

Stock parties, generally being larger than backpacker parties, consequently disturb a larger area, to which is added an adjacent area where stock are kept. The animals are often tied to trees, resulting in a large number of damaged trunks and exposed roots. Because stock parties usually carry saws and axes to clean windfalls from trails, trees are often felled for tent poles to support large canvas tents and for firewood.

Although stock are usually kept adjacent to the camp, they occasionally are brought into the central camp area. Here, the action of their shod hooves can cause rapid deterioration of the site. Loss of organic soil horizons, increased compaction, and decreased infiltration rates typical of all campsites are particularly pronounced on sites used by stock parties. *Seeds of exotic plants contained in horse feed readily germinate and grow on such disturbed sites.* On Bob Marshall campsites, exotic species accounted for just 5 percent of the vegetation cover on backpacker sites, compared with 43 percent of the cover on stock sites (Cole 1983a).

In areas where stock are grazed or confined for the night, impacts result from both trampling and defoliation of plants. These impacts, described in the earlier section on grazing impacts, are unique to parties with stock and often affect a much larger area than all other recreational impacts combined. In a portion of the Eagle Cap Wilderness, an estimated 1.8 percent of the area had been significantly altered by recreational use. About three-fourths of this disturbed area consisted of areas used only by stock for grazing (Cole 1981). Moreover, in comparison to the forests, the meadows and grasslands used for grazing are often both rare ecosystems and aesthetic attractions; therefore their disturbance is particularly undesirable.

Meeting parties traveling with stock or finding evidence of stock use, such as manure or corrals, also detracts greatly from the experience of many wilderness users (Watson and others 1993). This is particularly true in the majority of wildernesses where stock use is a small minority. For example, in the Bridger Wilderness, Wyoming, where backpacking is the norm, 59 percent of parties preferred not to meet horse users; in the Bob Marshall Wilderness, where stock use is common, only 21 percent of parties preferred not to meet horse users

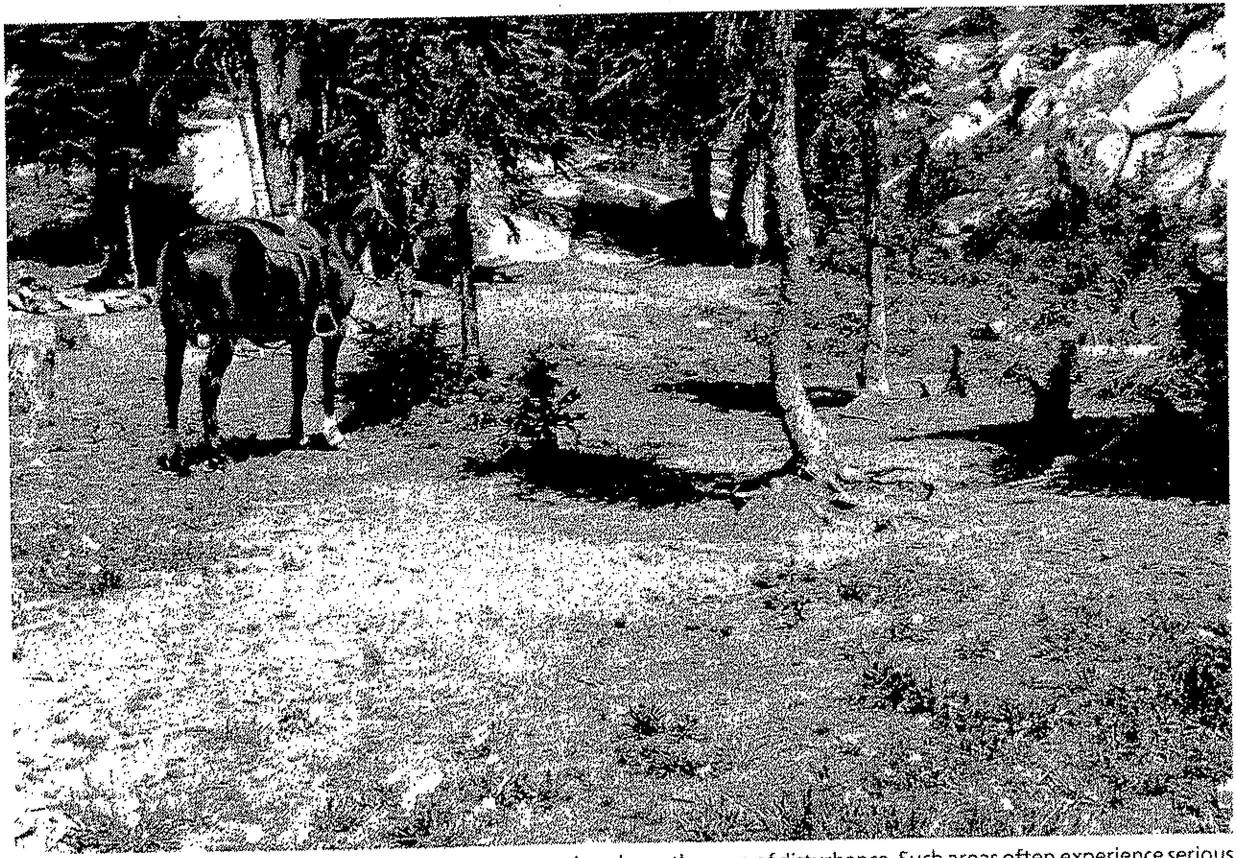


Fig. 15.22. Stock-holding areas adjacent to campsites greatly enlarge the area of disturbance. Such areas often experience serious tree damage, loss of vegetation, and soil erosion. Photo courtesy of the USFS.

(Stankey 1973). In the Rawah Wilderness, Colorado, where only 4 percent of the respondents to a survey used horses, 57 percent of those questioned wanted to see no horse users at all, not even small parties close to the trailhead (Badger 1975). Only 23 percent wanted to see no other hiking parties at all. The only situation wherein a party of hikers would be considered more objectionable than even a small party of horse users seen near a trailhead would be a large party of hikers walking or camped near the respondent's destination (Badger 1975).

In addition to dissatisfaction with meeting horse users, problems stem from finding evidence of horse use or dealing with inconveniences caused by their use. For example, in Yosemite National Park, Lee (1975) found that the presence of horse manure or facilities such as hitch rails were key sources of dissatisfaction with campsites. In addition to those that would rather not meet parties with stock in the wilderness, many visitors believed that use of stock in wilderness is inappropriate. For example, in the Sierra Nevada less than 15 percent of the parties surveyed approved of horses as a means of recreational travel; 60 percent thought that use of stock was inappropriate even to render emergency aid (Absher and Absher 1979). Although 59 percent of hikers in the Sequoia-Kings Canyon Wilderness felt it was undesirable to meet horse riders, only 25 percent of these respondents felt that the behavior of horse riders had ever interfered with the quality of their experience on any visit to the wilderness (Watson and others 1993).

Recent studies show that llamas cause substantially less impact to existing trails and to vegetation than horses, and visitor surveys suggest that hikers are less bothered by the use of llamas than the use of stock (Blahna and others 1985).

Management Strategies and Techniques

Despite a strong tradition of stock use in some wilderness areas, it is an inescapable conclusion that social, environmental, and administrative costs associated with stock use are much more pronounced than with a comparable amount of hiker use. This situation is aggravated by the large number of backpackers who feel that use of stock and its impacts are inappropriate. In many areas, the solution is complicated by a strong tradition of stock use by administrative agencies. In areas where use is already highly restricted due to ecological and social impacts, management must strive, particularly, to minimize those impacts associated with stock use.

Four Strategies to Minimize Stock Impacts

As with campsite and trail impact, a number of factors influence the *severity of stock impacts.* The most important are frequency and amount of use, party size and behavior, time of use, and location of use. These define *four primary management strategies: (1) limiting or reducing use, (2) encouraging less damaging behavior, (3) managing the timing of use—discouraging use during times of the year when the potential for damage is high, and (4) managing location of use—encouraging use of particularly resistant environments and containing use* is particularly valuable in controlling the spread of stock impact (table 15.5).

Limiting Use

Stock impacts on trails and campsites are unlikely to be greatly diminished merely by reducing use, unless use levels are cut to almost nothing (Cole 1987). Because stock use causes impact even more rapidly than hiker use, this conclusion has even more serious implications for managing stock use. Unless all

Table 15.5. Factors that influence pack-stock impacts. Each factor defines a strategy and set of specific techniques (of which only one example is provided here) for managing impacts.

Factor	Strategy	Technique (example)
Amount/frequency of use	Reduce use	Close overgrazed meadows
Party size/behavior	Change behavior	Promote low-impact use
Season of use	Change timing of use	Prohibit use during spring
Environmental/ site conditions	Increase site resistance	Reinforce trail with log cribbing
Use distribution	Contain use	Prohibit off trail travel with stock

others 2000). *Such high limits will have very little beneficial effect. Moreover, there is little equity in the common situation where the maximum allowable number of stock exceeds the allowable number of hikers.* The purpose of a party size limit is to restrict the impact that any given group can cause. Given that a horse will typically cause more than four times the impact of a hiker, a group of ten riders and fifteen stock will typically cause at least ten times the impact of a group of ten hikers. An equitable party-size limit would reflect these differences in potential impact. *Limits based on number of "heartbeats" are somewhat less discriminatory.* Using this approach, it is permissible for any group to have a given maximum number of heartbeats, say ten, which can consist of any combination of people, stock, or dogs.

Stock impacts could also be reduced by requiring parties to carry stock feed, thus virtually eliminating grazing damage. Seventeen percent of wildernesses with stock use, mostly NPS areas, have taken this action (McClaran and Cole 1993). Another 65 percent of wildernesses recommend packing-in feed. In many places, parties bring only enough feed to supplement grazing. Where deterioration is not yet critical, this approach may be more acceptable to users and may postpone or avoid the need for regulations. It is important, however, that the feed not contain exotic weeds. Certified weed-free hay is now required in many wilderness areas. Other possibilities include the prohibition of grazing where areas have been overgrazed.

Managing the Timing of Use

Although only 5 percent of areas prohibit stock use during certain seasons of the year (McClaran and Cole 1993), the impact of both grazing and trampling is highly dependent on seasonal variables, particularly the phenology or stage in the annual cycle of development of plants, and the moisture content of the soil. *Generally, plants and soil are most vulnerable to disturbance during spring when plants are using stored nutrients for growth and when soils are water saturated.* This has led Sequoia and Kings Canyon National Parks—the backcountry area with the longest history of research and management of pack-stock impact—to make their primary management tool a system of opening dates that are determined from information on the type of hydrologic year and the vegetation and soils (DeBenedetti and Parsons 1983). A research program examined the composition and distribution of the parks' major forage areas as well as their susceptibility to differing intensities, frequencies, and times of use. Opening dates were prescribed for three types of hydrological years (wet, normal, and dry), allowing the user to predict when use will be allowed.

Managing Location of Use

Probably the most effective way to manage the impact of stock is to control where stock use is and is not allowed. Reasons for this include (a) the high potential for damage wherever stock use occurs; (b) the high environmental, social, and maintenance costs of stock use that, in most areas, benefits only a small proportion of users; (c) the large numbers of impacts that are caused exclusively by stock; (d) the area affected only by pack stock, mostly grazing areas, is often much larger than the area affected by hikers; and (e) grazing impacts are concentrated on meadows that are often a rare and aesthetically important ecosystem type. In those few wilderness areas where stock use is the norm, confining use may be less justifiable and will be a less important strategy than changing behavior and practices.

A common action is to keep stock away from stream banks and lakeshores, where trampling can be particularly destructive and, in some cases, cause accelerated erosion. This will also reduce the risk of water pollution. Forty percent of areas with pack stock have this regulation, making it the second most common restriction on use of pack stock (McClaran and Cole 1993). Many more areas encourage this practice through educational programs.

In most NPS wilderness (91 percent), stock use is only permitted on established trails (McClaran and Cole 1993). Moreover, some parks—like Glacier National Park—only allow overnight stock use in selected areas judged to be resistant to stock impact. Less restrictive alternatives exist, although resultant impact will be greater. One approach is to permit stock use on mainline trails and selected trails into destination areas. For example, imagine a series of lakes up a tributary valley. Stock use might be permitted as far as a stock camp at the first lake above the valley bottom. However, foot traffic only is allowed beyond this first lake. Through this compromise, horse riders are provided with access to the tributary valley without opening up the entire string of lakes to the heavy impacts typically associated with stock traffic. Where certain trails are closed to stock use, trail-maintenance costs can be substantially reduced.

Sequoia and Kings Canyon National Parks have an even less restrictive policy. They prohibit stock use only in places that have never received regular stock use and in certain meadows being maintained as representative examples of pristine ecosystems (DeBenedetti and Parsons 1983). Such a policy provides opportunities for horse users to enjoy much of the wilderness while avoiding degradation of currently undamaged areas and providing protection for some representative examples of meadow types that might be entirely altered by unrestricted grazing. It also provides places for hikers to go where they know they will not see stock parties.

Confinement of stock impacts (limiting where they can go) appears to offer the optimal compromise between providing horse riders with access to wilderness while confining the heavy impacts typically associated with stock use. Because the job of management is to control impacts, it makes sense to equitably distribute the opportunity to cause impact. From this perspective, the confinement of stock to certain trails and areas is not discriminatory because it is necessary to compensate for the greater impact potential of stock users. Spildie and others (2000) evaluated the effectiveness of a confinement strategy designed to reduce the impact of stock in a subalpine lake basin in the Selway-Bitterroot Wilderness. Stock users were permitted to camp overnight at any of the lakes in the lake basin but were required to stay in a designated stock site provided at each lake. They were required to tie their stock to a hitch line that was to be strung between two designated trees, confining the impacts of stock containment to a very small area. The benefits of this program—in reducing impact—have been phenomenal. In just five years, disturbed area has decreased 37 percent and bare area has decreased 43 percent. Disturbed and bare area in the lake basin should eventually decline to just 36 percent and 24 percent, respectively, of what they were in the early 1990s. Moreover, costs to stock users are minimal. They retain the ability to access the entire lake basin, as long as they use specific campsites.

Forty-five percent of NPS wilderness areas require that stock parties camp at certain sites specifically designated for their use. This confines damage to one site in a particularly resistant area. In Yellowstone National Park, Wyoming, grazing is allowed only in designated meadows that are periodically closed to allow recovery. Corrals, drift fences, and hitch rails can also be used to confine the spread of impact. Where studied, most visitors support both restricting stock use in certain areas and requiring stock parties to use certain campsites (Badger 1975; Lucas 1980).

The Challenge of Stock Management

The damage caused by stock is generally much greater than that caused by hikers, many types of impact can be attributed solely to stock, and in most areas only a very small proportion of visitors benefit from and are associated with this impact. Many hikers consider this an inappropriate impact on the wilderness resource, and this along with other inconveniences, such as exposure to horse manure and moving off the trail to let horse users pass, creates conflicts between backpackers and horse users. These conflicts appear to be growing. Complaints about stock are the most common complaint from visitors in many wilderness areas.

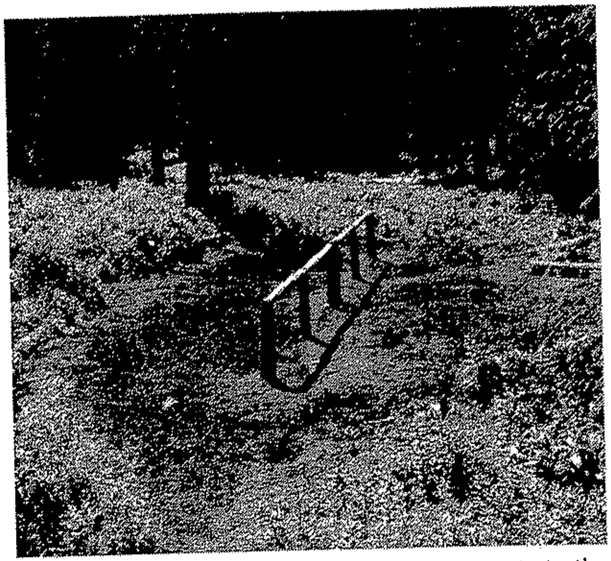


Fig. 15.23. Hitch rails, like corrals, serve to concentrate the impact of stock use in a small area. Photo courtesy of David Cole, USFS.

On the other hand, some stock use is a generally accepted, traditional type of wilderness use. Managers must grapple with the questions of how much of this impact is acceptable and where it should be allowed. An important question is whether to allow stock use in places now suffering from too much use. Stock impacts are likely to be less severe here than elsewhere because impacts are already so serious that further impact is unlikely. However, because such places receive heavy hiking use too, horse-hiker conflicts are likely to also be severe in such locations. Where impacts are excessive, managers can attempt to persuade stock users to use low-impact camping techniques, or they can confine stock use to certain trails and campsites. The most effective management programs will use a variety of techniques to reduce damage resulting from use of stock.

Summary

This chapter has identified the various environmental effects of wilderness recreation use and described many techniques for managing them *based on ecological impacts.* Several general points summarize this material.

First, impact is inevitable wherever wilderness recreation use is allowed. Therefore, consistent with the goal of providing recreation opportunities, management can only limit impact, not prevent it. Nevertheless, to prevent impact from increasing incrementally, with little ability to keep track of cumulative impacts, it is imperative to set specific objectives and standards that will place a limit on impact. Then, through monitoring of conditions, managers will be able to identify more clearly when specific impacts have become so pronounced as to demand management attention.

Second, many strategies and techniques are available to help managers deal with each type of impact. Too often, managers try only one technique—often the one they are most familiar with or one the neighboring manager is using. In most cases, however, using several techniques simultaneously will be much more effective than using just one. An appropriate process for selecting a suite of management techniques is to identify the source of the problem, to formulate actions that can eliminate the problem at its source, to implement a preferred set of actions, and, most important, to monitor results.

Managers have been preoccupied with "too much use" as the major cause of problems, and limiting use to a "carrying capacity" as the principal solution. Amount of use is just one of many factors influencing amount of impact; often it is one of the less influential factors. Likewise, limiting use to a carrying capacity is only one of many alternative management techniques, and often it is not very effective. However, there clearly are situations where use must be limited. *More consideration should be given to limiting use of wilderness that is still relatively lightly used and impacted—to see that it remains in that state.* Where use is limited, other actions—such as confinement of impact—is often necessary if use limits are to be beneficial.

Finally, managers must show equal concern for both quality of wilderness visitors' experience (see chap. 16) and environmental impacts. The two are inextricably bound together; actions that affect one will affect the other—sometimes in positive and sometimes in negative ways. Therefore, managers must clearly define problems and how alternative actions will deal with them (see chap. 16). Managers must also consider how an action to correct a problem in one specific place will affect other places and other wilderness conditions. Only through more effective integration of ecological and visitor experience concerns, both in research and management, can we develop the more holistic approach that will make wilderness management more effective.

Study Questions

1. Select two recreation impact "situations" (type of impact, environmental type, and location) that represent substantial alterations of natural conditions and two recreation impact situations that may *not* represent substantial alterations. Defend your choices.
2. Provide a detailed description and one example of (a) direct, (b) indirect, and (c) cyclic effects of trampling on vegetation and soil.
3. Suggest two actions that managers might take to influence the amount of use that campsites receive and, thereby, reduce impact. Contrast the appropriateness of each action on campsites in heavily used and popular destination areas with campsites in lightly used remote places in the wilderness.
4. Compare and contrast the magnitude and nature of impacts caused by (a) small parties and large parties and (b) hiker parties and stock parties. Describe where impacts are similar and where they differ.
5. What do studies suggest about the relative impact (magnitude) of horses versus hikers? What about llamas? Suggest and defend management actions that might be taken to minimize differences.
6. Discuss the dilemma between dispersing use and dispersing impacts. How would this dilemma affect decisions about: tearing down rock fire circles (rings) at a popular site or closing heavily used campsites?

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Professor of Resource, Recreation, and Tourism, and Professor Emeritus of the University of Idaho Wilderness Research Center, JOHN C. HENDEE is editor-in-chief for the *International Journal of Wilderness* and a director of the WILD Foundation. CHAD P. DAWSON is professor of Recreation Resources Management in the College of Environmental Science and Forestry at the State University of New York–Syracuse (ESF-SUNY). He is managing editor for the *International Journal of Wilderness.*

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CPC Exh 55

Dr. Paul Mankiewicz - June 22, 2004

1" runoff 1 acre cu.ft.	1" runoff 25 acres cu.ft.	2" runoff 25 acre cu.ft.	3" runoff 25 acre cu.ft.
3,605	90,133	180,267	270,400
gallons	gallons	gallons	gallons
26,968	674,197	1,348,395	2,022,592
	pounts silt at 10ppm	pounts silt at 10ppm	pounts silt at 10ppm
	56	112	169

25 acres square feet	square 25 acres
1,089,000	1,044
if 200 ft wide	
5,445	
if 500 ft wide	
2,178	

water lost to base flow per 500 acres cubic feet	each inch runoff water lost to base flow per 500 acres cubic feet
21,780,000	1,815,000

56

CPC Ex 56

STATE OF NEW YORK
OFFICE OF THE ATTORNEY GENERAL

ELIOT SPITZER
Attorney General

(518) 474-4843

DIVISION OF PUBLIC ADVOCACY
ENVIRONMENTAL PROTECTION BUREAU

April 23, 2004

Via Overnight Delivery

Mr. Alexander F. Ciesluk, Jr.
Deputy Regional Permit Administrator
New York State Department of
Environmental Conservation, Region 3
21 South Putt Corners Road
New Paltz, New York 12561

Re: SEQRA Draft EIS: Belleayre Resort at the Catskills Park
DEC App. Nos: 3-9903-00059/00001 (DEIS Reference Number)
0-9999-00096/00005 (SPDES Big Indian)
0-9999-00096/00007 (Section 401 Water Quality Certification)
0-0000-00096/00009 (SPDES Wildacres)

Dear Mr. Ciesluk:

Thank you for providing us with an opportunity to submit comments with respect to the draft Environmental Impact Statement and the above referenced permit applications for the proposed Belleayre Resort at the Catskills Park. These comments address issues associated with the proposed project as they relate to water quality. Our comments address the above-referenced SPDES permits as they relate to the adequacy of controls on polluted runoff during and after construction. We also submit detailed comments concerning wetlands, a matter that is relevant to the project sponsor's application for a Section 401 water quality certification.

Again, thank you for the opportunity to submit these comments. If we can be of any assistance on this matter please do not hesitate to call.

Very truly yours,

Jim Tierney

James M. Tierney
Watershed Inspector General
Assistant Attorney General

Charlie Silver

Charles D. Silver, Ph.D.
Watershed I.G. Scientists

cc: Distribution

The Capitol, Albany, NY 12224 ● (518) 474-8096 ● Fax (518) 473-2534

OFFICE OF THE NEW YORK STATE ATTORNEY GENERAL

COMMENTS OF THE NEW YORK CITY WATERSHED INSPECTOR GENERAL ON THE DRAFT ENVIRONMENTAL IMPACT STATEMENT AND ASSOCIATED ENVIRONMENTAL PERMITS WITH RESPECT TO THE PROPOSED "BELLEAYRE RESORT AT CATSKILL PARK."

New York State DEC Application No. 3-9903-00059/00001

April 23, 2004

We appreciate this opportunity to submit comments to the New York State Department of Environmental Conservation ("DEC") concerning the draft environmental impact statement ("DEIS") with respect to the Belleayre Resort at the Catskill Park (the "Project"). The position of New York City Watershed Inspector General is a joint appointment of the Governor and the Attorney General within the Attorney General's Office that was established pursuant to the 1997 New York City Memorandum of Agreement.

These technical comments present our concerns with respect to the adequacy and scope of the DEIS as it relates to adverse impacts on water quality. These comments focus on: (i) natural conditions related to water quality such as soil characteristics, rainfall intensity and construction slopes; (ii) the technical adequacy of the program to limit contaminants in runoff both during and after Project construction; (iii) the sufficiency of the assessment of secondary and cumulative growth inducing impacts of the Project; (iv) wetland destruction; and (v) the adequacy of the integrated pest management program that will govern the use and monitoring of pesticides and herbicides.

As explained below, there are significant deficiencies with the DEIS and related documents. We request that there be another opportunity for public comment on the revised DEIS and other documents.

I.

THE PROPOSED PROJECT IN ITS ENVIRONMENTAL CONTEXT WITH RESPECT TO WATER QUALITY.

The proposed Project is located within both the Catskill and Delaware water supply "systems" of the New York City Watershed ("Watershed").[1] This portion of the Watershed serves as an unfiltered drinking water source for over 9 million people. The only treatment this water receives from reservoir to tap is disinfection through chlorination. The Project is also

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[1] While the New York City Watershed provides drinking water for half of State, it only comprises 4.2% of the State's land mass. The entire "West of Hudson" Watershed, the usual source of 90% of the drinking water, constitutes only 3.4% of the State – an area that is roughly the size of Delaware County.

situated within the Catskill Park. No portion of the proposed Project is planned to be located within an existing village or hamlet area.

The proposed Project consists of two complexes on mountain ridges and sides that straddle both shoulders of the State-owned Belleayre Ski Center. It would involve 400 hotel rooms, a conference center, 351 additional hotel/condo units and two 18-hole championship golf courses, on 573 disturbed acres. A total of 130 new buildings would be constructed. Full-time employment is estimated by the developer at 542 individuals; part-time employment is estimated at 330.[2] The Project is located in the Towns of Shandaken, Ulster County and Middletown, Delaware County.

The portion of the Project site in Ulster County is generally drained by tributaries of the Esopus Creek, the major source of water flowing into the Ashokan Reservoir. The Project area within Delaware County generally is drained by tributaries of the East Branch of the Delaware River, the major water supply for the Pepacton Reservoir. Both the Ashokan and the Pepacton are classified by DEC as "AA" surface waters. Thus, by virtue of DEC regulation, these water bodies are required to be maintained at a quality that allows each to serve as an unfiltered drinking water source.

The Ashokan and the Pepacton reservoirs are particularly important reservoirs within the Watershed, as the waters of the two other large reservoirs of the Catskill and Delaware systems, the Cannonsville and the Schoharie, are often subject to significant environmental impairments. The Cannonsville Reservoir is affected by algae blooms and eutrophic conditions due to excess phosphorus.[3] The Schoharie Reservoir is adversely affected by high levels of turbidity and

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[2] These numbers are provided in the DEIS, although without any supporting analysis. The consultants for the Project sponsor did not independently model employment and wage projections, but rather, accepted estimates provided by the Project sponsor.

[3] The Cannonsville Reservoir has seen levels of total phosphorus decrease slightly over the past decade to levels that are slightly below State DEC's guidance value of 20 micrograms per liter (or 20 parts per billion) – a guidance value developed to protect recreational uses. According to the New York City Department of Environmental Protection ("DEP"), however, there has been a slightly upward trend in levels of chlorophyll *a* over the time period of 1990 to 2002. With respect to algae blooms, therefore, the water quality of the Cannonsville Reservoir is not improving and is actually getting somewhat worse. The Cannonsville Reservoir continues to be classified as eutrophic under the Carlson Trophic State Index ("TSI"). DEP's most recent evaluation of chlorophyll *a* levels gave the Cannonsville a TSI of 52. Any measurement of 50 or over is considered eutrophic. Problematic blue-green algae blooms continue to occur in the summer growing season. Moreover, low dissolved oxygen conditions persist in the lower and mid-level waters of the Cannonsville Reservoir. Due to these algae blooms, City DEP will frequently turn off the Cannonsville's flow. Algae blooms in the Cannonsville can also "seed" algae blooms in down-stream reservoirs, such as the Roundout Reservoir.

suspended solids.[4] Therefore, two of the key water pollutants of concern when reviewing new projects in the Watershed are phosphorus[5] and suspended sediment (also referred to as turbidity).[6]

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[4] The Schoharie Reservoir is often brown in color due to high levels of suspended sediments. The upland soils and stream beds within the Schoharie's drainage basin contain many clay or colloidal-type soils, as do the reservoir bottom and shores. Wave action, stream erosion, storm flows, construction excavation, soil tilling, roadway drainage cuts, timber harvesting, mud boils and underwater scour near the entrance to the Shandaken Tunnel inlet are some of the sources of this turbidity. High levels of sediment and silt have resulted in DEC formally listing the Schoharie Reservoir as "impaired" on its 2002 list of impaired water bodies under § 303(d) of the Clean Water Act.

[5] The adverse impacts of algae blooms due to phosphorus pollution are well established. Excess phosphorus leads to algae blooms, including increased growth of toxin emitting blue-green algae. Algae blooms lead to high bacteria growth that, in turn, depletes the reservoir bottom waters of dissolved oxygen. Low dissolved oxygen suffocates or drives off fish. Low oxygen levels cause a change in the biology of reservoir waters that result in impaired water taste, odor, and color. Iron, manganese and hydrogen sulfide are brought into the water column under these de-oxygenated conditions. Moreover, the higher levels of dead algae, bacteria and other chemicals in the water constitute an increase in organic matter that interacts with chlorine during the drinking water disinfection process – likely causing elevations in disinfection by-products; many of these chlorinated organic compounds are suspected by the U.S. Environmental Protection Agency ("EPA") of being carcinogens and have been identified in a number of medical studies as a factor linked to early term miscarriages. Finally, the increased material suspended in the water, resulting from phosphorus-induced algae blooms, can interfere with the effectiveness of chlorination and help to transport waterborne pathogens to water consumers.

[6] Turbidity in water can help to transport pathogens, serve as food for pathogens, promote the regrowth of pathogens in the water distribution system, and shelter pathogens from exposure to attack by disinfectants such as chlorine. The organic particles that cause turbidity can also combine with chlorine to create problematic disinfection by-products that are possible carcinogens and suspected of increasing the risk of miscarriage. For these reasons, the EPA in its Surface Water Treatment Rule, prohibited raw water turbidity measurements in unfiltered drinking water at the intake to the distribution system in excess of 5 nephelometric turbidity units ("NTU"), see 40 CFR § 141.71(a)(2). More than one violation per year is grounds for EPA to require construction of the water filtration plant for the New York City supply, estimated to cost over $6 million with an additional $200 to $300 million a year to operate. For an overview of the public health concerns raised by turbidity in drinking water, *see* U.S. EPA, *Guidance Manual for Compliance with the Interim Enhanced Surface Water Treatment Rule: Turbidity Provisions*, Office of Water, EPA 815-R-99-010, April 1999, Chapter 7 (and numerous cited references); *see* also Kistemann, T., *et al.*, *Microbial Load of Drinking Water Reservoir Tributaries During Extreme Rainfall and Runoff*, Applied Environmental Microbiology, Vol. 68, No. 5, pp. 2188-2197 (May 2002); Naumova, E., *et al.*, *The Elderly and Waterborne Cryptosporidium Infection:*

In addition, the Ashokan Reservoir itself exhibits high turbidity at times. For example, during most of the week of March 15, 2004, the Catskill system of the Watershed (which is comprised of the Schoharie and Ashokan Reservoirs) was in a "turbidity alert," with increasingly turbid waters flowing from the Ashokan Reservoir into the Kensico Reservoir and then into the water distribution system. Turbidity levels in water leaving the Ashokan Reservoir had reached 4.07 NTU's as of March 17, 2004. A review of records shows that there were at least eight other Catskill system turbidity events since 1996 – some of which lasted many days and even months.[7] DEC has formally listed the Ashokan as "impaired" due to high silt and sediment levels on its 2004 list of impaired water bodies pursuant to § 303(d) of the Clean Water Act.

Developments such as the Project can affect water quality through construction-related impacts as well as through increased runoff caused by increased impervious surfaces. As discussed below, the Project, particularly given the relevant environmental characteristics of the site, appears to present significant water quality concerns that are not addressed in the DEIS.

The portion of the proposed Project that is located within the "Catskill" portion of the Watershed would appear to raise more significant concerns with respect to drinking water quality. The Schoharie Reservoir, one of two reservoirs within the Catskill system, is already severely impaired, even though the Schoharie basin is not highly developed. The Esopus Creek, which drains the eastern portion of the Project site, has also been formally recognized as impaired on the State's Clean Water Act § 303(d) list due to excess silt and sediment. The Ashokan Reservoir basin is only approximately 257 square miles in size. While the water quality of the Pepacton Reservoir may recover by flowing through a series of other reservoirs before entering the water distribution system, the Ashokan Reservoir is a terminal reservoir so that water can be and is drawn directly from that reservoir into the water distribution system. Even during normal operations, the settling time available to Ashokan waters in the Kensico Reservoir is generally far shorter (approximately 30 days) than those available for Pepacton waters. Moreover, due to its relative proximity to population centers in the southeastern portion of New York State, it is also likely that the Ashokan Reservoir basin will be subject to the highest development pressure over the long-term.

Gastroenteritis Hospitalizations Before and During the 1993 Milwaukee Outbreak, Emerging Infectious Diseases, Vol. 9 No. 4, pp. 418-425 (2003). These articles are attached as Exhibit 1.

[7] Records maintained by the State Department of Health indicate that the initial dates of these eight additional turbidity alerts were: January 19, 1996; January 13, 1997; September 15, 1999; December 16, 2000; March 22, 2001; March 30, 2001; September 17, 2003; and September 29, 2003. The turbidity flowing from the Ashokan Reservoir was so significant on three occasions that DEC allowed DEP to add chemical flocculants into reservoirs to reduce turbidity (the events starting January 19, 1996, January 13, 1997, and December 16, 2000).

II.

SUMMARY ASSESSMENT OF SOILS FOR EROSION, PERCOLATION, SLOPES AND OTHER RELEVANT FACTORS AT THE PROJECT SITE.

A. Overview of Soils Analysis

We have undertaken a detailed assessment of the soil and slope characteristics of the Project site, and reviewed the soil and slope conditions that are found generally in the Catskill portion of the New York City Watershed. This information was obtained from the Project sponsor, City DEP, and the various County Soil and Water Conservation Districts that operate within the Watershed. Geographical Information System ("GIS") mapping was employed to assess the actual acreage of various soil types and slope conditions as they relate to specific areas of construction disturbance. This analysis employed the soil use ratings of the United States Department of Agriculture's Natural Resource Conservation Service.

This information, which was not contained in the DEIS, is of critical importance to designing effective engineering controls on polluted runoff and developing appropriate conditions for the SPDES individual stormwater construction permit. It also supports the recommendation (see Part III of these comments) that upward departures from the 5-acre State-wide limit on "raw earth" construction excavations be allowed only after careful evaluation. Further evaluation may also demonstrate that certain areas slated for construction may require reductions below the 5-acre standard. The detailed tables summarizing this assessment are presented as Exhibit 3. The tables are explained below. The background on soils and slopes in the Catskill portion of the Watershed (Table 9 of Exhibit 3) is useful for assessing potential risks associated with secondary or cumulative growth from the Project (see Part IV of these comments).

Many of the soil types located on the Project site have characteristics (high erosivity, clay or colloidal-type particles, low percolation rates, etc.) that can present significant erosion and water quality concerns. Slopes are often steep (15% and above) to very steep (35% and above). The project is in the highest rainfall region in the state. Precipitation for the one-year storm event is 3.5 inches, the two-year storm event is 4 inches, the ten-year storm event is 6 inches, the hundred-year storm event is 8 inches and average annual rainfall is 47.1 inches according to the Natural Resources Conservation Service. The project site is characterized by a combination of intense rain fall/snow melt events, low soil percolation, high soil erosivity, and colloidal soil particles that can remain suspended for many months and steep slopes, all of which create significant challenges with respect to the protection of water quality.

This soils analysis demonstrates that some of the areas of the Project site that are proposed for construction disturbance pose a very significant risk. Over 230 acres of the project will involve construction on slopes at or in excess of 15% with soils that are classified by the Natural Resources Conservation Service as being severely restricted for such use. Moreover, some 157 acres of the Project site will be constructed on slopes at or in excess of 35% with severely restricted soils. Hydrologic soils group C and D soils are the only soils groups found on the entire project site. These soils have very low percolation rates, a factor that tends to significantly increase volumes of stormwater runoff. Many of the soils found on slopes below 15% also present severe erosion potentials. In addition, over 52% of the entire Catskill portion of the Watershed is characterized by slopes at or in excess of 15% with soils that are classified as severely limited. (Table 9 of Exhibit 3).

B. Geology

The Project site is in an area that is strongly influenced by the activities of glaciers that covered the area during the most recent ice advance 16,000 years ago. Both depositional and erosional features resulting from the glaciers are found throughout the area. Although bedrock can be found close to the surface in the higher elevations, significant thicknesses of unconsolidated deposits are also found in the vicinity of the Project site, particularly in the lower elevations and on the valley floors. Depth to bedrock at the higher elevations ranges between 12 to 22 inches. In some areas of the valleys, bedrock can be found 80-100 feet below grade. The unconsolidated deposits are composed largely of glacial tills and glacial lacustrine deposits. Thick deposits of silts and clays, deposited by glacial lakes that once existed, are found throughout the region.

C. Soils

Soils on the Project site were characterized and delineated for the Project sponsor by Roger Case, a consultant and former Natural Resources Conservation Service ("NRCS") soil scientist. Mr. Case produced the "Soils Map Eastern Portion"and "Soils Map Western Portion" that are displayed in the DEIS (Figures 3-6 and 3-7 respectively) and which were employed in this analysis. To evaluate the level of impact to soils from construction we referred to two GIS files: (i) the soil maps and (ii) a map of proposed impervious surfaces (e.g., buildings and roads) and landscaped areas (e.g., golf fairways). This data was reviewed to evaluate whether the soils underlying the areas proposed for construction disturbance are suitable for their proposed use pursuant to federal guidelines. A number of tables were assembled to assist in evaluating potential adverse impacts associated with proposed construction.

D. Definitions, Evaluation Methods and Results of the Assessment

Tables 1 and 2 of Exhibit 3 present soil characteristics associated with slope, percolation rates, runoff, and erosivity for both the Big Indian (eastern) and Wildacres (western) portions of the Project site. The soils with specific characteristics are presented in gross acreage and in percentage of the Project site. Soils that comprised less that 1% of the Project site were not included in these tables (explaining why some columns do not add up to 100%). The terms used in these tables as well as the tables themselves are summarized below.

1. DEIS Soils Codes: This column lists the soil codes (e.g., "EkD") that represent the specific soils (e.g., Elka Silt Loam, 15 to 25 percent slopes) that were identified on a portion of the Project site. The soil codes (also called map units) presented in the first column were the ones used in the DEIS. One point of confusion was that different soils scientists and Soil Conservation Districts employ different soils codes for the same soils. We have conformed all of these definitions and identified the construction risk characteristics associated with these soils as defined by the federal Natural Resource Conservation Service.

2. Delaware County Soils Codes: The Eastern portion of the proposed development is in Ulster County and virtually all of the Western portion of the project site is in Delaware County. The Ulster County Soil Survey was published in 1979, whereas the Delaware County Soil Survey was released "on-line" in 2003. Soil scientists at the NRCS were contacted for their expertise and guidance concerning which soils codes to use to interpret site soils. The NRCS soil scientists selected the Delaware County soil codes.

3. % of Eastern / % of Western Project Site: Any soil that was referred to in the DEIS and was present on the Eastern or the Western portion of the site at greater than or equal to 1% is listed and quantified in this column.

4. Slope (%): This represents the slope of the land. Percent is employed as the standard term even though the term "degree" (as in a "30 degree angle") is thought to be more appropriate by some. Slopes exceeding 15% are designated as "steep slopes" by the New York State erosion control guidance manual. Slopes in excess of 15% are considered too steep and deemed unsuitable for siting septic systems in New York by the New York State Department of Health. See 10 NYCRR Part 75, Appendix 75-A p. 4503). Slope influences the retention and movement of water, the potential for soil slippage, accelerated erosion, the ease with which machinery can be used and the engineering uses of the soil. Slopes on this site are often quite steep. For example, about two thirds of the Project site is characterized by steep slopes (15% or more) and more than a third of this site (39%) is characterized by very steep slopes (35% to 70% slopes).

5. Hydrologic Soils Group: The NRCS has grouped soils into four distinct classes based on how they respond to water. The four classes are hydrologic soils group:

A: High Infiltration Rate (water "seeps" into the ground quickly)
B: Moderate Infiltration Rate
C: Slow Infiltration Rate
D: Very Slow Infiltration Rate (if the site is "flat" water is prone to form puddles, if the site is "hilly" the water will likely flow downhill)

(NRCS 2003 Part 618.35). Group A soils are often sandy, whereas Group D soils often have a high clay content or a restrictive layer (e.g., bedrock). Soils at the project site are classified as C and/or D. As a result, runoff is high and infiltration is low.

6. **Erosion Factor (Kf):** Erosion is an important process that affects soil formation and may remove all or parts of the soils formed in natural landscapes. Evaluating the degree of erosion that takes place is important in assessing the health of the soil and in assessing the soil's potential for different uses. Removing increasing amounts of soil alters various properties and capabilities of the soil. Soil erosion factors (Kf) were developed to quantify how susceptible very small soil particles (e.g., clay, fines, <2.0 millimeters) are to being detached from soil and rock by water. These factors are particularly important in the Watershed because (as discussed in Part I) detached clay particles suspended in water cause turbidity and adversely impact drinking water quality. The Kf soil erosion factor also accounts for freeze thaw cycles and predicts long term average soil loss. Kf erosion factors range from none (0.02) or slight to severe or very severe (0.49 in the northeastern US). The higher the Kf erosion factor the greater the probability that small particle erosion will occur. Soils at the project site have Kf erosion factors of .28 - .32 indicating that erosion of small soil particles at the project site is a significant concern. (NRCS 2003 Part 618.55).

7. **Runoff Class:** The index surface "runoff class" refers to the loss of water from an area by flow over the land surface. Runoff classes can be estimated using soil slope and permeability. There are six runoff classes: negligible (N), very low (LV), low (L), medium (M), high (H), and very high (HV). (NRCS 2003 Part 618.49). Applying the runoff class values to the soils on the Big Indian portion of the site, 35% of the soil (428 acres) is classified as having very high runoff potential, 37% (436 acres) as having high to very high runoff potential, and 28% (345 acres) has medium runoff potential. Applying the runoff class values to the soils on the Wildacres portion of the site, 30% of the soil (213 acres) is classified as having very high runoff potential, 51% (364 acres) as having high to very high runoff potential, and 18% (130 acres) has medium runoff potential.

8. **Soil Interpretation Rating Guides:** Soil Interpretation Rating Guides prepared by the NRCS were employed to assess a soil's limitations for different uses. Based on the proposed land use at the Project site, the following soil interpretation rating classes were assessed:

(1) dwellings with or without basements;
(2) local roads and streets; and
(3) golf fairways, lawns, and landscaping.

These soil ratings are defined in terms of severity such as "slight," "moderate," or "severe."

(i) Slight (Not limited): This rating is given to soils that have properties favorable for the use. The degree of limitation is minor and can be overcome easily. Good performance and low maintenance can be expected (NRCS 2003 Part 620.03).

(ii) Moderate (Somewhat limited): This rating is given to soils that have properties moderately favorable for the use. This degree of limitation can be overcome or modified by special planning, design, or maintenance. The expected performance of the structure or other planned use is somewhat less desirable than for soils rated slight. The needed measures usually increase the cost of establishing or maintaining the use, but the cost is generally not prohibitive.

(iii) Severe (Very limited): This rating is given to soils that have one or more properties unfavorable for the rated use. This degree of limitation generally requires major soil reclamation, special design, or intensive maintenance. Some of the soils, however, can be improved by reducing or removing the soil feature that limits use; but in most situations, it is difficult and costly to alter the soil or to design a structure so as to compensate for a severe degree of limitation. This rating does not imply that the soil cannot be adapted to a particular use, but rather that the cost of overcoming the limitation would be high.

Individual tables for each of these three rating classes and their limiting features -- the soil characteristics that create the risk -- were prepared for the eastern and western portions of the Project site (Exhibit 3, tables 3-8.) Use of the soil interpretation rating guides in the planning and evaluation process allow the user to identify and recommend site selection and plan measures that minimize impacts on the soil resource (NCRS 2003 Part 620.05).

Table 3 of Exhibit 3 evaluates the 14 acres of soil at the Big Indian portion of the property that has been set aside for buildings. The data demonstrate that more than two thirds (10.6 acres) of this area is proposed to be built on steep slopes that exceed 15%. The rating class for the proposed development with basements is severe for all 14 acres. Dwellings without basements have a moderate rating as long as the slope of the land does not exceed 15%.

Table 4 of Exhibit 3 evaluates the 10.5 acres of soil at the Wildacres portion of the property that has been set aside for buildings. The data demonstrate that just under half (4.8 acres) of this area is proposed to be built on steep slopes that exceed 15%. The rating class for the proposed development with basements is severe for 10.2 of the acres.

Local roads and streets are those roads and streets that have all-weather surfacing (commonly of asphalt and concrete) and that are expected to carry automobile traffic year-round. For the purpose of interpreting how these proposed impervious surfaces at the Project site might impact soils, parking lots were included in our local roads and streets evaluation.

Table 5 of Exhibit 3 evaluates the 36.7 acres of soil at the Big Indian portion of the property that has been set aside for roads, streets, and parking. The data demonstrate that approximately two thirds (24.0 acres) of this area is proposed to be built on steep slopes that exceed 15%. The rating class for 22.9 acres of the 24 acres is severe.

Table 6 of Exhibit 3 evaluates the 24.6 acres of soil at the Wildacres portion of the property that has been set aside for roads, streets, and parking. The data demonstrate that more than a third (8.8 acres) of this area is proposed to be built on steep slopes that exceed 15%. The rating class for more than 10.2 acres is severe.

Lawns, landscaping, and golf fairway soils are rated for their use in establishing and maintaining turf. The ratings are based on the use of soil material at the location that may have some land smoothing. Irrigation may or may not be needed and is not a criterion in the rating. Golf greens are not included in this rating.

Table 7 of Exhibit 3 evaluates the 235.2 acres of soil at the Big Indian portion of the property that has been set aside for lawns, landscaping, and fairways. The data demonstrate that over 60% (148.6 acres) of this area is proposed to be cleared on steep slopes that exceed 15%. The rating class for all 148.6 acres is severe. In addition, 100 acres of land that has a slope of greater than 35% is proposed to be disturbed.

Table 8 of Exhibit 3 evaluates the 161.2 acres of soil at the Wildacres portion of the property that has been set aside for lawns, landscaping, and fairways. The data demonstrate that almost half (73.7 acres) of this area is proposed to be cleared on steep slopes that exceed 15%. The rating class for the 73.7 acres proposed on steep slopes have been rated as severe. In addition, 30.5 acres of land that has a slope of greater than 35% is proposed to be disturbed.

This soil information was not included in the DEIS and reflects highly relevant data for the water quality impact analysis. The DEIS should be revised to address the challenges presented by the soil and slope characteristics of the site, recognizing the risks established by the NRCS.

III.

ASSESSMENT OF THE PROPOSED EROSION AND SEDIMENT CONTROL AND POST-CONSTRUCTION STORMWATER POLLUTION PREVENTION PLAN .

A. Overview

Polluted runoff flowing from the project site both during and after construction was correctly determined by DEC to be an attribute of the proposed development project that could have significant adverse impacts on the environment, thereby requiring review within an environmental impact statement. DEC has also determined that the proposed project will require an individual stormwater permit, as opposed to the project being "covered" under DEC's SPDES General Permit for Stormwater Discharges from Construction Activity (Permit No. GP-02-01)

("General Permit"). DEC is reviewing both the DEIS as it relates to stormwater pollution and the application for an individual SPDES stormwater permit at the same time. These comments also address both documents.

The potential for adverse impacts to water quality from construction of this Project is significant. According to EPA, sediment runoff rates from one acre of a construction site are typically 1,000 to 2,000 times that of one forested acre.[8] Therefore, the stormwater sedimentation and associated contaminants flowing from one uncontained acre subject to construction are generally equivalent to the sedimentation from two to three square miles of forest (1 square mile = 640 acres). Once eroded, clay particles (a type of particle that is represented at a high level in soils on and around the project site) often remain suspended for 6 to 9 months and even longer.[9] This period of suspension could allow these particles to remain in the water as it flows from the project site to the Ashokan Reservoir and on into the New York City water distribution system where it is then consumed. Similarly, the increased volume of stormwater from new impervious surfaces (e.g., parking lots, roadways, roof tops, etc.) is high. One acre of impervious surface creates the same amount of runoff as 16 acres of naturally vegetated meadow.[10] Numerous studies indicate that impervious surfaces areas at levels below 8 to 10% in a standard watershed can result in significant adverse impacts on water quality.[11]

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[8] EPA Storm Water Phase II Final Rule: Small Construction Program Overview EPA 833-F-00-013 (Fact Sheet 3.0) January 2000 (available at www.epa.gov/owm/sw/phase2); see generally, 64 F.R. 68722, 68728 to 68731 (December 8, 1999) (EPA Phase II Stormwater Pollution Control Program, Final Rule and Report to Congress summarizing adverse impacts of runoff from construction sites); National Research Council Watershed Management for Potable Water Supply: Assessing the New York City Strategy at 416-426 (2000) (discussing attributes and effectiveness of SPPPs in the context of the New York City Watershed).

[9] See, e.g., R.J. Davies-Colley, W.N. Vant, D.G. Smith, Colour and Clarity of Natural Waters, at 25 (1993).

[10] T. Schuler, The Importance of Imperviousness at p. 100, Watershed Protection Techniques, Vol. 1, Issue 3 (1994).

[11] See, e.g., Schueler, T., The Importance of Imperviousness, Watershed Protection Techniques, 1(3) pp. 100-11 (1994); Arnold, C. and Gibbons, J., Impervious Surface Coverage: The Emergence of a Key Environmental Indicator, Journal of the American Planning Association, 62(2) pp. 243-258 (1996); Booth, D. and Jackson, C., Urbanization of Aquatic Systems: Degradation Thresholds, Stormwater Detection, and the Limits of Mitigation, Journal of the American Water Resources Association, 33(5) pgs. 1077 to 1090 (1997); Wang, L., Lyons, J. Kanehl, P., Impacts of Urbanization on Stream Habitat and Fish Across Multiple Spacial Scales, Environmental Management, 28(2) pgs. 255-266 (2001). The EPA has also provided a detailed summary of the adverse water quality impacts of development when it promulgated its "Phase II" stormwater regulations. See 64 Fed. Reg. 68722, 68724 to 68727 (December 8,

Therefore, new impervious surfaces (as well as the substantially less-pervious surfaces created by the removal of vegetation and compaction of soils associated with construction excavations) can transmit very high volumes of stormwater relative to natural conditions that then operate to destabilize streams and cause additional erosion. As discussed in the introduction to these comments, elevated turbidity or suspended sediment levels present particular public health concerns in an unfiltered drinking water supply; a problem that already significantly affects the Catskill portion of the New York City Watershed, including the Schoharie and Ashokan Reservoirs and the Esopus Creek. Thus, the stormwater from the project must be carefully analyzed and fully addressed.

B. General Comments

1. The DEIS should include a detailed Stormwater Pollution Prevention Plan ("SPPP") for the entire project. The DEIS now contains only a limited proposed SPPP for an 85-acre portion of the Big Indian resort complex. This SPPP is to serve as an example of the type of program the project sponsor would follow for other portions of the site. A complete SPPP is necessary to analyze impacts as required by SEQRA. Moreover, engineering designs and calculations must be attuned to the highly varying conditions found throughout the project site, so one sample set of designs cannot address other portions of the site. A full SPPP is also required to allow DEC to adopt mitigation measures, as mandated by SEQRA, that will mitigate adverse environmental impacts to the maximum extent practicable taking into account social and economic considerations.

2. The limited SPPP contains numerous deficiencies with the proposed program to address both erosion and sediment controls (the controls on polluted runoff during project construction) and stormwater controls (the controls on polluted runoff after completion of the project). According to DEC guidelines, the SPPP should comply with the standards and requirements contained in the DEC General Permit for Construction Activity, as well as the technical manuals its references: New York State Standards and Specifications for Erosion and Sediment Control (Empire State Chapter of the Soil and Water Conservation Society) April 1997 and New York State Stormwater Management Design Manual (prepared for DEC by the Center for Watershed Protection) October 2001. Other guidance has been provided by U.S. EPA, see National Management Measures to Control Nonpoint Source Pollution from Urban Areas (published at www.epa.gov/owow/nps/urbanmm/index.html) (July 2002), as well as by numerous reports issued by technical organizations such as the Center for Watershed Protection (see generally, www.cwp.org). However, due to its incomplete and general nature, it is not possible to demonstrate compliance. Given the highly sensitive nature of this project site, the SPPP should be re-done in more detail, showing how it complies with these standards.

3. Overall, the SPPP must include much greater detail. The SPPP as it relates to the erosion and sediment control plan for the 85-acre Phase 2 area does not contain the "fully

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1999). These articles are attached as Exhibit 2 designed and engineered stormwater management practices with all necessary maps, plans and construction drawings" required by the General Permit at Part III.D.2. The specific requirements of the erosion and sediment control plan are outlined in the General Permit at Part III.D.2(a)(1 to 16); these requirements have not been met. The fact that this is a large site does not justify the use of a conceptual SPPP that would be unacceptable at smaller sites. Rather, the size indicates a need for greater, not lesser, detail. At a minimum, for each area of the site, the SPPP should contain specific design details concerning: (i) the phasing of construction; (ii) the clearing of vegetation; (iii) the movement and stockpiling of earth; (iv) the channeling and volume of stormwater; (v) the deployment and sizing of erosion control measures such as check dams, stone channels, geo-textile materials, hydro-seed, silt fencing, sod, and mulch; and (vi) detention basin sizing, location, peak flow attenuation, decantation and maintenance. This information should be presented on engineered construction plans in a manner that allows for actual implementation by construction contractors.

The SPPP must be designed based on the attributes of the construction site (e.g., average peak storm intensity, soil erosivity, soil percolation rates, levels of impervious surfaces after construction, slopes, etc.) and the use of standard engineering models and formulas to calculate the size and spacing of various stormwater control measures (e.g., the appropriate capacity of a detention pond based on likely stormwater volume within a particular catchment area). The conceptual SPPP presented in the DEIS does not allow for effective review and critique; nor does it provide sufficient information for DEC to make fact-based determinations on appropriate individual stormwater permit conditions.

C. Specific Comments

4. The DEIS has incorrectly identified design discharge points at the bottom of the mountain near the property boundary for stormwater calculation comparisons. The removal of vegetation, the manipulation of earth and the construction of the proposed project will significantly alter the hydrology of the project site. This change in hydrology will be most significant at the point where the construction disturbance ends and stormwater is discharged. The DEIS and its predicate calculations, however, do not assess the effects of the stormwater discharges (from basins or ditches or other methods) at the various locations on the side of the mountain where the discharges actually occur, but rather, assume the boundary is the discharge point. This failure has taken place in the development of both the erosion and sediment control plan and the post-construction stormwater plan. Therefore, these stormwater calculations were not determined in accordance with DEC's Stormwater Management Design Manual.

As a result, the calculations and assessments with respect to: (i) appropriate rates of discharge from basins; (ii) detention basin volume and outfall design; and (iii) the erosive impacts of the stormwater discharges at the point of discharge on the mountain side, are not valid and must be re-done. The redesign of stormwater controls based on correct inputs should be required.

The selection of design discharge points at the bottom of the mountain should not be accepted by DEC as it would tend to significantly reduce the projected impact of stormwater discharges by ignoring the impact on the undeveloped land within the Project's boundary. Moreover, contrary to what is suggested in the DEIS, natural "sheet flow" conditions will not be replicated along the middle of the mountainside in a manner that existed prior to construction because the hydrology of the project site will have been dramatically altered by construction activity. Finally, design discharge points at the base of the mountain are not appropriate because stormwater effects will not be mitigated as the water travels down mountain slopes because: (i) the project site consists of hydrologic soil group "C" and "D" soils that have very low percolation rates – especially under storm flow conditions and (ii) the site has steep slopes so there will be little retention time for infiltration.

5. The DEIS does not provide sufficient detail to demonstrate compliance with water quality standards and to further improvement of the impaired Esopus Creek. The DEIS must demonstrate compliance with all New York State Water Quality Standards. See 6 NYCRR Part 703. Of particular applicability to construction activity are the water quality standards for turbidity ("[n]o increase that will cause a substantial visible contrast to natural conditions") and for suspended, colloidal and settleable solids ("[n]one from . . . wastes that will cause deposition or impair the waters for their best usages"). 6 NYCRR § 703.2. The DEIS must also address the additional silt and sediment pollution that will be discharged from the eastern portion of the project site in light of the fact that the Ashokan Reservoir and the Esopus Creek, which drain this area, are listed as "impaired" for silt/sediment by State DEC on its 2004 Clean Water Act § 303(d) list, as the DEIS forms the basis for SEQRA mitigation measures and SPDES permit conditions. Currently, in both scope and specificity, the DEIS and SPPP lack such detail.

6. As detailed in Part II of these comments, all soils on the site are hydrologic soil group C and D soils with little to exceedingly low percolation rates. It appears that the DEIS indicates lower levels of stormwater volumes as a result of water infiltration in a number of situations (e.g., in detention basins and on steep mountain slopes after discharge from basins). For example DEIS Appendix 10 at pp. 2-3 describes a 29% volume loss in stormwater in the lined detention ponds that the are situated in low to no percolation soils. This would appear to be a very significant overestimate. Given the exceedingly large number of calculations associated with the design of the SPPP presented in the DEIS, we were not able to review all of the predicate calculations and modeling assumptions to determine the full extent of this inappropriate methodology. An underestimate of stormwater volumes due to assumed infiltration that is in fact unlikely to occur, would result in the inadequate design of numerous stormwater and erosion control measures. The DEIS should re-do calculations and model assumptions to determine where infiltration was improperly assumed, correct any mis-calculations, and re-design/re-size stormwater measures as appropriate.

7. The stormwater model used was not correctly calibrated. The DEIS employs a stormwater model known as "WinSLAMM" to support much of the stormwater plans contained in Appendix 10 of the DEIS. This office consulted with Professor Robert Pitt, Ph.D., who is the Cudworth Professor of Urban Water Systems in the University of Alabama's Department of Civil and Environmental Engineering. Professor Pitt is the principal author of the WinSLAMM model, as well as other stormwater modeling systems. After a detailed review of the DEIS, Appendix 10 and other data, Professor Pitt reports that it was inappropriate for the project sponsor to employ the WinSLAMM model to estimate pre-development conditions (e.g., stormwater volumes and pollutant levels). The existing project site is presently heavily wooded with some prior logging and minor clearance. According to Professor Pitt, the WinSLAMM model was never intended (or likely ever tested) for use as a mechanism to determine pre-development stormwater attributes of such an area. The "undeveloped" or "open space" conditions modeled in WinSLAMM are, according to Professor Pitt, for small undeveloped areas in otherwise developed urban areas. Furthermore, the model results for such areas are not likely to accurately represent wooded lands or lands that have been subject to logging. Professor Pitt further determined that the WinSLAMM model used in the DEIS was not calibrated with actual local water quality and flow measurement data; rather, the parameter files employed in the model to determine stormwater attributes prior to construction were simply the general "default" files that are supplied with the WinSLAMM program. As a result, the pre-development stormwater information in the DEIS lacks model support and should not form the basis of the stormwater plans. A re-calculation and re-assessment of the stormwater management program should be undertaken employing accurate modeling information concerning pre-development conditions as a predicate. Claimed pollutant removal efficiencies of stormwater and erosion controls that are presented in the DEIS relative to projected pre-development conditions should be revised to reflect valid calculations from a valid model. See General Permit at Part III.D.2(b)(5).

A fundamental element in the environmental analysis of stormwater and erosion impacts is an accurate understanding of pre-development conditions. Projected pollution and flow levels in stormwater both during and after construction are compared to pre-development conditions to understand potential adverse environmental effects relative to the "no-build" condition. Moreover, pre-development conditions often serve as a bench-mark for the pollutant removal efficiencies and flow attenuation levels to which an SPPP is required to be engineered. For example, City DEP generally requires pollutant loadings to be returned to pre-construction conditions as part of its individual permitting program. Similarly, an accurate assessment of pre-development sediment loadings is important when evaluating the additional burden this project may place on the Ashokan Reservoir and the Esopus Creek, water bodies that drain all of the eastern or "Big Indian" portions of the proposed project site and which are already classified as "impaired" due to high silt/sediment levels. An accurate depiction of pre-development sediment levels flowing from the project site is an essential element of such an analysis.

8. Construction phase discharges should be no greater than the current discharges to avoid further impairment. As discussed above, the Ashokan Reservoir and the Esopus Creek are already impaired due to silt/sediment levels and are in violation of state water quality standards. Given this status, the SPPP for the eastern portion of the proposed project that drains into the Esopus Creek should be designed to a standard that maintains stormwater sediment discharge levels at accurately determined pre-development levels during and after the eight-year construction period. This condition should be contained in the individual SPDES permit for the project and the project sponsor should be required to demonstrate compliance in the SPPP and supporting calculations. There is precedent within the Watershed for such a requirement, as City DEP generally requires all SPPPs, within the Watershed to be designed to achieve discharge levels that are no higher than pre-development conditions.

9. **Construction phasing should follow DEC guidelines and ensure proactive monitoring.** The General Permit at Part III.D.2(a)(4) requires the project sponsor to "provide a construction phasing plan describing the intended sequence of construction activities, including clearing and grubbing, excavation and grading, utility and infrastructure installation and any other activity at the site that results in soil disturbance." This provision further identifies the state-wide requirement that "there shall not be more than five acres of disturbed soil at any one time without prior written approval of the [DEC]." The New York State Standards and Specifications for Erosion and Sediment Control ("E&SC Standards"), that are the DEC recognized SPDES standards (see General Permit at Part III.D.1), also state that "[n]o more than 5 acres of unprotected soils should be exposed at any one time" and goes on to state that "[s]ite factors including topography, soil erosion potential, proximity to wetlands and water courses may require limiting the amount of raw earth that can be exposed at any one time to less than 5 acres." See E&SC Standards at Appendix A, Section E.1.

Despite these standards, the DEIS proposes a construction phasing plan that seeks to exceed the 5 acre standard, with construction phases exposing as much as 50 acres of raw earth at one time on the project site. The project sponsor has also requested that it be allowed to depart from the state-wide standard as part of its individual SPDES stormwater construction permit application.

As detailed in Part II of these comments, the soils, slopes and intensity of rain/snow melt events[12] present significant technical challenges for the design and implementation of effective controls on polluted runoff. The significant percentage of "small particle" or clay-type soils makes this site particularly sensitive because of its location within a major unfiltered drinking water system. Indeed, the sensitivity of this site would justify a downward departure from the normal 5 acre "raw earth" standard due to the risks associated with a significant failure. Moreover, the major deficiencies in the SPPP and the DEIS that these comments identify support the conclusion that there is no technical justification for a departure from the 5 acre state-wide standard.

Experience with construction in the Watershed suggests that the 5-acre standard is sound

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[12] As discussed, northwest Ulster County generally has the highest rainfall intensity in the state. Precipitation for a hundred year storm event is 8 inches, for the two year storm event 4 inches and for the one year storm event is 3.5 inches. The average annual rainfall is 47.1 inches. (Source: Natural Resources Conservation Service, 2003).

and appropriate. For example, the New York State Department of Transportation's approximately 50 acre construction site along the Taconic Parkway in Westchester County sent high volumes of highly turbid water on at least eight occasions into an adjacent stream that flows into the New Croton Reservoir. Expansive plumes of brown, sediment-laden, water were observed in the New Croton Reservoir repeatedly from the Fall of 2001 to the Spring of 2002 as a result of this construction site, despite vigorous enforcement actions by DEC and the Attorney General's Office, a full "stop work and remediate" order, and the emergency expenditure of approximately $1 million by DOT to deploy additional stormwater control measures.

Similar discharges occurred at the Hanna Country Inn and Golf Resort in Delaware County that is a short distance from the proposed project. The Hanna project involved the construction of an access road up a steep slope to a new club house. Even though this roughly 5 acre roadway excavation was the subject of a detailed SPPP approved by DEP, the site failed on repeated occasions from May of 2002 until at least the winter freeze of that year. Despite active monitoring and enforcement by City DEP, as well as extensive remedial programs by Hanna (e.g., staking sod along most of the slope) this site continued to discharge significant amounts of sediment into Hubble Hill Brook and then to the East Branch of the Delaware River and then to the Pepacton Reservoir. On numerous occasions as reported by City DEP staff and others, turbid flows from the Hanna Construction site gave the Hubble Hill Brook and the East Branch of the Delaware River the appearance of thick chocolate milk. The portion of the Hubble Hill Brook above the construction site was clear. Though it was not a large site, the clay/colloidal soils at the Hanna site combined with steep slopes and intense rainfalls to make the effective implementation of an erosion and sediment control plan exceedingly difficult. The relevant attributes of the Hanna site (steep slopes, problematic soils, intense rain events) are very similar to those of the project site.

Thus in accordance with DEC guidelines, there should be no deviation from the 5-acre standard, until a complete SPPP is submitted for the entire site, along with all supporting assumptions and calculations, in a manner that allows for effective evaluation. In addition, post-excavation "stop-work" authority should not be viewed as an effective back-up plan for the requested large excavations because very substantial volumes of turbid water frequently continue to discharge from problem construction sites despite enforcement actions and extensive remedial efforts by the site owner in response to enforcement. Construction phases could be limited to no more than 5 acres in any one reservoir drainage basin (e.g., the Ashokan or the Pepacton) at any one time for a total of 10 acres but should also be limited to levels below 5 acres on portions of the project site that are steeply sloped or have highly problematic soils. At a minimum, DEC should require the pilot testing of the erosion and sediment control plan on a small portion of the site (in a manner observed and verified by DEC and City DEP) prior to any grant of authority to the project sponsor to exceed the 5 acre standard.

10. Properly prepared site grading plans are needed. To the extent they are shown, the erosion and sediment control measures are presented on the "phasing" plans; these plans provide a large scale overview of what area is worked on during each phase of construction.

Phasing plans are not employed to govern actual project implementation by contractors. Rather, standard practice during construction is that the deployment of erosion and sediment control measures are depicted on the far more specific construction "grading" plans. The grading plans will be employed by the construction contractor to understand exactly what is to be accomplished and implemented. This failure, if not corrected, will confuse site contractors and frustrate effective implementation of the erosion and sediment control plan. The grading sheets should contain the appropriate tables and information describing the specific attributes of the erosion and sediment controls.

11. **The erosion and sediment control mechanisms for the proposed site (stone check dams, silt fencing, temporary drainage swales, etc.,) should be designed for a minimum 2-year storm, which is 4 inches.** Given the present status of the erosion and sediment control plan, it is not possible to determine the engineering criteria employed for the design of these measures, to the extent these measures are presented at all. The numerous steep drainage ditches need to be protected with stone lining or turf reinforcement mats.

12. **A sediment removal plan is needed.** The design goal for the sediment basins are properly targeted to capture the 10-year storm and the appropriate bare earth C soils curve number has been employed to determine storm flows. However, a detailed sediment removal plan for these basins is absent and must be presented. General Permit at Part III.D.2(a)(2).

13. **A detailed plan for clearing and grubbing waste disposal is needed.** The clearing and grubbing of this site would generate large quantities of waste materials (e.g., brush, sod and stumps) that would be many acres in size. Though the DEIS states that these materials will be buried, no waste areas are designated on the drawings. The high volume of wood wastes generated at this site has the potential to harm groundwater. The DEIS should address transporting the waste materials offsite. The waste material must not be buried in a ravine or in an area that could affect a drinking water well. If the waste material is to be buried onsite, an erosion and sediment control plan needs to be developed to account for additional deforestation and to address newly created stormwater concerns.

14. **The DEIS should conduct on-site studies of project soils.** Most of the soils at the project site have little or no percolation. Based on data provided in the DEIS for the soil test pits excavated on site, soils contain 50 to 60% silt and clay, and the clay content was between 12 and 22%. The very small size of these soil particles, which can flow through a size 200 micron sieve, means that they can remain suspended in water for a long period of time – with important implications for drinking water quality. It would be useful to better understand the actual suspension time by employing a hydrometer analysis. The results from this test will provide useful estimates concerning how long clay/silt soils should be expected to remain in suspension in still water and the rate of settling. (It would not provide useful information about settling rates in moving water). This information also will assist in the evaluation of whether the introduction of a chemical additive to detention ponds, as is proposed, will aid in removing clay particles from the water and will help determine the appropriate period of time that the water needs to be

retained in sediment basins before it will be clear enough to decant.

15. A detailed plan regarding use of a chemical additive for stormwater treatment that removes turbidity is needed. Should DEC decide to consider the use of a chemical additive to remove suspended clay and silt particles in detention basins, both laboratory "bench tests" and field tests need to be conducted to confirm the product's effectiveness on these soils. Field tests need to be run because the performance of chemical additives are affected by water temperature, clay type, flow rates, and chemical levels. The field tests are also necessary to determine whether the chemical additives will be decanted from the basins into area trout streams. If this chemical is placed in the detention ponds, it would appear highly likely that it will flow into area trout streams. Should there be a chemical discharge, the regulatory requirements associated with the addition of chemicals to area streams needs to be assessed, and a SPDES permit may be required.

16. A detailed plan for selecting a chemical additive for stormwater treatment that is safe to aquatic organisms is needed. The chemical additive that is proposed for use in detention ponds is soluble chitosan acetate. Tests need to be designed and run which will determine if this chemical will cause adverse impacts to the species that live in the trout streams that will receive stormwater flows from the project site. There is at least one detailed scientific study which found that the proposed chemical additive kills rainbow trout at fairly low running levels of 38 parts per billion over six days or at approximately one part per million over a few hours. G. Bullock, V. Blazer, S. Tsukuda, S. Summerfelt, Toxicity of Chitosan Acetate for Rainbow Trout (*Oncorhynchus mykiss*) Cultured in a Recycle System, published in the proceedings of the Twenty-Fourth Annual Eastern Fish Health Workshop (Atlantic Beach, N.C., March 9 to 11, 1999).[13]

17. A detailed plan to drain the detention ponds is needed. Draining detention ponds in a timely manner is an important practice that will better assure that the detention ponds have available capacity to retain stormwaters from the next storm. If the detention ponds are full, they will simply be by-passed and the stormwaters left untreated. As proposed, during construction, water would be pumped out of detention ponds and into a device called a "level spreader." The level spreader is a perforated plastic pipe that is proposed to run at level across a contour line of the mountain for long distances, often through forest. One of the level spreaders is to run some 1,000 feet. This practice is highly likely to fail. Placing the level spreader at *level* in the woods and along a mountainside will be exceedingly difficult, particularly given the trees, rock outcrops, topography curves and intermittent streams. The likely dips in the plastic piping will cause high pressure to build up and the piping to break. The resulting flow of water will likely cause severe hillside erosion at the point of failure. Therefore, some other workable method to decant the detention ponds should be developed and proposed.

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[13] The study's authors are from the U.S. Geologic Survey, Biological Resources Division, National Fish Health Research Laboratory, 1700 Leetown Road Kearneysville, W.V. and the Freshwater Institute, Shepherdstown W.V.

18. A detailed plan is needed for soil stockpiles. The project involves extensive construction excavations and grading throughout the project site. By necessity, large piles of earthen materials will be created and moved. Large piles of excavated soils, if not handled properly, have a significant potential to emit sediments during storms. The SPPP for the Phase 2 area does not take into account these stockpiles of excavated soils, describe their location or duration on grading sheets, or provide for any specific erosion control measures to stabilize these soil stock piles. This substantial omission is contrary to General Permit Part III.D.2.(a)(4) and good practice. The grading sheets should provide complete details with respect the manner in which these materials will be effectively managed as part of the overall SPPP. Moreover, while the various cuts and fills appear to be balanced, the timing and routing of excavated earthen materials is an important element of the program to control off-site sedimentation. The DEIS and the SPPP should contain far more detailed information so that it can be verified that the transfer of these materials will be managed effectively.

19. The numerous steep fill slopes proposed throughout the Project site must be carefully and individually evaluated. We were able to examine only a few of these fills for potential impacts on erosion and sedimentation. In the Belleayre Highlands map (SG-5) there are numerous slopes shown at 1.5 to 1 (one foot and a half horizontal to one foot vertical). This is extremely steep for fill slopes. Without information on the attributes of the fill material, a slope stability analysis is not possible and given the steepness, there is a risk of failure. One such fill is over 100 feet high and is topped with the weight of an access roadway. In addition, it appears that the project sponsor has proposed to place a level spreader to discharge stormwater on that slope – thereby adding large quantities of water from a detention pond in addition to natural rainfall. The weight and soaking effect of this water would likely further destabilize this slope – creating a possible safety risk to drivers, in addition to a risk of soil erosion. All steep fills on the site should be carefully evaluated for stability and more moderate grades or vertical retaining walls should be employed where appropriate. Level spreaders and other detention basin discharges should be removed from steep fill areas throughout the Project.

20. Significant erosion can occur from the unprotected portions of the project site. For example, a 1.38 acre area of exposed soil on sheet SG-5 has no identified erosion and sediment controls and drains to a roadside ditch. Calculations using the "Revised Universal Soil Loss Equation" show that 250 tons of soil will be lost from this area over the course of one construction season. This amount of soil is equivalent to the capacity of 10 large construction dump trucks. The 1.38 acre site is one of many uncontrolled areas where stormwater sediments can be transported off site without any containment. The SPPP should identify other such areas and present an adequate erosion and sediment control plan. Moreover, road side ditches throughout the proposed Project do not appear to include any erosion and sediment controls, a situation that should be rectified in a revised SPPP.

21. A revised grading and excavation schedule is needed. Grading and excavation operations should not be permitted outside of the growing season because vegetation will not be able to be effectively established to stabilize soils. This likely means that excavations and grading should not take place at this high altitude site before April 15th and after October 1st.

22. Methods to stabilize site soil need to be tested in the field. The DEIS does not mention the use of straw mulch. Instead Soil Guard and Eco-Aegis are discussed. These products cement soil and alter infiltration, which means that the use of these agents may promote more runoff. Field tests need to be performed on whatever product is selected to confirm whether or not the sponsor's selected measure is adequate for this climatic region.

23. A revised schedule to stabilize soil with vegetative cover is needed. As a best management practice, the project sponsor should develop a program where all graded slopes are seeded within 7 days of final grade. Any slopes in excess of 3 to 1 should be seeded and stabilized with a rolled erosion control mat. Once a road slope is excavated, the cut should be shaped and seeded immediately.

24. No construction waste (e.g., asphalt shingles, fuels, lubricants, garbage, etc.) management plan is detailed in the SPPP as required by General Permit III.D.2(a)(4).

25. Waste water from concrete production needs to be treated prior to release. Water will be used on site to wash aggregate to produce concrete. Wastewater from this process and from concrete truck washout facilities contains fine suspended material that needs to be treated separately from other site stormwater. The DEIS does not address this issue.

26. Although water quality volume ("WQV") computations are presented in the DEIS for the overall project, they are not presented for each sub-catchment. This information was not provided for the Phase 2 SPPP. This prevents an evaluation of whether the post construction stormwater quality measures were properly sized. These computations, as well as those for calculating pollutant removal efficiencies, need to be provided in the DEIS.

27. Water quality treatment volumes comparing rainfall and snow melt are needed. The computations used to compare the water quality treatment volume between rainfall and snow melt is absent from the DEIS and needs to be included, as per the 2003 New York State Stormwater Management Design Manual (Appendix I). Without further explanation, the DEIS appears to use low values.

28. Times of concentration used in the DEIS appear to be incorrect. Times of concentration (Tc's) for the "hydrocad" routings appear to be much too long for the steep watershed slopes (e.g., for sub-catchment 22, the Tc is stated at 30.5 minutes). A similar TR-55 model analysis would estimate the Tc at only 9.6 minutes. A longer Tc results in much lower estimates of peak rates of post-development discharge flows ("Q.") Thus, discharge rates that are presented in the DEIS appear to be much lower than they should be. Higher values would demonstrate more severe erosive forces, particularly on steep slopes. The Tc values should be re-evaluated for the entire SPPP and accurate assumptions employed in the calculations.

29. The "n" coefficients used in the DEIS appear to be incorrect. The "n" coefficients, which measure the "roughness" or friction associated with surface stormwater flows, and used in the DEIS for overland flow computation, appear incorrect when compared to values presented in USDA SCS TR55, chapter 3. This raises questions regarding the validity of the final routing values employed in the stormwater models. With the confused methods that were presented in the DEIS, it cannot be verified whether this value was correctly calculated. An incorrect "n" value would result in incorrect velocity and erosive force values, thereby making inaccurate the engineering calculations that serve as a predicate for the engineered design of stormwater controls. This value should be re-assessed and recalculated for the entire SPPP.

IV.

ANALYSIS OF SECONDARY GROWTH IMPACTS AND RECOMMENDATION THAT A DETAILED CUMULATIVE IMPACT ANALYSIS BE UNDERTAKEN TO ASSESS THE LONG-TERM IMPACTS OF GROWTH ON DRINKING WATER QUALITY.

This office requested that Dr. Gerrit Knaap, Director of the National Center for Smart Growth Education and Research at the University of Maryland (with the assistance of Terry Moore and others at Dr. Knaap's selected consulting firm, ECONorthwest), review the DEIS for the proposed Project as it relates to secondary and cumulative growth impacts. The large regional nature of this Project raised concerns that the Project might itself, or in combination with other developments, create a situation that injures drinking water quality.

As documented in Part II above, much of the entire Catskill portion of the Watershed, in addition to the project site, contains steep slopes, clay or colloidal-type soils, and intensive rainfall events (Exhibit 3, Table 9). A number of the relevant water bodies, particularly in the Catskill portion of the Watershed, are already impaired or stressed by pollutant loadings.

We requested that Dr. Knaap independently review and critique the secondary growth analysis conducted in the DEIS, identify points of concern or agreement, and conduct his own assessment of secondary impacts using data and economic models that are professionally appropriate and justified. We also requested that Dr. Knaap conduct an evaluation of whether the DEIS, which does not contain a cumulative impact analysis, should have done so given an economic evaluation of likely growth within the Watershed. The goal of Dr. Knaap's assessments was to provide projected estimates concerning likely off-site acres of land (i) that may be subject to construction disturbance and (ii) that may be converted to new impervious surfaces both as a result of the Project alone and in conjunction (cumulatively) with other projects. We were interested in understanding potential growth over the 10, 20 and 50 year period. Dr. Knaap's report, with associated appendices, is attached as Exhibit 4 and is incorporated into these comments.

With respect to the secondary growth impact assessment contained in the DEIS, Dr.

Knaap found numerous specific disagreements but largely concurred in the DEIS's basic conclusion: that the Project, standing alone, is not likely to cause extensive levels of new impervious surfaces and construction disturbances in off-site areas. Dr. Knaap's projections of new construction are higher than those contained in the DEIS, but not of a magnitude that we would characterize as significant.

The assessment of potential cumulative impacts does raise significant concerns. Dr. Knaap's report identifies the potential for sizeable amounts (many squares miles) of new acres of impervious surfaces and construction disturbances cumulatively in Watershed over time due to likely development pressure. The key finding of Dr. Knaap is that the DEIS is deficient because it failed to require a detailed cumulative impact analysis to better determine the full extent of growth impacts so as to better guide decision-making on the large-scale regional development Project proposed in the DEIS. We recommend that a cumulative analysis be undertaken in a revised DEIS.

V.

REVIEW OF PROPOSED INTEGRATED PEST MANAGEMENT PROGRAM: PESTICIDE AND HERBICIDE USE.

A. Overview

In general, the DEIS contains language describing the elements of an Integrated Pest Management Program ("IPM") designed to minimize - but not eliminate - the use of chemical pesticides. A review of DEIS Section 2.4.8 provides some discussion of non-chemical management techniques, a statement that pesticide use will be the lowest choice in the hierarchy of pest management options and a claim that pesticides will be used only for curative, and not preventive, purposes. All are elements of a good IPM program. It took careful review, however, to find those assurances and piece them together into a coherent statement of pest management policy.

For instance, Section 2.4.8 "Golf Course Integrated Pest Management" starts at page 2-73 with a discussion of pesticides, and the methods used to select the products to be used. The concept of limiting chemical use to curative treatments is introduced after the discussion of the chemical selection process, and is not an unqualified commitment (i.e., 2.4.8.C: "In almost all instances, only affected greens and tees would be treated . . ."). The hierarchy of pest management options, and the preference for non-chemical methods is not clearly stated until 2.4.8.D.6 at page 2-88. If there is a real commitment to constructing, maintaining and operating the facility in accordance with IPM/ITM principles and practices, there should be a clear statement to that effect at the beginning of 2.4.8.

In the correct hierarchy of pest management options, chemical controls are not only placed last, but in that category, emphasis is placed on the role of toxicity and risk assessment in the selection of specific products to be used. We were unable to find mention of that critical evaluation in the current DEIS. As is set forth in our specific comments below, the evaluation of the health and environmental risks of the pesticides proposed for use is seriously flawed by critical omissions.

B. Specific DEIS Comments

1. Inert Ingredients are not identified; their impacts are not assessed. The DEIS does not consider the potential impacts of "inert" ingredients, which generally comprise at least half of the formulated product. The narrative generally refers to pesticide products or pesticides (e.g., 2.4.8.B), but the assessments of toxicity and mobility deal only with active ingredients. (See also, Appendix 14, section 2.4 and Appendix 15). In fact, the only product identification is in Table 2-8 (page 2-90), where the absence of useful information on the inert ingredients formulated in the products proposed for use is clear. Although the inert ingredients are "not listed" that does not mean that they are not present.

The products identified in Table 2-8 are not the only ones which contain the listed active ingredients. Other products with the same active ingredients may well contain different formulations of inert ingredients. Will the products identified for each active ingredient be the only ones used, or will other formulations of the same active ingredients be applied? Note also, that inerts are not considered in the risk assessments summarized in Appendix 15. Without the identity of the inerts, the value of any health or environmental risk assessment is, at best, seriously compromised.[14]

2. There is little discussion of the health effects associated with the active ingredients proposed for use. EPA has identified two of the active ingredients proposed for use as "likely to be carcinogenic to humans." These are the insecticide ethoprop, and the herbicide oxadiazon. An additional half dozen active ingredients have been identified by EPA as "possible human carcinogens" (Fungicides propiconazole and vinclozolin, insecticides acephate and bifenthrin, and herbicides prodiamine and trifluralin.) There is no discussion of the carcinogenic potential of these compounds, and no justification for their use at the golf course, or in the Watershed, in light of their carcinogenicity.

Two of the insecticides proposed for use (acephate and ethoprop) are organophosphates - a class of pesticides whose neurotoxic effects are well documented, widely known and the subject of current reevaluation by EPA. Although still underway, the EPA reassessment has already resulted in substantial new restrictions on the use of several organophosphates. The

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[14] Bensulide is listed as an inert ingredient of the herbicide "Balan" in Table 2-8. Benefin is identified as the active ingredient. Both bensulide and benefin are herbicides, and bensulide is listed on page 2-86 and in Appendix 15 as a recommended herbicide. The identification of bensulide as an inert almost certainly is an error.

DEIS does not discuss the neurotoxic potential of these compounds, and does not justify their use at the golf course or in the Watershed in light of their neurotoxicity.

Of course, with little or no information about the inert ingredients formulated in the products proposed for use there is no discussion of their carcinogenicity, neurotoxicity or other chronic health effects.

3. LC_{50} is a crude instrument for the assessment of environmental risk. The assessment of environmental risk attributable to pesticide runoff is based on a comparison of maximum runoff concentrations to LC_{50} values for fish and aquatic invertebrates. Eight pesticides were eliminated as candidates for use because their maximum modeled runoff concentration exceeded one or more LC_{50} values. While it is appropriate that short term mortality of 50% of resident aquatic fauna is deemed unacceptable, there is no other threshold of damage applied. Chronic toxic effects of the pesticides on aquatic organisms is not addressed. Neurotoxicity might alter individual behavior and ability to survive long term in the natural habitat. Mutagenicity, teratogenicity and endocrine disruption can all diminish reproductive success. These chronic effects, not reflected in short term individual mortality can nonetheless result in the loss of local natural populations in a relatively short period of time, although measured in months or years and not hours or days as is the case with experimentally derived LC_{50} values.

Of course, with little or no information about the inert ingredients formulated in the products proposed for use there is no discussion of their environmental effects, even by such a crude measure as LC_{50} values.

4. There appears to be no adequate provision for monitoring ground and surface water resources for pesticides and fertilizers during the "operational phase." While modeling may provide the basis for the initial selection of chemicals and treatment regimes, it should not be the final determinant of long term operations. Provisions for ongoing ground and surface water monitoring for active and inert pesticidal ingredients, their degradation products as well as nutrients, should be included in the operational plans for the golf course. The deep ground water wells that have been proposed for use in operational monitoring are deficient as they will provide little to no useful information concerning impacts. The deep ground water to be tested is drawn from locations that are likely to be by-passed by ground water which is closer to the surface. It is the ground water that is closer to the surface that is most likely to be impacted. Shallow groundwater monitoring wells should be employed for comprehensive testing.

C. Specific Comments on Appendix 14

1. Historical uses do not justify development of the new course. The existence of other golf courses in the area "up to the 1960's" provides little comfort as to the current site suitability. The suite of chemicals used for turf management would have been quite different, as were the regulatory requirements and oversight practices. Were these golf courses maintained to the standards of the proposed course? Is there any monitoring data to support the implied conclusion that the previous golf courses did not adversely impact the local environment?

2. **The risks and costs associated with the use of chemical controls are substantially understated.** The discussion at Section 3.4 ignores a number of important considerations. While chemical controls may reduce labor costs, they also increase material costs and the probability of adverse effects on human health and environmental quality, thereby increasing liability costs. More important, the conclusion that the association of pesticide residues with adverse environmental impacts resulted only from improper use or over use is unsupported and unsupportable. The history of pesticides for which the registrations have been canceled or the uses modified after original registration demonstrate the fact that unanticipated adverse effects occur under the conditions of use originally accepted by EPA and DEC. In fact, federal regulations speak clearly on this point in the prohibition of any label claims as to the safety of the pesticide or its ingredients, even with a qualifying phrase such as "when used as directed." 40 CFR § 156.10(a).

3. **The discussion of Biological Controls is inappropriately argumentative and belies a questionable commitment to their inclusion in the pest management program.** In counterpoint to the overly sympathetic introduction to chemical controls (see above) biological controls are introduced with mention of "pseudo-factual reports" about pesticides and the unsupported conclusion that biological controls are "complex, not totally effective and not always predictable." One could easily say the same of chemical controls, based on the need for repeated re-treatment, the proposal of alternative chemical controls for specific pests, and the many instances in which unanticipated adverse effects have occurred after use of chemical pesticides in accordance with label instructions. Biological controls are not presented in the context of valuable tools for turf management, but rather as "[o]ne approach that may provide some level of relief for turf managers . . ." from increased pressure to reduce pesticide applications (see section 3.4 at top of page 26).

4. **Misleading terminology is used throughout Sections 4, 5 and 6 to describe the chemicals proposed for control.** In many instances, the reference to "products" is in fact a reference to an active ingredient without acknowledgment that the active ingredient is not used in isolation, but rather formulated with other ingredients generally not identified on the label and not included in the modeling and toxicological evaluations presented in this DEIS.

5. **The prioritization of control options in Sections 4, 5 and 6 is not clear, and does not reflect a commitment to the use of chemical pesticides only as a last resort.** Generally, options are presented in a sequence of "cultural," "biological" and "chemical." It is not clear here that the options will be implemented in that order, and what criteria will be used to judge that one option has proven inadequate and justify the implementation of the next option in the hierarchy for each specific pest. In some instances, chemical control seems to be the intended management tool to the exclusion of other options. For example, in section 6.3.6 chemical

treatment is listed as the second option, before at least two cultural controls. Cultural Strategy V for annual bluegrass, "Apply a preemergence herbicide . . ." is a chemical strategy, not a cultural one.

Similarly, in the discussion of control options for White Grubs (see 5.5.1 at page 50), parasitic wasps are discussed as the third option and parasitic nematodes as the fourth option. While the text notes that parasitic wasp populations may take 2 to 3 years to reach effective levels, there appears to be no plan to establish the wasps during the construction or early days of operation of the course. Without such preparation, it seems unlikely that parasitic wasps can play a meaningful role in the control of white grubs, and chemical controls will be used instead.

6. Record keeping, as described in the DEIS, is inadequate to assess the efficacy of pest management strategies. The brief discussion of record keeping in Appendix 14, section 3.3.3 (p. 24) and the accompanying Figure 4 deal only with records of scouting. While these are useful in determining when and if control measures are needed, they do not help with subsequent analysis of their effect. If any control methods are implemented as a result of scouting/monitoring then there should be a record of what was done, and what effect resulted. These records would not necessarily be required for those preventive measures that are part of the construction and routine operation of the course, but should be generated and kept for all actions taken in response to a pest infestation. These records will document the efficacy of treatments, chemical or otherwise, and should be a valuable resource to the golf course management and others. To maximize their utility, the records should be publicly available.

7. There is no provision for notice to golfers, other visitors and neighbors, when chemical pesticides are applied. Given the known and potential adverse health effects associated with chemical pesticides, adequate notice should be given to those who work at the golf course, those who use it and those who reside on neighboring property. This can be accomplished by signs posted around treated areas and by notices displayed prominently at key locations, such as the first and ninth tees. Neighbors should receive advanced notice of applications to allow them to take precautions as they see fit.

D. Specific Comments on Appendix 15: Fertilizer and Pesticide Risk Assessment

1. General Comment. To comment comprehensively on the modeling described in Appendix 15, it would be necessary to research each of the models used in some depth, and better understand all of the inputs used and assumptions made. Lacking time and resources for this kind of in-depth review, we can provide only the following general observations and comments. In no case did the modeling consider either pesticide degradation products or inert ingredients of pesticide products, which, as discussed above, is a severe shortcoming for an analyses described as a "risk assessment."

2. WINPST Modeling. In Section 2 (p.2) and 2.1 (p.3) the USDA's WINPST model is described as an initial screening tool for determining overall pesticide mobility. It is unclear why the WINSPT modeling was even conducted, because there is no indication that any pesticides were accepted or rejected for use based on this exercise. Although the properties of four different soil series were reportedly modeled, Attachment 1 presents only the results for one soil series. Although the modeling produces indices of both pesticide mobility and hazard (hazard potential is based upon toxicological data in an internal WINPST database), the hazard rankings are ignored. The writers apparently prefer to compare LEACHM and GLEAMS generated concentration results to drinking water standards and LC_{50} values than to consider in any way the hazard potential results generated by the WINPST modeling. This results in the retention of at least nine pesticides that WINPST predicts will present a high hazard to humans and/or fish. No basis is given for ignoring these results.

3. **LEACHM Modeling.** The modeling utilized 1996 precipitation records, with 1996 being described as a high-precipitation year. The precipitation records are not provided, and so it is not clear whether precipitation was in fact heavy during the pertinent time periods when pesticide applications were modeled (April - October).

Although soils were identified and mapped in the field by the LA Group soil scientists, the modeling incorporated characteristics of type location soils reported in the Greene County Soil Conservation Service publications and the National Resources Conservation Service. Site specific soil characteristics could well have been determined but were not. The modeling apparently did not consider the effects of golf course construction activities on soil parameters (disturbance/cut-and-fill/artificially constructed soils for tees and greens where heavy pesticide applications are the rule).

The criteria applied to retain or reject pesticide products was: "Only the products that did not leach at all through the soil profiles and the products that had undiluted leachate concentrations below drinking water standards are recommended for use based on this portion of the this risk assessment." Claims of the conservativeness of the chosen criteria aside, the use of these criteria seems to assume no uncertainty concerning either model results or the protectiveness of the applicable drinking water standard (which in most instances are the New York State Department of Health "default"standard of 50 parts per billion for unspecified contaminants). A more conservative approach would eliminate those products that were predicted to have undiluted leachate concentrations at 10% or more of the drinking water standard. EPA HALS could and should be considered as well.

4. **GLEAMS Modeling.** Section 4.3 (p. 20) reports that, "Of the 53 pesticide active ingredients analyzed, *all but two* [emphasis added] were present to some degree in the worst case modeling . . . ." The criteria applied to reject pesticides was a concentration in undiluted runoff equal to or greater than the LC_{50} for the pesticide in question. As discussed above, the LC_{50} is questionable as a protective criteria in any event, and the application of the criteria assumes no uncertainty concerning model results or toxicological effects other than death. To better account for all uncertainties and unknowns like sub-lethal effects and effects on different life stages, undiluted runoff concentrations that are greater than 10% of the LC_{50} could be used.

E. Conclusion.

The attached spreadsheet (Exhibit 5) summarizes an alternative pesticide retention/rejection scheme. Products in blue font are selected for use both in Appendix 15 and by application of the comments above. Products stricken out in red font are those that were retained in Appendix 15 but would be rejected based on the comments above. Products stricken out in black font are those that were rejected both in Appendix 15 and by application of the above comments. The purpose of this spreadsheet is to demonstrate how arbitrary the selection criteria used in Appendix 15 are. The pest management plan should be re-done with more consistent and conservative methods and incorporating a clear commitment to IPM.

VI.

ASSESSMENT OF ADEQUACY OF THE DEIS REVIEW OF THE DESTRUCTION AND DEFORESTATION OF HEADWATER WETLANDS ON THE PROJECT SITE.

A. Introduction and Recommendations

Wetlands provide flood control, wildlife habitat, and improve drinking water quality by retaining phosphorus and processing nitrogen, trapping sediments, removing and transforming human and animal wastes, and degrading certain pollutants. Any disturbance to wetlands or their adjacent "buffer" areas within the Watershed is highly disfavored. The restoration or re-creation of wetlands that have been disturbed is usually unsuccessful.

Within the New York City Watershed, wetlands play a particularly important water quality protection function, and they comprise only a small fraction of the total land area. In short, the Project can and should be re-designed pursuant to SEQRA so that there is no disturbance or destruction of the 4.5 acres of wetlands or the associated buffer area (an area that is generally 100 feet in width) contrary to what is presently proposed. Moreover, as presented below, there are significant factual and technical disputes over the scope and existence of certain wetlands and water courses on the Project site. These disputes must be resolved prior to the EIS process being found to be complete so that decisions are made on an accurate factual record.

The U.S. Fish and Wildlife Service ("FWS"), with the assistance of City DEP, conducted an inventory of wetlands located within the Watershed as part of the National Wetlands Inventory. Tiner, R.W., Atlas of National Wetlands Inventory Maps for Watersheds of the New York City Water Supply System (1996). This inventory of wetlands that generally are 1 acre or more in size was developed through the interpretation of aerial photographs taken in 1986 and 1987, as well as through partial on-ground verification. The inventory found that within the Delaware portion of the Watershed, wetlands, exclusive of streams, rivers, lakes, reservoirs, and reservoir shores comprise only about .81% of the total area. In the Catskill portion of the Watershed, wetlands, including large reservoir shore areas but excluding streams, rivers, lakes and reservoirs comprise about 1.06% of the total area. This is a low level of wetland coverage. The Croton portion of the Watershed, for example, is approximately 7% wetland.

Given the importance of wetlands for water quality protection and the location and scale of the proposed development, potential impacts to wetlands are an important component of this DEIS. As is discussed in more detail below, however, the DEIS is deficient in this area because the document:

1. Fails to analyze the adverse environmental impacts of the proposed filling of 1.47 acres of wetlands, the removal of trees from forested swamps and stream corridors totaling 2.84 acres, and the destruction of associated wetland buffer area;

2. Fails to discuss why the wetland impacts could not be avoided through alternative project size or layout;

3. Fails to clearly describe the area of affected wetlands by erroneously excluding from the substantive discussion of wetlands in the DEIS the so-called "isolated" wetland areas;

4. Does not accurately depict existing site conditions because it excludes stream corridors that drain wetland complex ## 33-35 and wetland complex ##19-22, and apparently connect those purported "isolated" wetlands to Birch Creek and Emory Brook, respectively;

5. Fails to differentiate between the "waters of the United States" regulatory jurisdiction of the U.S. Army Corps of Engineers under the federal Clean Water Act and the analysis of adverse impacts to wetlands for purposes of SEQRA; and

6. Does not propose any wetland replacement for the area of wetlands proposed to be filled or cleared by creating, expanding or enhancing wetlands elsewhere in the affected watersheds, proposing instead to "mitigate" the wetland impacts by preserving other existing wetlands on the development's property, but for which there appears to be no reasonably foreseeable plans to fill or alter.

B. Federal Regulation of Wetlands

Separate and apart from SEQRA, filling or clearing wetlands in New York State may be subject to regulation under federal law. Federal Clean Water Act jurisdiction over "waters of the United States," includes wetlands. The Clean Water Act mandates that the federal government "restore and maintain the chemical, physical, and biological integrity of the Nation's waters."

The U.S. Army Corps' program to implement that mandate with respect to wetlands is specified under Section 404 of the Clean Water Act, 33 U.S.C. § 1344. Rather than being subject to New York State programs, small headwater wetlands like those at issue here are regulated under the federal Clean Water Act.

U.S. Army Corps regulations adopted under the Clean Water Act define "waters of the United States" to include, among other wetlands, wetlands that are themselves tributaries or are adjacent (bordering, contiguous or neighboring) to tributaries of traditional navigable waters, and wetlands that are themselves water, or are adjacent to other water, "the use, degradation, or destruction of which could affect interstate or foreign commerce including any such waters which are or could be used by interstate or foreign travelers for recreational or other purposes . . ," 33 C.F.R. §§ 328.3(a)(3); 328(a)(5) and (7) and 328.3(c).

Not all water, however, is included within the "waters of the United States" and regulated under the Clean Water Act. In *Solid Waste Agency of Northern Cook County v. U. S. Army Corps of Engineers* ("*SWANCC*"), 531 U.S. 159 (2001), the United State Supreme Court ruled that water that collected in abandoned pits from a defunct sand and gravel mine, creating a scattering of permanent and seasonal ponds, were not "waters of the United States." Courts have recognized, however, that *SWANCC* created a narrow exception to the broad scope of the original definition.

C. DEIS Analysis of Wetlands.

The DEIS addresses wetlands in Section 3.5.2 (pages 3-89 through 3-96), and incorporates material submitted to the U.S. Army Corps of Engineers regarding wetlands delineation (a delineation report identifies, maps, and discusses the wetlands on site) and permitting under the federal Clean Water Act as Appendix 17.

The DEIS includes no further analysis of wetlands other than present the material submitted to and accepted by the U.S. Army Corps of Engineers. That approach is not adequate for compliance with SEQRA because it erroneously delegates all relevant wetlands issues and decision-making to the U.S. Army Corps, a federal agency that is not subject to SEQRA, and improperly narrows the scope of the issues in terms of both geographic area and subject matter.

For example, the summary in the DEIS states that "the project requires the placement of clean fill in jurisdictional wetlands totaling 0.0993 acre." (DEIS at 3-94.) Yet material in Appendix 17 makes clear that the projected impacts to wetlands include the filling (destruction) of an additional 1.47 acres of wetlands. (Appendix 17A at 19, table 19). There is, however, no mention or analysis in the DEIS of the adverse impacts of that projected filling of those wetlands, apparently under the belief that the additional 1.47 acres of wetlands was outside the definition of "waters of the United States" for purposes of Army Corps jurisdiction. That omission in the DEIS appears to be both factually and legally unsupported. Factually, as described below, information from scientists from FWS and DEP suggests that there are additional wetlands.

Legally, it is not dispositive to a SEQRA analysis whether or not a wetland is regulated by the Corps of Engineers (or DEC or any other agency); SEQRA demands an analysis of the site regardless of other statutory requirements. Here, the DEIS does not discuss the fact that a much larger area of wetlands is projected to be filled, does not analyze the adverse environmental impacts of such filling, and provides no analysis of avoiding or mitigating those impacts. Those elements must be part of the SEQRA review of this project regardless of federal regulatory jurisdiction.

Those same requirements also apply to the projected clearing of trees from almost 3 acres of forested swamps and stream corridors. While the wetland tree removal protocols convinced the Army Corps that the clearing activity would not itself require an Army Corps' permit, those "how it will be done" protocols do not present a SEQRA analysis of the habitat or other environmental impacts of removing the trees from forested swamps and stream corridors, alternatives to avoid the impacts, or practicable ways to mitigate unavoidable impacts.

D. The DEIS Omits Stream Corridors Found by FWS and the City DEP.

The developer's wetland delineation report was submitted to the U.S. Army Corps of Engineers. On August 16, 2000, an Army Corps official met with the project sponsor to examine the wetlands on site. The FWS became involved with this project when asked to review a Pre-Construction Notification Permit Application (Number 2000-00748-YS) by the Army Corps. In response, a biologist from the FWS inspected portions of the proposed project site for wetlands. In addition, wetland scientists from the DEP also inspected the proposed project site for wetlands and water courses.

Based on site wetland investigations conducted by scientists representing both the FWS and DEP, the wetlands section of the DEIS is factually incorrect and deficient because it does not identify all of the water courses or streams on site. Without a thorough and accurate accounting of the water courses and streams on the project site, the DEIS cannot properly present the environmental impacts and mitigation measures associated with the proposed development.

1. FWS Site Inspection. Following the field inspection, the FWS sent a letter dated July 11, 2003 to the Army Corps identifying a number of potential inconsistencies concerning site wetlands. One week later the Army Corps filed an internal "memorandum for record" document entitled "Statement of Findings for Application No. 2000-00748-YS by Crossroads Ventures, LLC". The FWS letter to the Army Corps challenged whether all of the wetlands at the site had been properly delineated. According to the FWS:

> Direct wetland impacts are associated with the construction of road crossings over four stream and wetland complexes. Project plans also include numerous crossings of streams and wetlands by golf course paths. Numerous road crossings are also planned over non-jurisdictional wetlands. At least 13 crossings were noted on the project plans of both streams and wetlands. <u>It is unclear if all of the</u>

> streams including the ephemeral and intermittent streams have been shown on the plans. We recently visited the project site and found channels and discernable bed and banks located downslope of mapped channels. For example, we observed channels south of Gunnison Road adjacent to proposed golf tee #5, which are not shown on the plans. If all of the water courses have not been documented, then not all of the impacts have been considered. Intermittent and ephemeral streams provide important functions on the landscape such as carrying storm flows and providing habitat for life cycles of some species of fish and invertebrates. (Emphasis added.)

The importance of the FWS observations concerning unmapped water courses or streams is two-fold. First, accurate assessment of the potential impacts of filling or clearing wetlands cannot be performed if water courses and streams downslope from the impacted wetland areas – the stormwater pathways from those impacted areas – are not accurately mapped and depicted in the DEIS. Second, if the relevant wetland areas are drained by streams or water courses, then those wetlands would likely constitute "waters of the United States" that would also require an Army Corps' permit before they legally could be filled.

The Army Corps' response to FWS was that the FWS was mistaken concerning the location of the stream in question and that it was "confident that all waters of the United States were identified within the project area." The Army Corps was correct that the stream in question was not south of Gunnison Road at proposed golf tee #5. (The area of concern being questioned by the FWS was actually south of Gunnison Road, near the green at hole 13, as well as north of Gunnison Road).

In an effort to resolve this contradiction, a freedom of information act request was sent to both the FWS and the Army Corps concerning the proposed project wetlands. After reviewing the files, a March 30, 2004 telephone conversation with the FWS biologist who had walked the site both north and south of Gunnison Road revealed the following observations down slope from wetland complex ##19-22: drift patterns, drainage patterns, erosion, defined bed and bank, exposed roots, rocks and deposited sediment. These factors in concert with the site topographic map tend to indicate that the wetland complex ## 19-22 is connected to the north to this drainage channel, which likely connects to a tributary of Emory Brook under high precipitation conditions. Wetlands identified on either side or parallel to this wetland complex were not classified as isolated in the DEIS. Wetland #16 located to the west, and wetland # 23 located to the east, both flow into a tributary of Emory Brook, which is a tributary of the Pepacton Reservoir. This factual issue needs to be resolved before the EIS process under SEQRA is concluded.

2. DEP Site Inspection. Independent of the FWS review, the DEP wrote a letter to the Army Corps dated December 8, 2003, disagreeing with some of their jurisdictional determinations concerning wetlands at the project site. The DEP confirmed FWS's suspicion that the area north (downslope) of wetland complex ## 19-22 was not properly delineated or mapped as an "isolated" wetland. DEP scientists field identified those wetlands as tributaries of

Emory Brook. The DEP also found that the area north of wetland complex ## 33-35, on the eastern portion of the site, was not properly characterized. According to the site DEP's inspection, these three wetlands are tributaries to Birch Creek, which in turn is a tributary of the Ashokan Reservoir. This factual issue also needs to be resolved before the EIS process under SEQRA is concluded.

E. The Proposed Wetland Mitigation is Inadequate

To the extent that filling wetlands cannot practicably be avoided, the adverse impacts of the lost wetland functions and values must be mitigated under SEQRA unless demonstrated to be impracticable, by replacing the wetland area to be filled by restoring a larger area of former wetland or expanding a larger area of existing wetland within the same tributary system. To the extent that clearing trees from forested swamps and stream corridors cannot practicably be avoided, those impacts must also be mitigated, unless demonstrated to be impracticable. The mitigation proposed in the DEIS, to preserve other wetlands existing on site for which there appears to be no reasonably foreseeable plans to fill or alter, does not meet SEQRA's requirement that "to the maximum extent practicable, adverse environmental effects revealed in the environmental impact statement process will be minimized or avoided." ECL § 8-0109(8).

* * * * *

Respectfully submitted,

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Dr. Robert Pitt – June 23, 2004

CPC
Ex 57

Check Sheet for the Use of WinSLAMM Model

General steps to take when using WinSLAMM are summarized below:

1) Make sure you have the most recent model updates. Review recent model changes by examining the update logs at http://www.winslamm.com/WinSLAMMLog.Txt.

2) Identify your modeling objectives. This may include examining development alternatives, comparing stormwater management options, or calculating pollutant loadings for different subwatersheds. List the basic characteristics of the areas to be modeled, such as location, size, time frame, land uses, and existing stormwater controls.

3) Gather Data. Collect the basic information needed for the analyses.

- *Local Stormwater Data*. All models need to be calibrated and verified using local data. Although WinSLAMM comes with several default "parameter" files, they should be adjusted for local conditions.[1] Many regions have local stormwater data available from past projects such as EPA's Nationwide Urban Runoff Program. However, local data may not be available. For important projects needing a high level of accuracy, a local monitoring program may be necessary for suitable calibration and verification of the model.[2]
- *Rain Data*. Local rain data, preferably of many years duration, is a critical input parameter. The winter snow period also needs to be identified.
- *Site Descriptions*. Another critical set of data corresponds to the sites being modeled. WinSLAMM requires detailed information concerning each land use area. Field surveys, that can be used to obtain the information necessary to supplement aerial photographs, are described in WinSLAMM. For example, the size of each source area and how it is connected to the drainage system is required information. In addition, soils data and other parameters can be obtained during the field surveys. If the project is not yet built, some information must be obtained from the site plans.
- *Stormwater Management Options*. Existing stormwater controls, if present, should be explained. For future stormwater control alternatives, design attributes need to be described.

4. File Preparation and Model Use. Once the needed information is gathered and organized, the WinSLAMM files need to be prepared. Basic files (having minimal controls or other "unusual" features) can be prepared first and saved using a suitable file

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[1] It may be acceptable to use the basic WinSLAMM parameter files to compare alternatives for small projects. But for large projects, or projects in sensitive areas where absolute discharge values with the least possible error are sought, a formal calibration and verification process is necessary.

[2] When WinSLAMM is used with the unmodified parameter files distributed with the program, the predicted discharges can be in error by as much as 50 to 100% of the actual values. With calibration using local data, these errors are typically reduced to less than 50%, and can approach 10%, depending on the constituent and the monitoring data available.

naming protocol to minimize confusion. That file can then be edited to include options and additions, with each separately named.

5. Evaluating Model Output. After the model runs are completed, the results need to be tabulated and otherwise summarized. Calculated concentrations and unit area loadings can be compared to results from regional monitoring studies (such as the NPDES National Stormwater Quality Database at: http://rpitt.eng.ua.edu/Research/ms4/mainms4.shtml). The predicted benefits of the structural stormwater controls can also be compared to the results presented in the American Society of Civil Engineers BMP Database at: http://www.bmpdatabase.org/. Since the purpose of WinSLAMM is to predict **site-specific** results (considering local rains, site development characteristics, and unique designs of stormwater practices) the predicted results will vary somewhat from the information presented in these referenced databases, but should be questioned if there are considerable differences. The model predictions can also be examined for internal consistency, such as by examining results for different rain categories. In order to obtain the most reliable predictions, the preferred approach is to compare the predicted results to monitored results for test watersheds and then to modify the parameter files during a calibration process. The calibrated model can then be run again and compared to data and conditions that were not included in the initial calibration data, for additional verification.

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A.5 SMP Pollutant Removal

The removal efficiencies of various SMP practices also help determine final annual pollutant loads. Table A.4 provides estimates of the average pollutant removal efficiency of the five SMP categories.

Table A.4. Suggested Removal Rates for SMPs

	TSS	TP	TN	Metals[1]	Bacteria
Wet Ponds	80	50 (51)	35 (33)	60 (62)	70
Stormwater Wetlands	80[2] (76)	50 (49)	30	40 (42)	80 (78)
Filtering Practices	85 (86)	60 (59)	40 (38)	70 (69)	35 (37)
Infiltration Practices [4]	90[3] (95)	70	50 (51)	90[3] (99)	90[4]
Water Quality Swales	85 (84)	40 (39)	50[5] (84)	70	0 (-25)[6]

1. Average of zinc and copper. Only zinc for infiltration
2. Many wetland practices in the database were poorly designed, and we consequently adjusted sediment removal upward.
3. It is assumed that no practice is greater than 90% efficient.
4. Data inferred from sediment removal.
5. Actual data is based on only two highly performing practices.
6. Assume 0 rather than a negative removal.

Note: Data in parentheses represent median pollutant removal data reported in the *National Pollutant Removal Database - Revised Edition* (Winer, 2000). These data were adjusted for convenience and to reflect biases in the data.

These efficiencies represent ideal pollutant removal rates that cannot be achieved at all sites, or at a watershed level. Typically, they need to be "discounted" to account for site constraints, and other factors that reduce practice efficiency. For example, the removal rate should be adjusted to reflect the fraction of runoff captured by a practice on an annual basis (90% if this guidance is followed). For more detail on how to apply these discounts, consult Caraco (2001).

One particularly important consideration is how to account for practices applied in series (e.g., two ponds applied in sequence). If the volume within the practices adds up to the total water quality volume, they are assumed to act as a single practice with that volume. Otherwise, total pollutant removal should be determined by the following equation:

$$R = L\ [(E_1)+(1-E_1)E_2+(1-((E_1)+(1-E_1)E_2)E_3+\ldots]$$

Where:

R = Pollutant Removal (lbs)

L = Annual Load from Simple Method (lbs.)

E_i = Efficiency of the ith practice in a series

Another adjustment can be made to these removals to account for loss of effectiveness and "irreducible concentrations." Evidence suggests that, at low concentrations, SMPs can no longer remove pollutants.

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CPC Ex 59

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EXPERIENCE

Pall Corporation, Water Processing Division, East Hills, New York
Project Engineer/Project Manager, 1997-Present

- Manage and implement pilot studies in water treatment and membrane filtration for municipal and industrial water/wastewater applications.
- Optimize polymeric membrane filtration processes.
- Provide field and technical support for test equipment and full-scale filtration systems.
- Design and support remote-monitored and controlled test equipment.
- Develop Human-Machine Interfaces (HMI) with data trending and graphic displays for real-time data acquisition and control.
- Prepare equipment specifications.
- Generate technical reports for internal and external customer base.
- Provide internal training worldwide in automated pilot testing for water processing applications.
- Travel extensively to customer locations during all project phases.
- Maintain regular communication with customers and consulting engineers.

New York City Department of Sanitation, Bureau of Waste Prevention and Recycling, Staten Island, New York
Project Manager, 1996-1997.

- Developed and implemented pilot studies in municipal solid waste planning.
- Designed and operated pilot facility for material recycling.
- Conducted waste composition audits and feasibility studies in recycling.
- Directed procurement and staffing under project grant.
- Administered $670K annual budget.
- Supervised and managed contracts.
- Administered Ethernet system for office network.

The Coca-Cola Company, Engineering Development Center (EDC), Atlanta, Georgia
Contract Engineer, 1994-1996

- Analyzed and developed point-of-use water treatment systems.
- Evaluated capability of third-party water treatment systems.
- Designed and tested proprietary marketing equipment.
- Performed data validation and instrument capability studies.
- Applied Statistical Process Control (SPC) in developing standardized test protocols.
- Developed data management system for ISO 9000 compliance.
- Served on EDC Safety/Environmental committee.
- Trained EDC personnel on usage of PC-based applications.

College of Staten Island, Department of Engineering Technologies, Staten Island, New York
Adjunct Instructor, 1990-1994

- Instructed students on use of CAD/CAM (Computer Aided Design/Manufacturing), CNC (Computer Numerical Control) applications, robotics, engineering test apparatus, and laboratory instrumentation.
- Planned, tested and organized laboratory experiments.

New York City Department of Parks, Borough Office, Staten Island, New York
GIS Analyst 1992-1994

- Developed GIS (Geographic Information System) for City-owned properties.
- Digitized analog and GPS (Global Positioning System) data in creating GIS database.
- Wetland restoration.

New York University/National Science Foundation, Advanced Routing Technologies, New York, New York
GIS Consultant, 1994

- Converted scanned imagery to GIS format.
- Performed hydrologic modeling with resulting databases.

EDUCATION

MS Environmental Science, GPA: 3.8, 1994
Long Island University/C.W. Post, Brookville, New York

BS Engineering Science, *cum laude,* 1990
City University of New York, New York, New York

SPECIALIZED TRAINING

- **Leadership Training for Managers,** Dale Carnegie Training
- **Project Management,** Management Systems International
- **Design of Experiments,** Pall Corporation
- **Applications in RS View and RS Logix,** Rockwell Software
- **Statistical Process Control for Engineering Laboratories,** The Coca-Cola Company
- **Waterborne Particulate Monitoring**, Georgia Water Pollution and Control Association
- **Applications in GIS**, Rutgers University

AFFILIATIONS

- Water Environment Federation
- New York Water Environment Association
- Georgia Water Pollution and Control Association-Wastewater Plant Safety Committee, 1995
- American Society of Mechanical Engineers

REFERENCES

Furnished upon request.

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H1

Ver 1

CPC Ex 65

TABLE 1A
2000-2001 MONTHLY
SPRING AND STREAM FLOW MEASUREMENTS (GPM)

[redacted]
Alpha Project No. 00109

		2000												2001			
	Stream/Spring	18-Jan	2-Mar	27-Mar	20-Apr	22-May	26-Jun	26-Jul	29-Aug	28-Sep	26-Oct	28-Nov	27-Dec	30-Jan	28-Feb	29-Mar	25-Apr
A	Woodchuck Hollow Spring (Upper Spring)	NM[6]	NM	NM	NM	NM	214	67	70	54	138	94	96	NM	NM	NM	558
B	Railroad Spring[1]	NM	NM	NM	NM	951	866	476	610	197	156	251	1073	246	754	491	1295
C	Crystal Spring Brook-above Bonnie View Spg.	179	2478	1917	2168	2217	1615	301	296	114	191	193	1059	259	543	250	4054
D	Bonnie View side ditch[2]	46	96	58	137	121	122	72	34	24	10	22	135	63	109	37	110
E	Pine Hill H_20 Supply (meter)	0	NM	118	118	0	118	114	114	112	112	113	NM	113	113.5	113.4	119
F	Pine Hill H_20 Supply overflow	48	11	10	10.5	102	7.5	0.7	.25 ^{es}	0	0	0.7	9.5	NM	3	2.8	17.7
G																	
H	Crystal Spring Brook-above Cathedral Glen Brook	312	3591	2644	2721	2765	2442	485	732	368	453	566	1336	579	918	1131	4716
I	Cathedral Glen Brook-above CSB	597	9627	9197	6240	7122	5714	1800	2078	705	1611	2639	1473	826	2845	1143	19433
J	Black ABS Pipe-above Silo A	NM	NM	19	19.7	18	18	9.9	5.1	2.2	2.2	1.7	11.5	5.6	9.4	12	20.6
K	Silo A	120	212	150	175	178	125	104	98	87	86	87	139	109	113	106	167
L	Crystal Spring Brook-below Silo A	1073	12183	11367	11976	10619	7783	3429	2648	1970	3196	3214	4636	1480	3204	2038	23180
M	Silo B 4" Pipe	NM	NM	NM	NM	NM	NM	96	94	51	121	113	150	133	161	176	189
N	Silo B Overflow	29	25	28	24	26	25	25	26	25	25	26	28.5	25	26.5	NA	NA
O	Silo B (M + N)	NM	NM	NM	NM	NM	NM	121	120	76	146	139	178.5	158	187.5	176	189
P	Station Rd. ditch-above Station Rd. Spg.	67	248	136	557	707	404	220	63	0	124	28	557	0	166	122	768
Q	Station Rd. ditch-below Station Rd. Spg.	254	1067	412	992	917	1050	543	605	221	476	435	1164	303	1001	955	2005
R	Schaedel Spring Total[3,4]	206	844	304	459	236	671	348	568	246	377	435	635.5	328	861.5	833	1237
S	Crystal Spring Brook-below Station Rd. Spg.	1923	13720	10642	12178	11269	10251	4135	2890	2585	3618	4641	6765	2683	3767	3386	22286
T	Bailey Brook-above Crystal Spring Brook[5]	NM	NM	NM	NM	2280	1256	314	149	54	215	256	1100	100	175	208	4189
U	Crystal Spring Brook-above Birch Creek	NM	NM	NM	15870	14873	12439	4601	2751	2087	3631	4524	6970	2098	4190	3564	29972
V	Birch Creek-above Crystal Spring Brook	NM	NM	NM	27636	25694	15934	10718	6234	2675	6167	5637	17574	6118	8555	9424	30220
W	Birch Creek-below Crystal Spring Brook	NM	NM	NM	39409	42762	24371	15687	9807	4726	10812	11916	23429	9551	12278	13572	61878
X	Wildacres #1 Spring	1	10.7	1.7	10	10.6	5.8	3.3	2.9	1	NM	NM	NM	NM	NM	NM	NM
Y	Wildacres #2 Spring	5.6	15	0.6	5.5	7.1	4.6	2.5	1.3	0.9	NM	NM	NM	NM	NM	NM	NM
Z	Wildacres #3 Spring	8.4	17.5	6.8	17.5	5.8	5.3	10.3	11.5	4.8	NM	NM	NM	NM	NM	NM	NM
AA	Davenport Spring	3.2	10.1	5.6	12.4	12.5	6.7	2	1.8	1.1	NM	NM	NM	NM	NM	NM	NM
BB	Highmount Spring	3.8	11.5	10	23	18.7	10.2	2.4	1.8	0.5	NM	NM	NM	NM	NM	NM	NM
CC	Leach Spring	3.4	4.4	6.1	13	5.1	6.9	11.1	6.3	5.6	6.8	6.1	12.2	2.5	4.9	NM	5.6
DD	Esopus Creek at USGS Allaben Gauging Station	50718	235187	77648	105026	127468	72710	33213	25583	10772	22890	29823	63285	22442	45781	60143	Unavailable

Notes:

1 Railroad Spring drains into Cathedral Glen Brook, upstream from its confluence with Crystal Spring Brook

2 Bonnie View Side Ditch = Water from Bonnie View Spring that does not enter piping to Bonnie View Spring collection system.

3 Schaedel Spring flow = Station Rd ditch flow below Spring, minus Station Rd. ditch flow above Spring, plus Silo B overflow

4 Silo B overflow to reservoir disconnected in March 2001. For March 2001 and subsequent dates, total Schaedel Spring flow = Station Rd Ditch below Spring, minus Station Rd. Ditch above spring

5 Bailey Brook = Name given to unnamed stream in Woodchuck Hollow.

6 NM = Not Measured

Version 2

TABLE 1A
2000-2001 MONTHLY
SPRING AND STREAM FLOW MEASUREMENTS
Gallons Per Minute

Belleayre Resort
Alpha Project No. 00109

		2000															
	Stream/Spring	18-Jan	2-Mar	27-Mar	20-Apr	22-May	26-Jun	26-Jul	29-Aug	28-Sep	26-Oct	28-Nov	27-Dec	30-Jan	28-Feb	29-Mar	25-Apr
A	Woodchuck Hollow Spring	NM[6]	NM	NM	NM	NM	87	27	28	22	56	38	39	NM	NM	NM	226
B	Railroad Spring[1]	NM	NM	NM	NM	386	351	193	247	80	63	102	435	100	306	199	525
C	Crystal Spring Brook-above Bonnie View Spg.	73	1005	777	879	598	655	122	120	46	77	78	430	105	220	101	1644
D	Bonnie View side ditch[2]	19	39	24	56	49	49	29	20	10	8	10	55	26	44	15	45
E	Pine Hill H_20 Supply (meter)	0	NM	118	118	0	118	114	114	112	112	113	NM	113	113.5	113.4	119
F	Pine Hill H_20 Supply overflow	48	11	10	10.5	102	7.5	0.7	.25	0	0	0.7	9.5	NM	3	2.8	17.7
G																	
H	Crystal Spring Brook-above Cathedral Glen Brook	127	1,456	1,072	1,104	1,121	990	197	297	149	184	230	542	235	372	459	1,913
I	Cathedral Glen Brook-above CSB	242	3,499	3,730	2,531	2,889	2,317	730	843	286	653	1,070	597	335	1,154	464	7,882
J	Black ABS Pipe-above Silo A	NM	NM	19	19.7	18	18	9.9	5.1	2.2	2.2	1.7	11.5	5.6	9.4	12	20.6
K	Silo A	120	212	150	175	178	125	104	98	87	86	87	139	109	113	106	167
L	Crystal Spring Brook-below Silo A	425	4,941	4,818	4,857	4,307	3,157	1,391	1,074	799	1,296	1,304	1,880	600	1,299	527	9,401
M	Silo B 4" Pipe	NM	NM	NM	NM	NM	NM	96	94	51	121	113	150	133	161	176	189
N	Silo B Overflow	29	25	28	24	26*	25	25	26	25	25	26	28.5	25	26.5	NA	NA
O	Silo B (M + N)	NM	NM	NM	NM	NM	NM	121	120	76	146	139	178.5	158	187.5	176	189
P	Station Rd. ditch-above Depot Spg.	35	101	55	226	287	164	89	26	0	50	11	226	0	67	49	311
Q	Station Rd. ditch-below Depot Spg.	107	433	167	402	372	426	220	245	90	193	176	472	123	406	357	813
R	Depot Spring Total[3,4]	101	357	140	200	111	287	156	246	115	168	192	275	148	365	338	502
S	Crystal Spring Brook-below Depot Spg.	780	5,565	4,316	4,939	4,570	4,158	1,677	1,172	1,048	1,467	1,882	2,744	1,088	1,528	1,373	9,039
T	Bailey Brook-above Crystal Spring Brook[5]	NM	NM	NM	NM	925	509	127	60	22	57	104	446	41	71	84	1695
U	Crystal Spring Brook-above Birch Creek	NM	NM	NM	6,437	6,032	5,045	1,856	1,116	846	1,473	1,835	2,827	851	1,699	1,445	12,156
V	Birch Creek-above Crystal Spring Brook	NM	NM	NM	11,209	10,421	6,463	4,347	2,526	1,085	2,501	2,286	7,128	2,481	3,470	3,822	12,257
W	Birch Creek-below Crystal Spring Brook	NM	NM	NM	15,984	17,343	9,584	6,252	3,978	1,917	4,385	4,833	9,502	3,874	4,980	5,505	25,096
X	Wildacres #1 Spring	1	10.7	1.7	10	10.6	5.8	3.3	2.9	1	NM	NM	NM	NM	NM	NM	NM
Y	Wildacres #2 Spring	5.6	15	0.6	5.5	7.1	4.6	2.5	1.3	0.9	NM	NM	NM	NM	NM	NM	NM
Z	Wildacres #3 Spring	8.4	17.5	6.8	17.5	5.8	5.3	10.3	11.5	4.8	NM	NM	NM	NM	NM	NM	NM
AA	Davenport Spring	3.2	10.1	5.6	12.4	12.5	6.7	2	1.8	1.1	NM	NM	NM	NM	NM	NM	NM
BB	Highmount Spring	3.8	11.5	10	23	18.7	10.2	2.4	1.8	0.5	NM	NM	NM	NM	NM	NM	NM
CC	Leach Spring	3.4	4.4	6.1	13	5.1	6.9	11.1	6.3	5.6	6.8	6.1	12.2	2.5	4.9	NM	5.6
DD	Birch Creek at USGS Big Indian Gauging Station[7]	5,835	41,741	19,300	25,134	26,481	13,914	6,284	4,488	2,154	3,725	2,873	12,567	5,386	8,527	9,874	31,418
EE	Esopus Creek at USGS Allaben Gauging Station[7]	50,718	235,187	76,301	107,719	132,854	80,789	33,662	24,686	11,220	22,890	29,623	72,710	22,890	38,151	55,206	121,633

Notes:
1 Railroad Spring drains into Cathedral Glen Brook, upstream from its confluence with Crystal Spring Brook
2 Bonnie View Side Ditch = Water from Bonnie View Spring that does not enter piping to Bonnie View Spring collection system.
3 Depot Spring flow = Station Rd ditch flow below DepotSpring, minus Station Rd. ditch flow above Depot Spring, plus Silo B overflow
4 Silo B overflow to reservoir disconnected in March 2001. For March 2001 and subsequent dates, total Depot Spring flow = Station Rd Ditch below Depot Spring, minus Station Rd. Ditch above Depot Spring
5 Bailey Brook = Name given to unnamed stream in Woodchuck Hollow.
6 NM = Not Measured
7 Esopus Creek and Birch Creek flow values for September 2000 through December 2001 are "Provisional Data Subject To Revision" by the USGS

Table 1 Discrepancy Factor

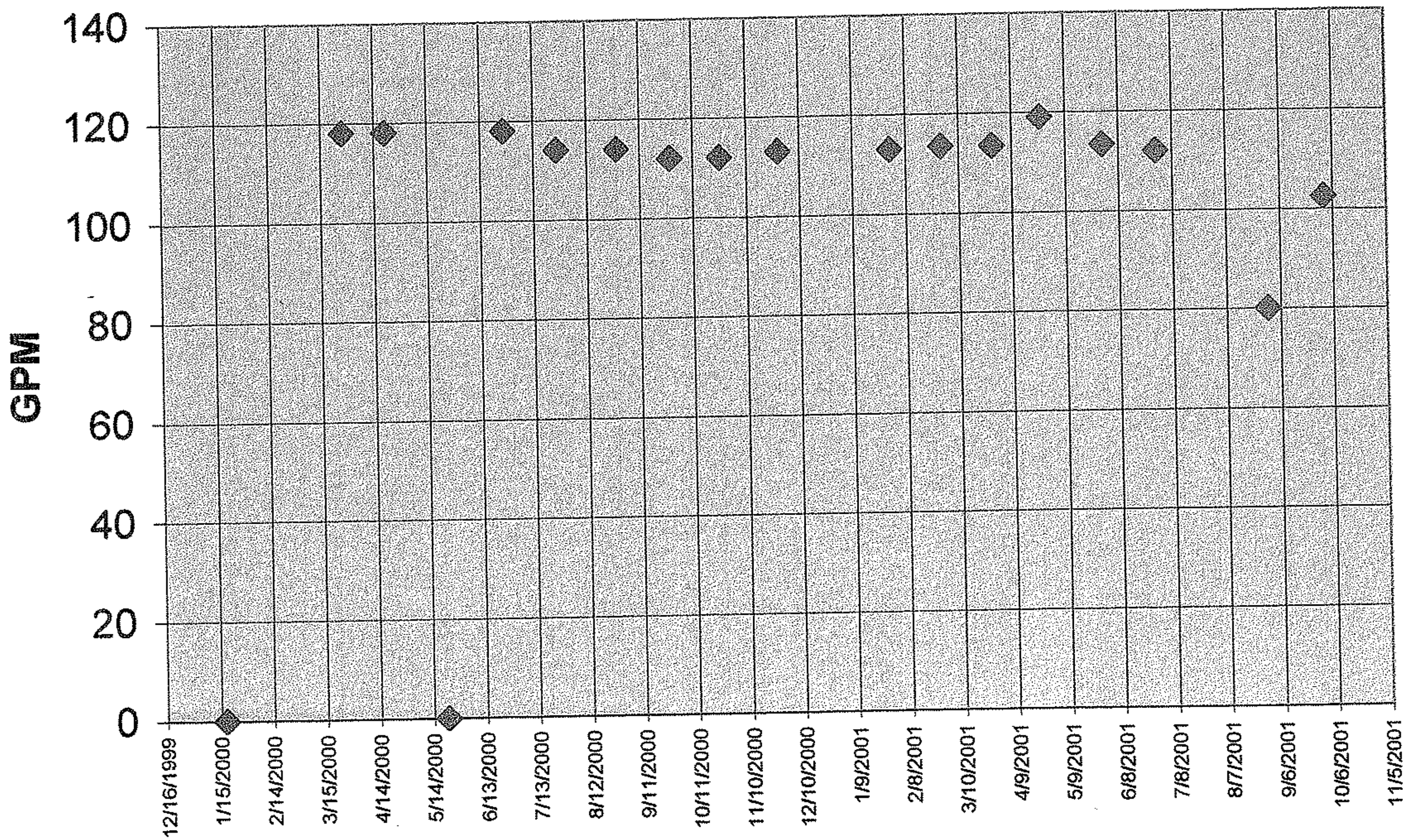
		1/18/00	3/2/00	3/27/00	4/20/00	5/22/00	6/26/00	7/26/00	8/29/00	9/28/00	10/26/00	11/28/00	12/27/00	1/30/01	2/28/01	3/29/01	4/25/01
ROW									DISCREPENCY FACTOR								
a	WOODCHUCK	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	2.5	2.5	2.5	2.5	2.5	2.5	2.5	#DIV/0!	#DIV/0!	#DIV/0!	2.5
b	RAILROAD SP	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
c	CRYSTAL SPF	2.5	2.5	2.5	2.5	2.5	2.8	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
d	BONNIE VIEW	2.4	2.5	2.4	2.4	2.5	2.5	2.5	1.7	2.4	1.3	2.2	2.5	2.4	2.5	2.5	2.4
h	CRYSTAL SPF	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
l	CATHEDRAL (	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
l	CRYSTAL SPF	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
p	STATION RD [	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	#DIV/0!	2.5	2.4	2.5	#DIV/0!	2.5	2.5	2.5
q	STATION RD [	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
r	SCHAEDEL SF	2.0	2.4	2.2	2.3	2.1	2.3	2.2	2.3	2.1	2.4	2.3	2.3	2.2	2.4	2.5	2.5
s	CRYSTAL SPF	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
t	BAILEY BROO	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.4	2.5	3.3	2.6
u	CRYSTAL SPF	#DIV/0!	#DIV/0!	#DIV/0!	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
v	BIRCH CREEK	#DIV/0!	#DIV/0!	#DIV/0!	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
w	BIRCH CREEK	#DIV/0!	#DIV/0!	#DIV/0!	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5

Table 2: Occurrences of Alpha Geoscience Stream and Flow Study

	LOCATION	VERSION
2002 WSA MODIFICATION APPLICATION	6/6/01 DELEWARE ENGINEERING LETTER TO DEAN PALEN	1
	EXHIBIT 1 - 2/28/02 ENGINEERS REPORT	2
	EXHIBIT 5	2
DEIS	VOL. 2-APPENDIX 2.1-BIG INDIAN PLATEAU WATER SUPPLY.pdf P25	1
	VOL. 2-APPENDIX 2.2-WILDACRES RESORT WATER SUPPLY.pdf P49	2
	VOL. 3-APPENDIX 7-BIG INDIAN PLATEAU WATER SUPPLY D.pdf P4	2
	VOL. 3-APPENDIX 7-BIG INDIAN PLATEAU WATER SUPPLY G.pdf P27	2
	VOL. 3-APPENDIX 7-WILDACRES RESORT WATER SUPPLY C.pdf P4	2

FIG 1.

PINE HILL WATER SUPPLY METER



WATER REQUIREMENTS OF SYSTEM[3]

(Gallons)

Date	December (2000)	January (2001)	February (2001)
1	139,900	165,600	71,200
2	133,350	144,300	68,800
3	140,900	160,400	70,300
4	138,300	157,200	95,600
5	128,400	156,000	72,100
6	131,100	148,100	62,300
7	131,900	165,100	79,100
8	131,600	160,600	71,100
9	138,500	162,800	69,800
10	139,400	166,000	79,500
11	133,600	163,500	76,100
12	134,000	164,300	74,500
13	140,100	167,500	68,600
14	135,400	163,800	71,500
15	146,200	164,100	78,100
16	143,600	165,700	75,300
17	146,600	164,900	78,300
18	156,300	162,900	75,300
19	176,700[4]	164,600	87,700
20	153,100	164,000	77,800
21	171,700	164,400	72,400
22	167,200	167,600	74,700
23	166,200	–[5]	70,000
24	165,900	100,900	86,800
25	164,600	79,000	86,900
26	154,600	76,800	59,300
27	162,000	75,800	71,300
28	165,000	85,000	69,500
29	160,300	74,100	
30	166,100	69,600	
31	158,500	70,500	

---

[3] Because meter readings, which represent the amount of water going into the system, are taken early in the morning they actually reflect consumption from the previous day.

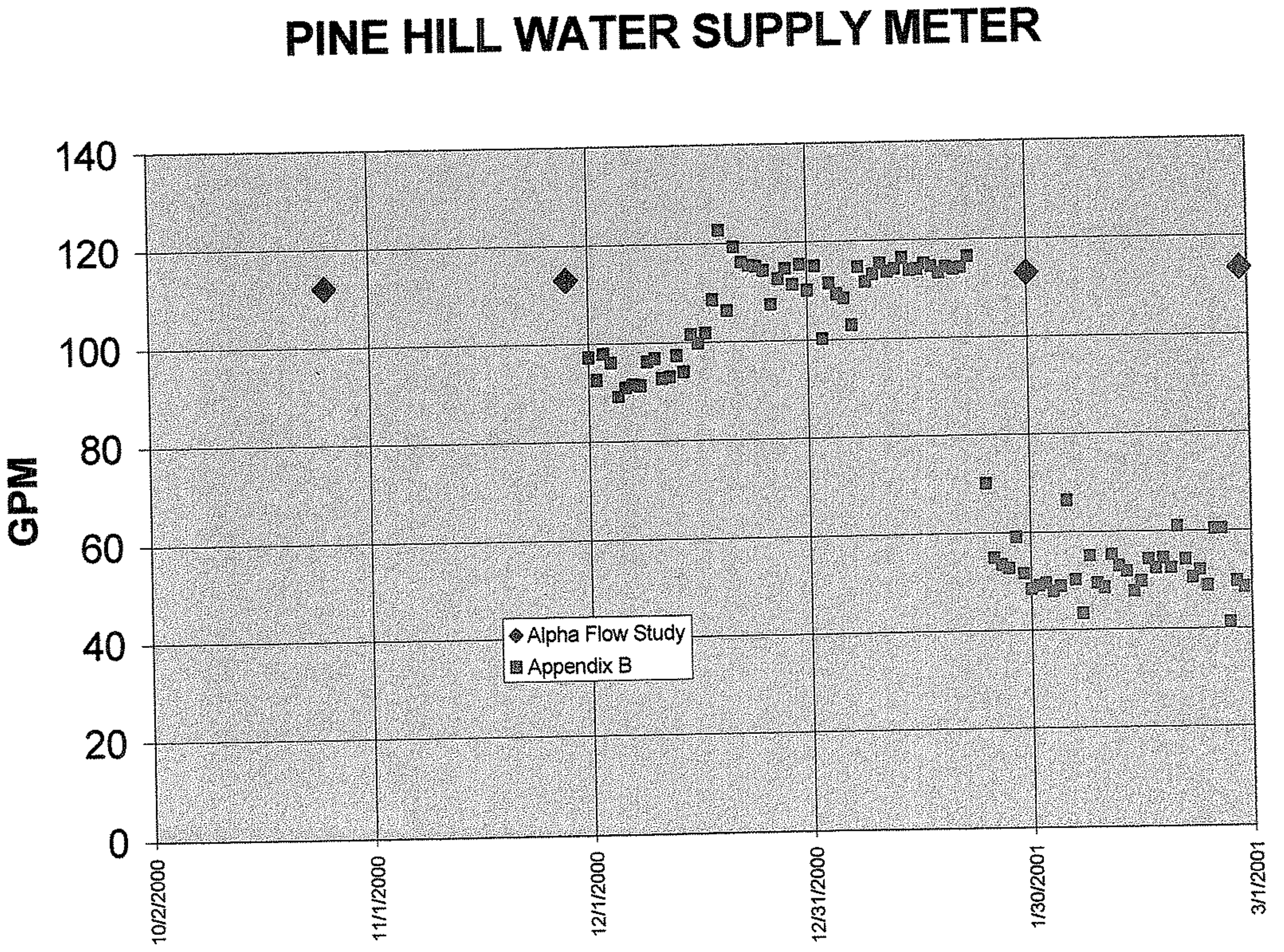
[4] Reservoir began dropping.

[5] All major leaks repaired.

Table 3. Alpha Flow Study vs. Vol 3, Appendix 7 Big Indian Plateau Water Supply - Appendix B

	Alpha Flow Study (Version 1 or 2)	**Appendix B**
12/27/00	Not Measured	162000 gpd (112.5 gpm)
1/30/2001	113 gpm	69600 gpd (**48.3 gpm**)
2/28/2001	113.5 gpm	69500 gpd (**48.3 gpm**)

Figure 2: Appendix B. vs Alpha Flow Study



PINE HILL WATER SUPPLY METER

Average Monthly Flow = 0.7 * Bonnie View Flow = 0.7(H-C+D+F+E)

Using Version 1 data:

Average Monthly Flow =0.7(368-114+24+0+112) = 273gpm=393,120 gpd*

Using Aug. 2001 as low flow month from Version 2:

Average Monthly Flow =0.7(45-30+5+0+80) =* ***70gpm=100,800 gpd***

Not 87 gpm

Average Flow =0.7(558-373+30+99+5) = 223 gpm* (not 134 gpm)

Y2

CPC
60A
6.25.04
PENGAD-Bayonne, N.J.

TABLE 1A
2000-2001 MONTHLY
SPRING AND STREAM FLOW MEASUREMENTS
Gallons Per Minute

Belleayre Resort
Alpha Project No. 00109

	Stream/Spring	2000												2001										
		18-Jan	2-Mar	27-Mar	20-Apr	22-May	26-Jun	26-Jul	29-Aug	28-Sep	26-Oct	28-Nov	27-Dec	30-Jan	28-Feb	29-Mar	25-Apr	30-May	29-Jun	30-Aug	1-Oct	13-Nov	29-Nov	14-Dec
A	Woodchuck Hollow Spring	NM[6]	NM	NM	NM	NM	87	27	28	22	56	38	39	NM	NM	NM	226	44	31	12	41	NM	NM	38
B	Railroad Spring[1]	NM	NM	NM	NM	386	351	193	247	80	63	102	435	100	306	199	525	214	172	0	0	0	0	0
C	Crystal Spring Brook-above Bonnie View Spg.	73	1005	777	879	899	655	122	120	46	77	78	430	105	220	101	1644	97	80	30	16	NM	NM	NM
D	Bonnie View side ditch[2]	19	39	24	56	49	49	29	20	10	8	10	55	26	44	15	45	35	68	5	0	NM	NM	NM
E	Pine Hill H_20 Supply (meter)	0	NM	118	118	0	118	114	114	112	112	113	NM	113	113.5	113.4	119	113.4	112	80	102.5	NM	NM	NM
F	Pine Hill H_20 Supply overflow	48	11	10	10.5	102	7.5	0.7	.25	0	0	0.7	9.5	NM	3	2.8	17.7	13.5	2.3	0	0			
G																								
H	Crystal Spring Brook-above Cathedral Glen Brook	127	1,456	1,072	1,104	1,121	990	197	297	149	184	230	542	235	372	459	1,913	322	280	45	69	NM	NM	NM
I	Cathedral Glen Brook-above CSB	242	3,499	3,730	2,531	2,889	2,317	730	843	286	653	1,070	597	335	1,154	464	7,882	920	540	42	372	NM	NM	NM
J	Black ABS Pipe-above Silo A	NM	NM	19	19.7	18	18	9.9	5.1	2.2	2.2	1.7	11.5	5.6	9.4	12	20.6	9.9	5	1	0	NM	NM	NM
K	Silo A	120	212	150	175	178	125	104	98	87	86	87	139	109	113	106	167	93.5	93	69.5	73	69.3	70.8	79.7
L	Crystal Spring Brook-below Silo A	435	4,941	4,618	4,857	4,307	3,157	1,391	1,074	799	1,296	1,304	1,880	600	1,299	827	9,401	1,312	785	182	853	NM	NM	NM
M	Silo B 4" Pipe	NM	NM	NM	NM	NM	NM	96	94	51	121	113	150	133	161	176	189	187	185	27.5	159	NM	NM	165
N	Silo B Overflow	29	25	28	24	26	25	25	26	25	25	26	28.5	25	26.5	NA	NA	NA	NA	NA	NA	NM	NM	NA
O	Silo B (M + N)	NM	NM	NM	NM	NM	NM	121	120	76	146	139	178.5	158	187.5	176	189	187	185	27.5	159	NM	NM	165
P	Station Rd. ditch-above Depot Spg.	35	101	55	226	287	164	89	26	0	50	11	226	0	67	49	311	0	4	0	0	NM	NM	NM
Q	Station Rd. ditch-below Depot Spg.	107	433	167	402	372	426	220	245	90	193	176	472	123	406	387	813	223	170	28	147	NM	NM	NM
R	Depot Spring Total[3,4]	101	357	140	200	111	287	156	246	115	168	192	275	148	365	338	502	223	166	28	147	NM	NM	NM
S	Crystal Spring Brook-below Depot Spg.	780	5,565	4,316	4,939	4,570	4,158	1,677	1,172	1,048	1,467	1,882	2,744	1,088	1,528	1,373	9,039	1,336	1,022	280	738	NM	NM	NM
T	Bailey Brook-above Crystal Spring Brook[5]	NM	NM	NM	NM	925	509	127	60	22	87	104	446	41	71	84	1699	110	141	0	24	NM	NM	NM
U	Crystal Spring Brook-above Birch Creek	NM	NM	NM	6,437	6,032	5,045	1,866	1,116	846	1,473	1,835	2,827	851	1,699	1,445	12,156	1,460	946	188	601	NM	NM	1080
V	Birch Creek-above Crystal Spring Brook	NM	NM	NM	11,209	10,421	6,463	4,347	2,528	1,085	2,501	2,286	7,128	2,481	3,470	3,822	12,257	3,046	2,101	614	591	NM	NM	1435
W	Birch Creek-below Crystal Spring Brook	NM	NM	NM	15,984	17,343	9,884	6,362	3,978	1,917	4,385	4,833	9,502	3,874	4,980	5,505	25,096	4,453	3,214	696	1,225	NM	NM	2205
X	Wildacres #1 Spring	1	10.7	1.7	10	10.6	5.8	3.3	2.9	1	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM
Y	Wildacres #2 Spring	5.6	15	0.6	5.5	7.1	4.6	2.5	1.3	0.9	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM
Z	Wildacres #3 Spring	8.4	17.5	6.8	17.5	5.8	5.3	10.3	11.5	4.8	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM
AA	Davenport Spring	3.2	10.1	5.6	12.4	12.5	6.7	2	1.8	1.1	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM
BB	Highmount Spring	3.8	11.5	10	23	18.7	10.2	2.4	1.8	0.5	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM
CC	Leach Spring	3.4	4.4	6.1	13	5.1	6.9	11.1	6.3	5.6	6.8	6.1	12.2	2.5	4.9	NM	5.6	4	12	0	0	NM	NM	NM
DD	Birch Creek at USGS Big Indian Gauging Station[7]	5,835	41,741	19,300	25,134	26,481	13,914	6,284	4,488	2,154	3,725	2,873	12,567	5,386	8,527	9,874	31,418	7,630	6,732	987	1,885	1,212	2,289	5,386
EE	Esopus Creek at USGS Allaben Gauging Station[7]	50,718	235,187	76,301	107,719	132,854	80,789	33,662	24,686	11,220	22,890	29,623	72,710	22,890	38,151	55,206	121,633	66,307	25,583	4,937	11,221	7,630	8,303	23,788

Notes:

1 Railroad Spring drains into Cathedral Glen Brook, upstream from its confluence with Crystal Spring Brook

2 Bonnie View Side Ditch = Water from Bonnie View Spring that does not enter piping to Bonnie View Spring collection system.

3 Depot Spring flow = Station Rd ditch flow below DepotSpring, minus Station Rd. ditch flow above Depot Spring, plus Silo B overflow

4 Silo B overflow to reservoir disconnected in March 2001. For March 2001 and subsequent dates, total Depot Spring flow = Station Rd Ditch below Depot Spring, minus Station Rd. Ditch above Depot Spring

5 Bailey Brook = Name given to unnamed stream in Woodchuck Hollow.

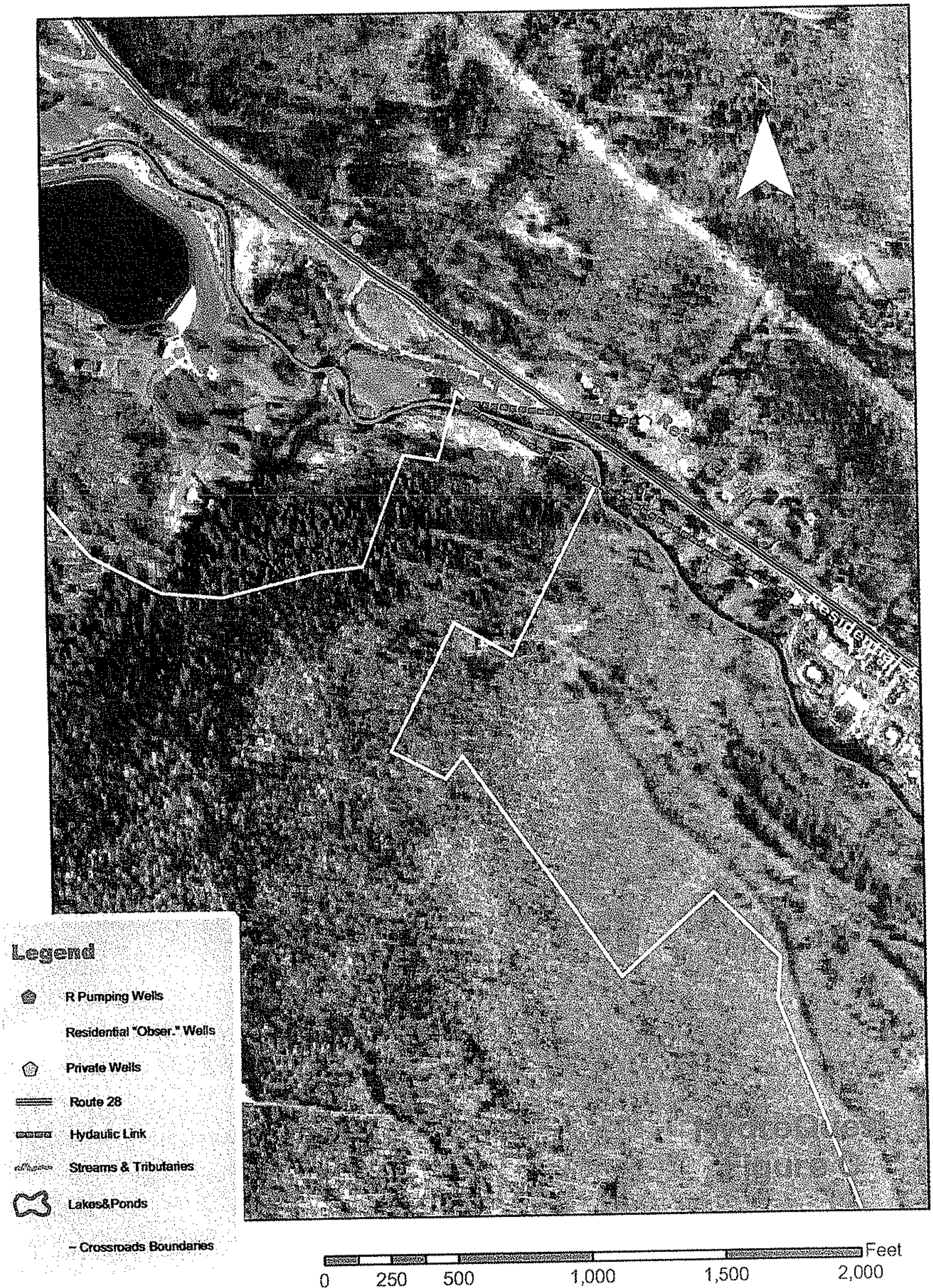
6 NM = Not Measured

7 Esopus Creek and Birch Creek flow values for September 2000 through December 2001 are "Provisional Data Subject To Revision" by the USGS

61

CPCEx61

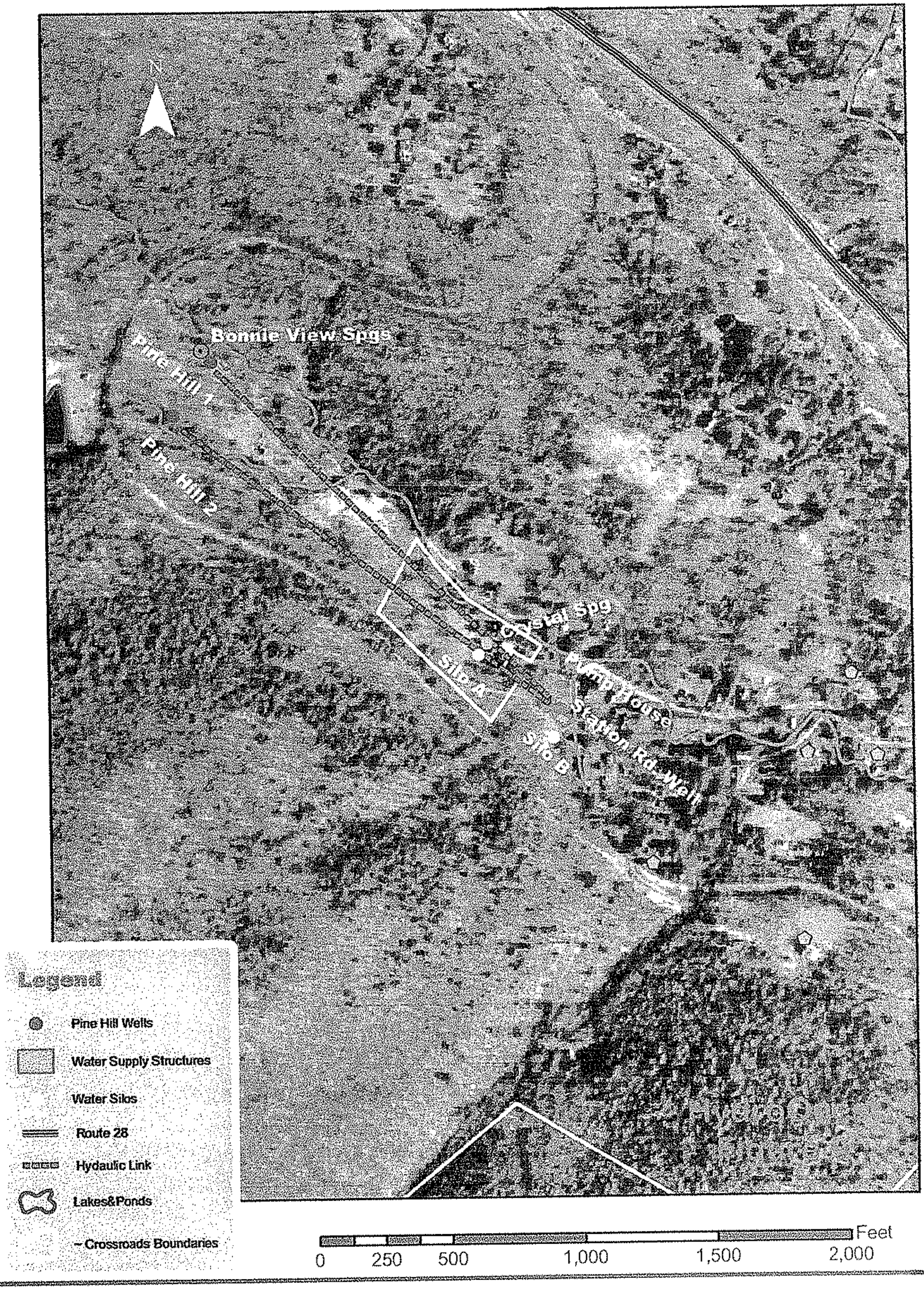
"R" Well Pumping Test Area



62

CPCEx62

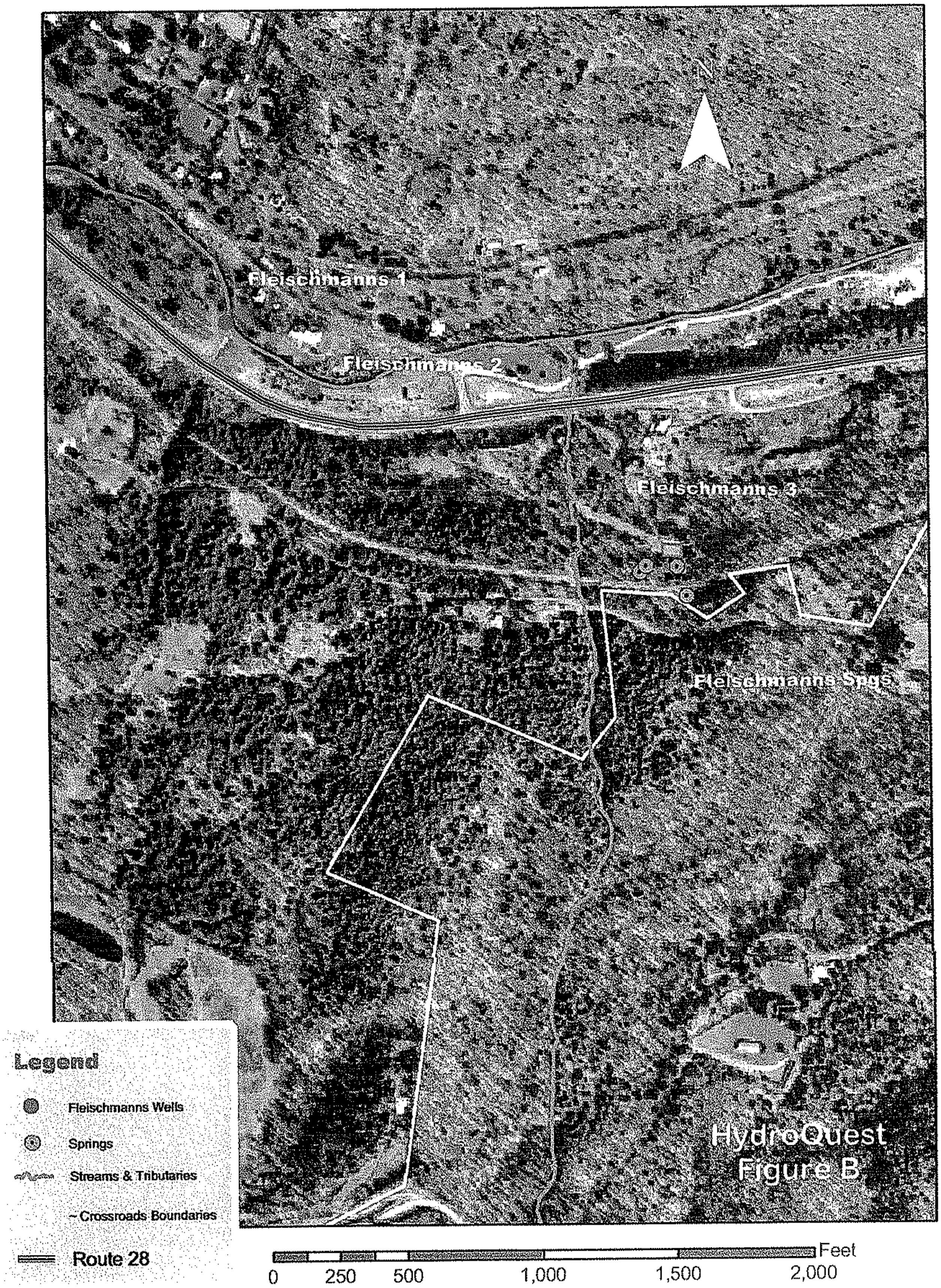
Pine Hill Water Supply Area



63

CPC Ex 63

Fleischmanns Water Supply Area



64

CPC 64

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64
6.25.04
PENGAD-Bayonne, N.J.

PINE HILL WATER DISTRICT COALITION
PO BOX 628
PINE HILL NY 12465

April 23, 2004

Mr. Alexander F. Ciesluk, Jr.
Deputy Regional Permit Administrator
NYS DEC Region 3
21 South Putt Corners Road
New Paltz, NY 12561-1620

Dear Mr. Ciesluk:

The Pine Hill Water District Coalition (the Water Coalition) submits this request for "Change in the Capacity of Existing Facilities" on behalf of the Pine Hill Water District. The Water Coalition seeks to modify Water Supply Permit # 3-515-00365/00001 (WSA # 10181) under 6 NYCRR 621.14(a) in order to correct erroneous data in the permit application and supporting papers and to revise the District's needs to reflect revised estimates of current and future water demand.

The capacity of the water sources for the Pine Hill Water District and the amount of water required to meet the District's needs as specified in WSA Number 10181 issued by the New York State Department of Environmental Conservation (DEC) on September 18, 2002 (and subsequently reissued to the Town of Shandaken following the purchase by the Town of the water sources named in the permit), appear to be in error.

Under 6NYCRR 621.14(a), the grounds for modification of an existing permit include

> "(1) materially false or inaccurate statements in the permit application or supporting papers; ....
>
> (4) newly discovered material information or a material change in environmental conditions, relevant technology or applicable law or regulations since the issuance of the existing permit;
>
> (5) noncompliance with previously issued permit conditions, orders of the commissioner, any provisions of the Environmental Conservation Law or regulations of the department related to the permitted activity."

Requests for modification under Section 621.14 can be requested "at any time" by "any interested party." The Water Coalition makes this request on behalf of the Pine Hill Water District after having failed to secure the cooperation of the Town of Shandaken's Supervisor, Robert Cross, Jr., on this and related matters concerning the water district.

The Water Coalition, through its experts (as specified below), will supply information that challenges the accuracy of the statements in the permit application for WSA # 10181 and the conclusions drawn from those statements. A nationally known and highly respected professional hydrogeologist, Paul Rubin, has independently reviewed the District's water supply system and the data supplied to calculate the District's needs and supply. He and others, including Joseph Habib, an environmental engineer working on the Water Coalition's behalf, have raised detailed concerns about the data and many of the conclusions that have been drawn from it (see attached letter and affidavit of Paul Rubin and attached letter from Joe Habib).

The major errors in the permit can be summarized as follows:

1) the "tested capacities" of Pine Hill Well # 1 and the Depot (Station) Road Well, 15 gallons per minute (gpm) and 38 gpm respectively, have not been confirmed under conditions of severe drought and sustained pumping of these wells, which are known to be hydrologically connected;

2) the "tested capacit[y]" reported for the Station Road Spring of 28 gallons per minute relies on faulty flow data and calculations related to adding flows from Silo B to the flows for the Station Road Spring, when in fact the flow of the spring comes from either Silo B or the spring source but not both (i.e., the same flow has been added in twice);

3) irregularities in the reporting of flows occur in tables supplied with the application, calling into question the stated capacities of all springs and wells described in the application and undermining subsequent calculations based on those flows;

4) the zoning information supplied with the original application for permit modification reports the zoning along Main Street in Pine Hill as Hamlet Residential and Residential 1.5, when in fact the zoning along Main Street in Pine Hill is primarily Hamlet Commercial, a zoning category that generates a much higher figure for both current and future projected water uses than the zoning categories used to justify lowering Pine Hill's water takings from 300,000 gallons per day to 210 gallons per day; and

5) adverse impacts on the water users within the Pine Hill Water District were insufficiently considered in the DEC's decision to remove water sources from the previous permit (WSA # 5889, 1970).

Because of substantial overlap in described water sources, water needs, and supporting materials, this request for modification of WSA # 10181 is filed concurrent with the Water Coalition's request for full party status (Application Number 0-9999-00096/00005) as a member of the Catskills Preservation Coalition in the DEC's review of Crossroad's Ventures "Belleayre Resort at Catskill Park" and related permits, particularly the Application for Public Water Supply Permit for the Big Indian Plateau.

The Water Coalition submits with this request the following materials:

1) Four copies of WSA: Supplement W-1 for Public Water Supply Permit and four copies of Form 95-19-3)
2) Application is made by the Pine Hill Water District Coalition as described above; if errors are discovered, the DEC has an obligation to notify the owner, the Town of Shandaken, of its intention to modify the permit (under 6 NYCRR 621.14(b))
3) The Water Coalition requests that the requirement to submit a Water Conservation Program Form be waived as the Water District's Water Conservation Program will remained unchanged (except for flow revisions)
4) Location of facilities is described in the previous WSA
5) Exhibits as described
6) Suitable place for public hearing: same locations as described for hearings related to review of the Belleayre Resort at Catskill Park
7) Applicant's attorney: the Water Coalition is currently proceeding pro se
8) Applicant's engineer: Joseph Habib
9) Other consultants: Paul Rubin, HydroQuest (hydrogeologist)
10) List of all maps and exhibits

We appreciate the DEC's willingness to undertake the needed review and to accommodate the Water Coalition in its attempt to insure that decisions about water supply resources in the hamlet of Pine Hill are based on accurate information and sound engineering and hydrological analysis. Such a review is clearly in the interest of the Pine Hill Water District — indeed, to have correct data and analysis as a basis for water supply determinations is a public necessity.

Sincerely,

Richard Schaedle, Chair
Pine Hill Water District Coalition

95-19-4 (JULY 2000)

NEW YORK STATE DEPARTMENT OF ENVIRONMENTAL CONSERVATION
ALBANY, NEW YORK, 12233-0001

FOR DEPARTMENT USE ONLY
APPLICATION NUMBER
WSA NUMBER

WATER SUPPLY APPLICATION
Supplement W-1 for Public Water Supply Permit

READ THE INSTRUCTIONS ON PAGE 2 BEFORE COMPLETING THIS FORM

PLEASE TYPE OR PRINT CLEARLY IN INK

1. PROJECT DESCRIPTION (INCLUDE LOCATION - for multiple well heads, identify and attach additional coordinates)
Correctly document the existing water assets, and current and future needs of the Pine Hill Water District and detail its practices and service area

COORDINATES
NYTM-E ______
NYTM-N ______

2. PROJECT PURPOSE
correction/modification of the current WSA permit

3. THIS PROJECT INVOLVES: (Check all that apply and, for each item checked, provide a brief description or identification)

☐ ACQUISITION of existing facilities

☐ INSTALLATION of new facilities

☒ CHANGES in capacities of existing facilities Station Road Well - sustained capacity not documented;

☐ ABANDONMENT of existing facilities Station Road Spring - negligible flow; Silo B flow revision

4. This project will takie of up to 300,000 gallons of water ☐ (per minute) ☒ (per day) from Pine Hill Water District sources (Name of source)

Figure given represents ☒ increase in taking, ☐ total taking. Returns takings to level of 1970 permit

5. If certain exhibits are omitted or reduced in scope because of reference to documents submitted with prior applications, list the exhibits so affected, identify the prior application (by Water Supply Application Number and name of applicant) and specify the document(s) to be referenced.

EXHIBIT	WSA NO.	APPLICANT'S NAME	REFERENCED DOCUMENT(S)
	5889	Pine Hill Water Company	WSA and supporting documents
	10181	PHWC → Town of Shandaken	" " "
	"Big Indian Water Works Company"	Crossroads Ventures	DEIS, WSA and supporting documents

6. PROJECT AUTHORIZATION
This application must be accompanied by proof of adequate authorization for the proposed project.. List below all exhibits documenting such authorization, such as resolutions, certificates of incorporation, contracts, referendum results, etc. (See *Public Water Supply Program, Applicant's Guide* for further details.)

6 NYCRR 621.14 (a) "Permits may be modified ... at the request of any interested party ... on any ground set forth in paragraphs (1) through (5) of this subdivision...." - See transmittal letter for text of paragraphs 1, 4, and 5

7. PROJECT JUSTIFICATION
By the act of signing this application, the applicant certifies that each of the following statutory conditions is or will be satisfied, AND that a proper justification for each is given in the specified exhibits attached to this application:

A. The proposed project is justified by the public necessity .... See Exhibit(s) 1
B. The proposed project takes proper consideration of other sources of supply that are or may become available. .... See Exhibit(s) NA
C. All work and construction connected with the proposed project will be proper and safe .... See Exhibit(s) NA
D. The supply will be adequate .... See Exhibit(s) 1
E. There will be proper protection of the supply and watershed or proper treatment of any additional supply. .... See Exhibit(s) NA
F. The proposed project is just and equitable to all affected municipalities and their inhabitants and in particular with regard to their present and future needs for sources of water supply .... See Exhibit(s) 1
G. There is provision for fair and equitable determinations of and payments of any direct and indirect legal damages to persons or property that will result from the acquisition of any lands in connection with the proposed project or from the execution of the proposed project .... See Exhibit(s) NA
H. The applicant has developed and implemented a water conservation program in accordance with local water resource needs and conditions .... See Exhibit(s) NA

8. SEQR STATUS
Lead Agency - DEC

9. SIGNATURE fr PHWC

10 DATE 4/23/04

95-19-3 (8/00) pip

JOINT APPLICATION FOR PERMIT

New York State
United States Army Corps of Engineers

Applicable to agencies and permit categories listed in Item 1. Please read all instructions on back. Attach additional information as needed. Please print legibly or type.

1. Check permits applied for:

NYS Dept. of Environmental Conservation

☐ Stream Disturbance (Bed and Banks)
☐ Navigable Waters (Excavation and Fill)
☐ Docks, Moorings or Platforms (Construct or Place)
☐ Dams and Impoundment Structures (Construct, Reconstruct or Repair)
☐ Freshwater Wetlands
☐ Tidal Wetlands
☐ Coastal Erosion Control
☐ Wild, Scenic and Recreational Rivers
☐ 401 Water Quality Certification
☐ Potable Water Supply
☐ Long Island Wells
☐ Aquatic Vegetation Control
☐ Aquatic Insect Control
☐ Fish Control

NYS Office of General Services
(State Owned Lands Under Water)

☐ Lease, License, Easement or other Real Property Interest
Utility Easement (pipelines, conduits, cables, etc.)
☐ Docks, Moorings or Platforms (Construct or Place)

Adirondack Park Agency

☐ Freshwater Wetlands Permit
☐ Wild, Scenic and Recreational Rivers

Lake George Park Commission

☐ Docks (Construct or Place)
☐ Moorings (Establish)

US Army Corps of Engineers

☐ Section 404 (Waters of the United States)
☐ Section 10 (Rivers and Harbors Act)
☐ Nationwide Permit (s)
Identify Number(s)

For Agency Use Only:
DEC APPLICATION NUMBER

US ARMY CORPS OF ENGINEERS

2. Name of Applicant (Use full name): Pine Hill Water District Coalition ("Water Coalition")
Telephone Number (daytime): 845-254-5638
Mailing Address: PO Box 628
Post Office: Pine Hill **State:** NY **Zip Code:** 12465

3. Taxpayer ID (If applicant is not an individual): EIN 22-3744258

4. Applicant is a/an: (check as many as apply) ☒ 501(c)(4) Not for Profit advocate for the Pine Hill Water District
☐ Owner ☐ Operator ☐ Lessee ☐ Municipality / Governmental Agency

5. If applicant is not the owner, identify owner here - [✓ otherwise] you may provide Agent/Contact Person information.
Owner or Agent/Contact Person ☐ Owner ☒ Agent /Contact Person: ~~Town of Shandaken~~ Richard Schaedle
Telephone Number (daytime): 845-254-5638
Mailing Address: ~~Route 28~~ ~~[illegible]~~
Post Office: ~~Shandaken~~ **State:** ~~NY~~ **Zip Code:**

6. Project / Facility Location (mark location on map, see instruction 1a.)
County: Ulster **Town/City/Village:** Shandaken **Tax Map Section/ Block /Lot Number:** 4,037-1-16, 4,037-1-17, and 4,045-1-5
Location (including Street or Road): Bonnieview Avenue, Station Road **Telephone Number** (daytime):
Post Office: Pine Hill **State:** NY **Zip Code:** 12465

7. Name of Stream or Waterbody (on or near project site): Cathedral Brook, Railroad Brook

8. Name of USGS Quad Map: West Kill
Location Coordinates: NYTM-E NYTM-N 4

9. Project Description and Purpose: (Category of Activity e.g. new construction/installation, maintenance or replacement; Type of Structure or Activity e.g. bulkhead, dredging, filling, dam, dock, taking of water; Type of Materials and Quantities; Structure and Work Area Dimensions; Need or Purpose Served)

The purpose of this application is to document accurate flows and current and future water needs of the Pine Hill Water District and modify existing Permit # 3-5150-00365/00001; WSA #10181 as needed.

This application is submitted on behalf of the Pine Hill Water District by the Water Coalition under 6NYCRR 621.14(a) allowing "any interested party" to correct "materially false or inaccurate statements in the permit applications or supporting papers," etc.

10. Proposed Use: ☐ Private ☒ Public ☐ Commercial

11. Will Project Occupy State Land? ☐ Yes ☒ No

12. Proposed Start Date: NA

13. Estimated Completion Date: NA

14. Has Work Begun on Project? (If yes, attach explanation of why work was started without permit.) ☐ Yes ☐ No

15. List Previous Permit / Application Numbers and Dates: (If Any)
WSA #5889 (Aug 31, 1970); WSA #10181 (April 3, 2001)
Note! Filed as application for "Public" Use by Private Owner

16. Will this Project Require Additional Federal, State, or Local Permits? ☐ Yes ☒ No If Yes, Please List:

17. If applicant is not the owner, both must sign the application
I hereby affirm that information provided on this form and all attachments submitted herewith is true to the best of my knowledge and belief. False statements made herein are punishable as a Class A misdemeanor pursuant to Section 210.45 of the Penal Law. Further, the applicant accepts full responsibility for all damage, direct or indirect, of whatever nature, and by whomever suffered, arising out of the project described herein and agrees to indemnify and save harmless the State from suits, actions, damages and costs of every name and description resulting from said project. In addition, Federal Law, 18 U.S.C., Section 1001 provides for a fine of not more than $10,000 or imprisonment for not more than 5 years, or both where an applicant knowingly and willingly falsifies, conceals, or covers up a material fact; or knowingly makes or uses a false, ficticious or fraudulent statement.

Date 4/23/04 Signature of Applicant PHWDC Title Chairman

Date ________ Signature of Owner ________ Title ________

EXHIBIT 1
PROJECT JUSTIFICATION

A. The proposed project is justified by the public necessity....

Under 6 NYCRR 621.14(a), the grounds for modification of an existing permit include

> "(1) materially false or inaccurate statements in the permit application or supporting papers; ....
>
> (4) newly discovered material information or a material change in environmental conditions, relevant technology or applicable law or regulations since the issuance of the existing permit;
>
> (5) noncompliance with previously issued permit conditions, orders of the commissioner, any provisions of the Environmental Conservation Law or regulations of the department related to the permitted activity."

Information has been supplied to the DEC that challenges the accuracy of the statements in the permit application for WSA # 10181 and the conclusions drawn from those statements. In addition, proposals for new development within the hamlet of Pine Hill raise concerns about the adequacy of the existing water supply and the takings restrictions in the current permit.

B. The proposed project takes proper consideration of other sources of supply that are or may become available....

Not applicable

C. All work and construction connected with the proposed project will be proper and safe....

Not applicable

D. The supply will be adequate....

This request is made specifically to determine the adequacy of the existing water supply

E. There will be proper protection of the supply and watershed or proper treatment of any additional supply....

Not applicable

F. The proposed project is just and equitable to all affected municipalities and their inhabitants and in particular with regard to their present and future needs for sources of water supply....

The municipality is required to base its determinations regarding the water supply on accurate and complete information

G. There is provision for fail and equitable determinations of and payments of any direct and indirect legal damages to persons or property that will result from the acquisition of any lands in connection with the proposed project or from the execution of the proposed project....

Not applicable

H. The applicant has developed and implemented a water conservation program in accordance with local water resource needs and conditions....

Not applicable

HydroQuest

Paul A. Rubin
P.O. Box 387
Stone Ridge, N.Y. 12484
845-687-4020
hydroquest@yahoo.com

Paul A. Rubin

EDUCATION:

M.A. - Geology, May 1983, State University of New York at New Paltz. Major fields of study: Hydrogeology, Water Quality and Pollution, Structural Geology, Photogeologic Interpretation. Thesis topic: *Hydrogeology and Structure of the Shawangunk Mountains, Ulster County, New York.*

B.A. - Anthropology, minor Geology, May 1977. State University of New York at Albany.

SPECIAL SKILLS:

Hydrologic and Geologic Characterizations; Land Use Planning; SEQRA reviews; Expert Testimony and Litigation Background; Surface Water and Groundwater Quality Evaluations; Sediment Transport; Evaluation of Remedial Technologies; Geotechnical Assessments; Hydrologic Investigations (Design, Coordination, Implementation, and Evaluation); Aquifer Testing and Analysis; Karst Hydrology; Rosgen Analyses; GIS Map Making and Analyses; Affidavit and Report Preparation; Public Speaking; Public Relations; Research Skills; Strategy Development; Leadership.

EXPERIENCE:

HYDROLOGIST/ HYDROGEOLOGIST:

Independent Consultant. Stone Ridge, New York. Consulting firm name: *HydroQuest*.

1994 - Present **Provide hydrologic, geologic and land use technical consulting services to environmental groups, Towns, business associations, law firms, and individuals. Assist groups in identifying issues and developing strategies designed to protect water resources and community character.**

***HydroQuest* work includes SEQRA reviews, review and fatal flaw analyses of consultant reports and environmental impact (EISs) analyses, field characterizations, stream and wetland evaluations, geotechnical analyses, hydrologic and geologic mapping, hydrogeologic analyses, regulatory assessments, public presentations, coordination work with attorneys and Technical Committees, strategy development, panel member at Town meetings with legislators, press interactions, report and affidavit preparation.**

INSTRUCTOR:

Jan. 2001- Present **Employed full-time by a college - name intentionally omitted to avoid any possible association between this work and hydrogeologic consulting work. Teach ArcGIS, Environmental Geology, Geology, Hydrology, and Geography. Coordinator of the Geographic Information Systems certificate program. Also teach a summer field hydrology course at the College of the Atlantic in Bar Harbor, Maine.**

HYDROLOGIST:

New York City Department of Environmental Protection (NYC DEP), Division of Drinking Water Quality Control, Shokan, New York.

April 1993- Jan. 2001

Conducted research and field studies designed to assess the water quality of watersheds. Responsible for directing geologic research designed to assess the sources, geomorphic context and best management practices (BMPs) related to sediments causing turbidity water pollution problems. Hydrologic and geologic work included geologic mapping of glacial sediments, field evaluation of stream channel armoring, morphologic characterization of stream channels (including Rosgen analyses), bedload transport studies, assessment of critical shear stresses, particle size analysis, stream gauging, water quality sampling and trend analysis, chemical and sediment loading calculations, graphic production, report preparation and technical presentations. Assisted other governmental divisions in evaluating lands for possible purchase, conducted geotechnical assessments of structurally unstable stream reaches, evaluated BMP designs. Supervised several Research Assistants.

RESEARCH SCIENTIST:

Martin Marietta Energy Systems, Inc. April 1993 under contract with the U.S. Dept. of Energy; Oak Ridge National Lab; Environmental Sciences Division, Oak Ridge, TN.

Aug. 1991- April 1993

Responsible for hydrogeologic evaluation of groundwater issues (e.g., characterization, monitoring network setup, data analysis, remedial design evaluation) at multiple Oak Ridge Reservation hazardous waste sites. Developed and documented conceptual model of carbonate and shallow storm flow systems comprising pathways of rapid contaminant transport. Work also involved characterization of hydrologic and geochemical trends and thermal infrared photo analysis. Presented results of research at conferences, as well as to DOE management and State and Federal officials. *Served in a Resource Management Organization as the hydrologic lead for the Environmental Sciences Division.*

HYDROGEOLOGIST:

New York State Attorney General's Office; Environmental Protection Bureau, Albany, New York.

Feb. 1983- Aug. 1991

Responsible for the design, protocols, coordination, implementation, evaluation, characterization and remediation of many major water and soil contamination sites throughout New York State (e.g., Love Canal, Superfund sites). Designed, performed and supervised chemical field sampling at hazardous waste sites. Evaluated geotechnical and chemical data sets.

Primary responsibilities included coordination of multiple companies along with their respective legal and scientific consultants. Worked with all parties involved to produce test plans and consent decrees to facilitate site remediation. Responsible for the management of the testing, site characterization and technical assessment. Worked with attorneys on summary judgment motions, complaints, trial preparation and depositions. Attorney General's spokesperson at public meetings. Expert witness at SEQRA hearings. Testimony given before the Assembly Standing Committee on Environmental

HYDROGEOLOGIST continued:

Conservation and Grand Jury. Worked with DOL staff and attorneys to develop office initiatives (e.g., Racketeering; bottled water contaminants). Initiation, development and drafting of legislation.

Supervision of personnel: expert witnesses, consultants, research assistants, interns. Responsible for selection, job descriptions, work schedules, and products.

HYDROGEOLOGIST:

Stone & Webster Engineering Corporation, Geotechnical Division, Boston, Massachusetts.

Oct. 1981- Feb. 1983 **Directly responsible for the planning, preparation, execution, and analysis of pumping tests and a fluid sampling program designed to investigate deep basin groundwater characteristics for the siting of a nuclear waste repository within the Permian Basin of the Texas panhandle.**

ACTIVITIES:

Cave exploration, hiking, and skiing. Former Captain: Albany-Schoharie County Cave Rescue Team. Made a Fellow of the National Speleological Society in recognition of karst research and water resource protection. Boy Scout Merit Badge Counselor for Environmental Science, Soil and Water Conservation, Geology, Skiing, Archaeology and Orienteering.

PUBLICATIONS & REPORTS **Over 24 technical publications and over 100 reports and affidavits. Partial list available upon request. Leader of geology conference field trips.**

ADDENDUM - SELECTED REPORTS AND SELECTED PUBLICATIONS

SELECTED OAK RIDGE NATIONAL LABORATORY REPORTS

1993	Jan. 2; Rubin, P.A.; Copper Ridge Cave: facts, observations, and interpretations. Report details flow readings, structural and hydrologic conditions controlling groundwater flow in Oak Ridge carbonate aquifers, and geomorphic interpretations; 9 pages, 1 map.
1992	Nov.; Rubin, P.A.; Pulse train analysis: A relatively cheap and rapid technique to establish the hydraulic connection between highly transmissive Oak Ridge Reservation wells. Includes discussion of methodology, relevant hydraulics, and an example.
1992	July 13; Rubin, P.A.; Grant Proposal: Location of karst exit pathways: geophysical high resolution subsurface imaging methods to locate conduits in bedrock terranes overlain by thick residuum; Submitted to the Dept. of Energy Characterization, Monitoring and Sensor Technology Integrated Program; 9 pages, 3 figures.
1992	July 8; Rubin, P.A.; Presence of active Oak Ridge Reservation karst flow systems further confirmed; 7 pages, 1 figure.
1992	June 22; Rubin, P.A.; ORR carbonate "cavities"; with emphasis on the Y-12 solution cavity and related Bear Creek Valley land use implications; 6 pages, 2 figures.
1992	June; Rubin, P.A., Poling, R.S., and Lemiszki, P.J., Hydrogeologic characterization plan for the Oak Ridge K-25 site; Oak Ridge, TN. Prepared for Martin Marietta Energy Systems, Inc., K-25 Plant, Report No. K/EM-1.
1992	May 21; Rubin, P.A., Huff, D.D., Stow, S.H., and Early, T.O.; Karst hydrology of Parcel A2 (technical discussion of contaminant concerns related to sale of DOE lands, with specific recommendations); 3 pages, 3 figures.

SELECTED ATTORNEY GENERAL REPORTS

1986- 1991	Rubin, P.A.; Love Canal trial activities - depositions, photointerpretation, testimony preparation, witness preparation, cross-examination.
1991	February; Rubin, P.A. and Sommer, D.S.; Complaint - State of New York against Allied-Signal Corporation; 8 pages.
1991	February 1; Rubin, P.A.; Tully Valley trial proofs; 5 pages.
1990	August 29; Rubin, P.A.; Hydrogeologic dynamics leading to the formation of the Tully Valley, New York mud boils and remedial considerations for effluent treatment; 15 pages.
1990	June 7; Ayers, J.C. and Rubin, P.A.; Geochemistry and hydrogeology of groundwaters and sand volcano effluents in Tully Valley, New York; 122 pages, multiple tables, figures, maps and appendices.
1990	January-October; Rubin, P.A.; Chemical sampling and characterization of five construction and demolition sites for Racketeering office initiative.
1990	April 30, Rubin, P.A.; Testimony before Grand Jury regarding tracer testing in Schenectady criminal case. Indictment achieved and company shut down.
1990	March 20; Rubin, P.A.; Affidavit in support of motion for summary judgment: The State of New York (plaintiff) against Becker Electronics Manufacturing Corp. (defendant); Affidavit deals with the hydrogeology and aquifer characteristics of a contaminated bedrock aquifer, 11 pages, 4 exhibits.
1990	March 20, Rubin, P.A.; Piezometry and groundwater flow directions proximal to the Johnstown landfill, 3 pages, 9 figures; draft.

1990	January 24; Rubin, P.A.; Multiple reports and testimony before Investigative Grand Jury relating to criminal case involving Kodak. Testimony helped lead to out-of-court settlement.
1989	December 14; Rubin, P.A.; Testimony before New York State Supreme Court regarding contaminant migration in a West Hurley fractured bedrock aquifer. Testimony led to rapid case settlement.
1989	October 25; Rubin, P.A.; Hydrogeologic testing required to fully assess aquifer contamination and insure State cost recovery; West Hurley, New York; 7 pages.
1989	August 30; Rubin, P.A.; Philmont aquifer analysis evaluation; Claverack Quad., N.Y.S.; 5 pages, 1 table, 5 figures.
1989	June 6; Rubin, P.A.; Pulse-train analysis; a relatively cheap and rapid technique to establish the hydraulic connection between the Allied brine field and the sand volcanos; 14 pages, 1 figure.
1989	April 12; Rubin, P.A.; Aquifer analysis of the proposed Newman distribution well; West Branch Creek, Allegheny Town, New York; 34 pages, 8 tables, 5 figures.
1989	February 2; Rubin, P.A. and Grady, K.A.; Man-induced evaporite karst formation via mechanical failure of formerly competent beds above a solution mining operation; Tully Valley, New York; 42 pages, 51 figures, 3 tables.
1988	November 16; Rubin, P.A.; Hydrogeologic assessment of risk factors associated with sand and gravel mining proximal to the Philmont municipal well; Claverack Quad., N.Y.S., 11 pages, 2 tables.
1988	August 31; Rubin, P.A.; Affidavit in support of motion for summary judgment: The State of New York (Plaintiff) against Sabin Metal Corporation and Yardney Electric Corporation (Defendants); Affidavit (draft) deals with hydrogeology of the Sabin Metal site; Modena, New York, 16 pages, 12 exhibits.
1988	July 14; Rubin, P.A. to Executive Chamber of the Governor; Analysis, comments and recommendations regarding Legislative Bill No. 8663-A, Article 20-A Petroleum Well Casings and Pipes; 3 pages, attachment.
1988	July 12; Rubin, P.A.; Affidavit in support of motion for summary judgment; The State of New York (Plaintiff) against The City of Gloversville, New York (Defendant); Affidavit deals with hydrogeology of the Gloversville landfill, 6 pages. Summary judgment awarded.
1988	June 10; Rubin, P.A.; Affidavit in support of motion for summary judgment: The State of New York (Plaintiff) against the City of Gloversville, New York et al. (Defendants); Affidavit deals with hydrogeology of the Gloversville landfill, 8 pages, 1 exhibit.
1988	April 14; Rubin, P.A.; Affidavit in support of motion for summary judgment: The State of New York (Plaintiff) against the City of Gloversville, et al. (Defendant); Affidavit deals with hydrogeology of the Gloversville landfill, 8 pages, 8 exhibits.
1988	February 25; Rubin, P.A.; Hydrogeology and chemical interpretation of existing analytical data as applied towards the components of the FICA landfill RI/FS work plan; 30 pages, 7 figures, 14 tables, 7 appendices.
1988	February 19; Rubin, P.A.; Chemical and aquifer testing designed to evaluate a new multi-family water distribution system; West Branch oil contamination - Allegheny Town (State v. Newman Oil); 5 pages, 2 addenda.
1987	September 23-24; Rubin, P.A.; Panel member/speaker DOT Highway Maintenance Engineers' Conference - Road salt: hydrogeologic dynamics associated with groundwater and surface water contamination, cleanup and prevention; Glens Falls, New York.
1987	September 1; Rubin, P.A.; Hydrogeologic evaluation of proposed remedial options at the Becker Electronics site as related to human exposure to a contaminated drinking water supply, East Durham, New York; (includes aquifer analyses of Becker Electronics site and a New Paltz site); 29 pages, 6 figures, 1 table.

1987	July 15; Rubin, P.A.; Testimony before Grand Jury regarding tracer testing in Canajoharie criminal case.
1987	June 26; Rubin, P.A.; Presentation to NYSDOH, DOL and DEC: Hydrogeology and potential health risks associated with the Onondaga Landfill; 80 slides, geologic cross-section, 4 maps, rose diagram, 10 figures, 7 tables.
1987	May 19, Rubin, P.A.; Review of draft Disaster Preparedness Commission report; pages 13-18 (on Fort Hunter Thruway bridge collapse - hydrology); 4 pages, 3 computer graphs on flood return intervals.
1987	April 29; Rubin, P.A.; The anatomy of the Fort Hunter Thruway bridge failure: floodwater frequency analysis, soil mechanics, and design considerations - an offer of technical assistance(with specific details); 9 pages.
1987	April 17; Rubin, P.A.; Onondaga landfill Phase II work plan particulars as designed to enhance contaminant definition in a karst network; 10 pages.
1987	April 10; Rubin, P.A. and Chinery, R.; Solvent Savers "Supplemental Data Collection" work plan of March 27, 1987; 23 pages, 3 figures.
1987	February 12, Rubin, P.A., et al.; State of New York Senate-Assembly (S. 2236-A; A. 3075-A) Title 6 Legislation on road salt; 4 pages.
1987	February; Rubin, P.A.; Hydraulic gradients and groundwater flow directions at the Solvent Savers and Novak Farm sites; 7 pages, 8 figures, 5 tables.
1987	January 8; Rubin, P.A.; Hydrogeology of the Sabin site, Modena, New York; 20 pages, 3 tables, 15 figures; 2 pages analytical parameters.
1986	December 2; Rubin, P.A.; New York State's interpretation of the hydrogeology of the Novak Farm site; 2 hours of testimony presented before Judge Munson; 30 pages, 9 figures.
1986	September 26; Rubin, P.A.; Geotechnical assessment of the hydrologic testing conducted to date and recommendations for additional testing to provide the necessary proofs for a summary judgment motion documenting groundwater contamination resulting from the Newman West Branch Creek oil field water flooding operation; 21 pages.
1986	September 4; Rubin, P.A.; Review of the remedial investigation work plan for the Johnstown landfill (essentially a total rewrite of a consultants poor work plan outlining all necessary testing and methodologies); 17 pages, 7 page appendix, 1 figure, 2 tables.
1986	May 16; Munro, D.A., Rubin, P.A., and Chinery, R.: State of New York v. Allied Corporation, et al. - Solvent Savers site (Calculations on seepage velocities and mounding as related to a proposed flushing remedial scheme); 12 pages.
1986	February 27; Rubin, P.A., Flatow, J., and Kupferman, R.; Proposed legislation initiatives to remediate contaminated groundwater and surface water resulting from road salting activities; 11 pages, 13 pages of appendices.
1986	February 25; Rubin, P.A.; Hydrogeology and chemical interpretation of the FICA landfill as applied toward a RI/FS work plan; 22 pages, 13 tables, 4 figures.
1985	December 24; Rubin, P.A.; Geophysical assessment of the Cortese landfill and environs, Narrowsburg, New York; 9 pages, 5 figures, 1 table.
1985	October 23; Rubin, P.A.; Public investigatory hearings into the adverse effects, remedies, and legislation governing salt storage and dispersal; 13 pages.
1985	October 17; Rubin, P.A. and Flatow, J.; Salt storage and deicing related policy in the northeastern states; 28 pages.
1985	October 2; Rubin, P.A.; Appraisal of groundwater contamination adjacent to the Cortese landfill based on visual Delaware River soil and water contamination; 8 pages, 1 map.

1985	September 19; Spiegel, N., Osar, R.L., and Rubin, P.A.; Consent order agreement with attached work plan in New York State v. Sabin Metal Corp., et al.; 20 pages.
1985	July 24; Rubin, P.A.; The concept of "unusual" or "act of God" precipitation being responsible for the release of chemicals from Love Canal (prepared for use as an affidavit analyzing return intervals in the Love Canal litigation); 7 pages, 3 figures.
1985	May 3; Moore, M.J., Skinner, P.N., and Rubin, P.A.; Testimony of the office of New York State Attorney General before the Assembly Standing Committee on Environmental Conservation; Concerns about the impacts of oil and gas drilling practices on the quality of New York's groundwater; (Water well drilling requirements); 15 pages, 2 maps, 1 figure, 1 table.
1985	March; Rubin, P.A.; Report on the chemicals, technical processes used and residual contamination found at the Yardney Electric and Sabin Metals Corporations site in Modena, New York; 57 pages, with numerous tables.
1985	January 10; Rubin, P.A.; Plan for remedial investigation and feasibility study of the Cortese landfill, Narrowsburg, New York; 31 pages.
1984	December 28; Rubin, P.A.; Road salt contamination - tracer selection and detection methodology, Churchland Lane, Town of Saugerties; 10 pages.
1984	September; Rubin, P.A.; Report on the status of groundwater contamination in the vicinity of the Johnstown landfill; 48 pages with numerous chemical tables.
1984	March 22; Rubin, P.A.; Groundwater investigation for the American Thermostat Corporation site; 29 pages.

SELECTED PUBLICATIONS FROM PROFESSIONAL AND PERSONAL RESEARCH

Rubin, P.A., Engel, T., Nardacci, M. and Morgan, B.E., 2002, ***Geology and paleogeography of Mount Desert Island and surrounding area, Maine.*** Guidebook paper National Speleological Society annual meeting, Camden, Maine, p. 47-91, Trip Leader.

Rubin, P.A., Schultz, B. and Haberland, P., 2002, ***Hydrologic, land use, and historic concerns relative to the Rosendale mining industry.*** Abs. National Speleological Society annual meeting, Camden, Maine.

Rubin, P.A. and Morgan, B., 2002, ***Relict sea caves record temporary coastal stillstands.*** Abs. National Speleological Society annual meeting, Camden, Maine.

Morgan, B., Albrechtsen, C., Dido, R., Hubsch, R., Rubin, P.A., Sheeley, D., Skerritt, F. and Vaeth, L., 2002, ***Development of a GIS-based land-use coverage: Black Creek Watershed, Southeastern NYS.*** Abs. Northeast Natural History Conference VII. N.Y. State Museum Circular 64: p. 50-51.

Hubsch, R., Albrechtsen, C., Dido, R., Morgan, B., Rubin, P.A., Sheeley, D., Skerritt, F., Terzella, D. and Vaeth, L., 2002, ***Critical environmental area delineation in the Black Creek Watershed, NYS via GIS analysis.*** Abs. Northeast Natural History Conference VII. N.Y. State Museum Circular 64: p. 51.

Sheeley, D.A. and Rubin, P.A., 2002, ***Land-use preservation scenarios in the Black Creek Watershed using GIS; NYS.*** Abs. Northeast Natural History Conference VII. N.Y. State Museum Circular 64: p. 51.

Schultz, B., Rubin, P.A. and Haberland, P., 2002, ***GIS-based historic inventory of early cement district industrial artifacts: Southeastern NYS.*** Abs. Northeast Natural History Conference VII. N.Y. State Museum Circular 64: p. 40.

Rubin, P.A. and Morgan, B., 2002, ***Geomorphic reconstruction of emerged and submerged coastlines using GIS technology, Mount Desert Island, ME.*** Abs. Northeast Natural History Conference VII. N.Y. State Museum Circular 64: p. 39.

Rubin, P.A. and Privitera, J.J., 1997, ***Engineered and*** **unregulated degradation** ***of karst aquifers: Two case studies in New York State, USA. In*** The Engineering Geology and Hydrogeology of Karst Terranes, Beck & Stephenson (eds), Proceedings of The Sixth Multidisciplinary Conference on Sinkholes and the Engineering and Environmental Impacts of Karst; Balkema, Rotterdam; p. 467-476.

Rubin, P.A., Engel, T., and Nardacci, M., 1995, ***Geomorphology, paleoclimatology and land use considerations of a glaciated karst terrain, Albany County, New York.*** Guidebook for joint meeting of the New York State Geological Association (67th Annual) and the American Association of Petroleum Geologists. Trip leader, p. 81-107.

Rubin, P.A., 1995, ***The geology of Clarksville Cave, Albany County, New York.*** Guidebook for joint meeting of the New York State Geological Association (67th Annual) and the American Association of Petroleum Geologists. Trip leader, p. 251-273.

Rubin, P.A., 1995, ***The geology of Cherokee Caverns; Tennessee. In*** Karst Geohazards (ed. by B. Beck), Proceedings of: The Fifth Multidisciplinary Conference on Sinkholes and the Engineering and Environmental Impacts of Karst; Sponsors include the National Ground Water Association and the American Society of Civil Engineers, Gatlinburg, TN, p. 541-547.

Rubin, P.A., 1994, ***Paleohydrology of the Kämper Avenue area; Mammoth Cave National Park, Kentucky.*** Mammoth Cave National Park's Third Science Conference; Sponsored by Mammoth Cave National Park and The Cave Research Foundation, Mammoth Cave National Park, Kentucky, p. 265-279.

Rubin, P.A., Zerr, B., Davies, G.J., Lemiszki, P.J., Neuhoff, P.S., and Aiken, J., 1993, ***Preliminary hydrogeologic studies in carbonate aquifers of the Oak Ridge Reservation, Tennessee.*** Abs. Fourth Annual Walker Branch Watershed Research Symposium, Oak Ridge, TN, p. 15-16.

Davies, G.J., Rubin, P.A., and Quinlan, J.F., 1993, ***Indirect observation of the rapid-flow and slow-flow components of recharge to the Knox aquifer, Oak Ridge, Tennessee.*** Abs. Fourth Annual Walker Branch Watershed Research Symposium, Oak Ridge, TN, p. 17.

Rubin, P.A., Lemiszki, P.J., and Poling, R.S., 1992, ***Strategy for definition and protection of East Tennessee karst groundwater basins.*** Tennessee Water Resources Symposium (5th, Nashville, TN., Oct. 1992), Proceedings. American Water Resources Association, Nashville, TN, p.7-10.

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October 3, 2003

Mr. Alexander F. Ciesluk, Jr.
NYS DEC Region 3
21 South Putt Corners Rd.
New Paltz, New York 12561-1696

RE: Pine Hill Water Supply; Town of Shandaken

Dear Mr. Ciesluk,

This letter is submitted on behalf of the Catskill Heritage Alliance in the matter of Crossroads Ventures LLC's proposal to use the Silo A Spring in Pine Hill as a backup water supply for their Belleayre Resort at Catskill Park. I have 22 years of specialized expertise in both surface water and groundwater hydrology. My curriculum vitae is attached.

Respectfully, we wish to recommend that the Department of Environmental Conservation request Crossroads Ventures to remove the Silo A Spring from consideration as a backup water supply for the Big Indian Plateau component of their proposed resort. Historically, this spring has been integral in providing sufficient water for Pine Hill during times of drought. The Silo A Spring was integrated into the Pine Hill water supply system to provide additional water supply during periods of drought, including those more severe than the one the Applicant refers to that occurred in 2001. The proposed removal of the Silo A Spring from the Pine Hill water supply system will jeopardize the integrity of the water supply system, is likely to limit future growth in Pine Hill, and simply does not make sense hydrologically from a water supply perspective.

The attached November 11, 2002 affidavit was prepared, but not submitted, in anticipation of an adjudicatory hearing requested by the Pine Hill Water District Coalition and others in reference to a permit application (WSA 10,181; DEC Permit Number 3-515-00365/00001) submitted on September 12, 2002, by the Pine Hill Water Company under the ownership of Dean Gitter. This affidavit addresses the serious hydrologic issues associated with any reduction in water availability to the hamlet of Pine Hill. The Department of Environmental Conservation declined to conduct that hearing, and that decision was upheld during litigation, with the court ruling that consideration of these issues was more appropriately raised in the context of the SEQRA review and the permitting process associated with the proposed Belleayre Resort Project submitted by Crossroads Ventures for review by the DEC.

The Applicant has identified and tested a primary water supply in their Rosenthal #2 well. Rather than jeopardize the water supply of Pine Hill homeowners and commercial businesses both now and in the future, we would like you to request the Applicant to locate a different backup water supply. The Applicant succeeded in locating the Rosenthal #2 well and is fully capable of locating a different backup water supply than the Silo A Spring.

Review of the Applicant's December 2, 2002 Surface Water and Groundwater Assessment report (pp. 1-19) reveals that 1) the Silo A Spring is not capable of continuously meeting the requirements of the Ten States Standards during periods of drought, and 2) the Applicant's comparison of flow between Crystal Spring Brook and the Allaben USGS gauging station is inappropriate.

The Applicant's assumption (p. 13) that the Crystal Spring Brook drainage basin is typical of the Esopus Creek at Allaben is in error. In an effort to show that the Silo A Spring will continue to flow during drought conditions, the Applicant compares the drought flow of Crystal Spring Brook to that of the Esopus Creek at Allaben. The Applicant reports that the Crystal Spring Brook drainage basin, which includes Silo A Spring, is approximately 2.54 mi2 in extent. The Applicant's Figure 7 reveals that the Silo A Spring sub-basin is a substantial percentage of this 2.54 mi2 basin that Pine Hill has historically relied upon for their water supply. The watershed tributary to the Allaben gauging station is 63.7 mi2 in extent. Having conducted geologic mapping and stream flow measurements throughout the Esopus basin for many years, I can state with confidence that geologic and hydrologic factors associated with the Allaben valley bottom setting vs. the headwater reaches of Birch Creek are significantly different (e.g., basin size, soil/sediment thickness, hydraulic gradient).

In the absence of long-term stream flow data for Crystal Spring Brook, the Applicant's basin-to-basin comparison method of assessing likely low flow conditions and potential water availability is reasonable. However, a comparison of this nature is best conducted for similar headwater tributaries with small catchment basins. Ideally, basin-to-basin comparisons should be conducted for basins of similar size. Reference to the USGS's web site readily provides such information for both basins of similar size (i.e., Panther Mountain, Hollow Tree Brook, Beaver Kill) and somewhat larger (and less geologically similar) basins in the Esopus drainage (see Table 1). These records, even though some are of limited duration, clearly show record low flows far below that required to use the Silo A Spring as a backup water supply when compared to an Applicant-determined minimum required Silo A Spring discharge of 0.14 cfs for a basin size of less 2.54 mi2. It should be noted that other stream discharge values are present in the USGS data that are also far below the Applicant's 10.19 cfs Allaben equivalent discharge for their respective basin sizes, and that they often remained low or dry for extended periods of time (e.g., see attached Panther Mtn. tributary data - 2 pages). Further basin-to-basin comparisons with NYC Department of Environmental Protection stream gauging records specific to Esopus basin headwater tributaries are also likely to show that headwater tributary stream flows decrease markedly during dry periods.

Table 1: Esopus Tributary USGS Discharge Data:

Esopus Tributary	**USGS Station #**	**Period of Record**	**Basin Size (mi2)**	**Lowest Recorded Q (cfs)**
Beaver Kill	01362465	7/27/00-9/30/02	0.98	0.00
Panther Mtn	01362192	10/01/01-9/30/02	1.54	0.00
Hollow Tree Bk.	01362342	10/01/97-9/30/02	1.95	0.17
Birch Ck.	013621955	10/01/98-9/30/02	12.5	1.9
Bush Kill	01363382	8/11/00-9/30/02	16.2	2.2
Little Beaver Kill	01362497	10/01/97-9/30/02	16.5	0.15
Stony Clove	01362380	2/01/07-9/30/02	31.5	4.0

The danger of relying on the Silo A Spring as a backup water supply for the Crossroads Ventures resort project (vs. as an important and integral add-on component of Pine Hill's water supply) is further accented even when using the Applicant's Allaben USGS gauging station data. The Applicant reviewed the USGS's Esopus Creek historical discharge data through November, 2001 and found that the data "indicates that monthly, mean, daily discharge dropped below the threshold flow rate indicator of 10.19 cfs (4571 gpm) for 12 months out of the 458 months since measurements began in 1963." The Applicant determined that the average potable daily water demand for Big Indian Plateau is 64 gpm (0.14 cfs), which correlates to an Esopus Creek flow at Allaben of 4,571 gpm (10.19 cfs). This value of 10.19 cfs was determined by the Applicant to be a threshold indicator discharge value below which there may not be enough discharge from Silo A Spring to meet the potable demand for Big Indian Plateau.

Importantly, mean daily discharge values at the Allaben USGS gauging station often fall below the Applicant-determined low discharge threshold value of 12.19 cfs (i.e., for portions of 28 years of the 39 years of record from 1963-2002). The lowest recorded mean daily discharge value for the Allaben gauging station is 3.3. cfs. The Applicant's means of assessing periods of potential water supply deficit based on monthly, mean, daily discharge data for the Allaben gaging station vs. mean daily discharge data does not provide a representative picture of the duration and actual number of times daily water needs historically dropped below 10.19 cfs. The Applicant's monthly, mean, daily discharge approach minimizes the number of months with below Applicant determined cut-off discharge values (i.e., below their 12.19 cfs value). This approach minimizes the measured low daily discharge values and occurs as a result of averaging both high and low mean daily discharge values together to achieve a monthly, mean, daily discharge value above the Applicant's threshold discharge value of 12.19 cfs. Looked at from a different vantage, the total number of months (not individual days) with one or more days with discharge values less than 12.19 cfs at Allaben are 73 vs. the Applicant's 12. This 73 number equates to about 15.6 percent of all the months of record that have one or more days with less than the required discharge recommended for backup water supply purposes (based on USGS records from 10/01/63 to 9/30/02). Thus, the Silo A Spring does not continuously meet the Ten States Standards as a backup water supply for the proposed Crossroads Ventures project, as it does not "equal or exceed the average day demand with the largest producing well out of service." During those times when the backup water supply may be most needed, sufficient quantity is not likely to be available. An alternate backup water supply should be required.

The use of the Silo A Spring by the Applicant during times of drought conditions, when it may be needed by the hamlet of Pine Hill, may have a significant adverse impact on the Pine Hill water supply. We are submitting these materials now because the issues raised are relevant to the current application. Essentially the question is whether Silo A (the Crystal Spring), which was used historically to supply the hamlet of Pine Hill with water during periods of drought, can be permitted to another entity (Crossroads Ventures) for use outside the hamlet of Pine Hill. The Applicant documents (p. 13-14) that the discharge from the Silo A Spring during the recent study (not during a drought emergency situation) comprised up to 37 percent of the total stream flow measured in Crystal Spring Brook. The materials contained in the attached affidavit demonstrate that the record established in regard to Water Supply Permit Number 3-515-00365/000 (to remove Silo A Spring) from the Water Supply Permit of the Pine Hill Water Company) and submitted on January 15, 2002 (to use Silo A as a water supply for the proposed Belleayre Resort) is insufficient to demonstrate compliance with governing law and regulations. As detailed in the affidavit, the adequacy of water sources now owned by the Town of Shandaken for the Pine Hill Water District has not been demonstrated under drought emergency and disaster conditions, nor has it been demonstrated under sustained groundwater pumping conditions. Other materials submitted to the DEC by the Catskill Heritage Alliance question the accuracy of the data used to calculate expected current and future water needs.

We request that the DEC not issue a determination of completeness until data necessary to evaluate these substantive issues has been provided. We strongly recommend that the Department of Environmental Conservation require the Applicant to seek an alternate backup water supply other than the Silo A Spring for the reasons addressed in this letter and the attached affidavit. The Applicant's hydrologic consultants are fully capable of locating an alternate backup water supply. Thank you for your attention to this matter.

Sincerely,

Paul A. Rubin
HydroQuest

STATE OF NEW YORK

SUPREME COURT: COUNTY OF ULSTER

In the Matter of the Application of THE PINE HILL WATER DISTRICT COALITION (PHWDC), RICHARD SCHAEDLE, ADAM NAGY, for himself and as Chairman of the CATSKILL HERITAGE ALLIANCE,

AND THE NATIONAL RESOURCES DEFENSE COUNCIL, INC.

Plaintiffs/Petitioners,

For Judgment pursuant to Article 78 of the Civil Practice Law and Rules

-against- **Affidavit**

NEW YORK STATE DEPARTMENT OF ENVIRONMENTAL CONSERVATION, ERIN M. CROTTY, as Commissioner of the New York State Department of Environmental Conservation, MARC MORAN, as Regional Director, Region 3, New York State Department of Environmental Conservation, ALEXANDER F. CIESLUK, JR., as Deputy Permit Administrator, Region 3, New York State Department of Environmental Conservation,

AND PINE HILL WATER COMPANY,

AND SILK ROAD ORGANIZATION NY, INC.,

AND CROSSROADS VENTURES, LLC,

AND THE TOWN OF SHANDAKEN

Defendants/Respondents

STATE OF NEW YORK)
)
COUNTY OF ULSTER)

Paul A. Rubin, being duly sworn, deposes and says:

1) I am a hydrogeologist with twenty-one years of professional experience. I make this affidavit on behalf of the Petitioners, Pine Hill Water District Coalition and Richard Schaedle, Chair of the Pine Hill Water District Coalition, in support of previous submissions by the Pine Hill Water District Coalition, documenting that substantive and significant comments were provided in the public comment process that may have resulted in denial of the permit application or the imposition of significant conditions on the hamlet of Pine Hill's water supply system. A public hearing on the application should have been held relative to the Pine Hill Water Company's water supply permit modification. Concerns raised by the Plaintiffs clearly indicate that partial disassembly of the historic water district is likely to A) adversely impact the growth potential of Pine Hill because the application fails to demonstrate that the proposed water supply is adequate, and B) potentially result in insufficient water availability for existing water users during dry conditions. Hydrologically, in terms of water resource availability and future land use, it is not scientifically sound to remove portions of Pine Hill's water supply system. This affidavit accents some of the key issues previously raised. In addition, this affidavit documents that the Defendant did not adequately evaluate material submitted by the Pine Hill Water Company in support of their proposed water supply permit modification.

2) I received a B.A. degree from the State University of New York at Albany in 1977 and a M.A. degree in geology with a specialty in hydrogeology from the State University of New York at New Paltz, New York in May, 1983. My educational background and professional experience are more fully set forth in my curriculum vitae, which is attached hereto.

3) Within the broad field of hydrology, I have specialized expertise in both surface water and groundwater hydrology. I have conducted detailed assessments of groundwater flow systems, springs, streams, and watersheds. This work has been conducted for both professional characterizations and as part of my own personal research. I have published papers and led all day field trips relating to this work at professional conferences (see curriculum vitae).

4) In evaluating the issues related to the proposed water supply permit modification, I reviewed material prepared by the Pine Hill Water Company and the Plaintiffs. I visited the water supply area on November 3, 2002 to observe the physical relationship between the various components of the water supply system. These components include the physical topographic and geologic setting, bedrock exposures, springs, wells, and reservoirs. One obvious conclusion based on this site visit and material submitted by the Plaintiffs is that, through time, Pine Hill water demands required the addition and integration of a series springs and reservoirs to meet existing water needs. If this were not the case, there would only be one spring area connected to a single reservoir. There are three main spring and reservoir areas that have historically been connected. It is highly unusual to remove a significant portion of any Town's water supply system, as is called for in this permit modification.

5) Newkirk, Marx, and Goldstein of the National Resources Defense Council, on behalf of the Pine Hill Water District Coalition, in their letter of June 26, 2002, raise the substantive and significant issue of future water needs (e.g., p. 2 and 4). A key, and unreasonable, premise underlying the Pine Hill Water Company's water supply permit modification is the assumption that Pine Hill's water needs will always be what they are today. Pine Hill should retain the potential to, at a minimum, revitalize the hamlet's infrastructure to previous maximum water usage. The Defendant should have required the Applicant to fully address both present and future water needs. Accordingly, historic maximum water usage figures should be increased in keeping with water demands of modern plumbing systems and societal water use. At this time, revitalization within Pine Hill is occurring. Similarly, regular upgrades, expansions, and new programs at nearby Belleayre Ski Center are likely to increase ecotourism and Pine Hill water demands.

6) The Defendant's acceptance of the proposed water supply permit modification without a public hearing will irreparably harm Pine Hill's ability to expand to or exceed its historic residential and commercial capacity because a significant portion of the historic water supply is targeted for private ownership and usage. The removal of any portion of Pine Hill's water supply system will almost certainly limit the hamlet of Pine Hill's future growth. The Plaintiffs have provided written comments addressing this issue. Similarly, the Pine Hill Water District Coalition has raised substantive and significant issues relative to the reliability, accuracy, and omissions of Applicant provided flow measurements that may alter the quantity of available groundwater (e.g., PHWDC letter of 6/18/02).

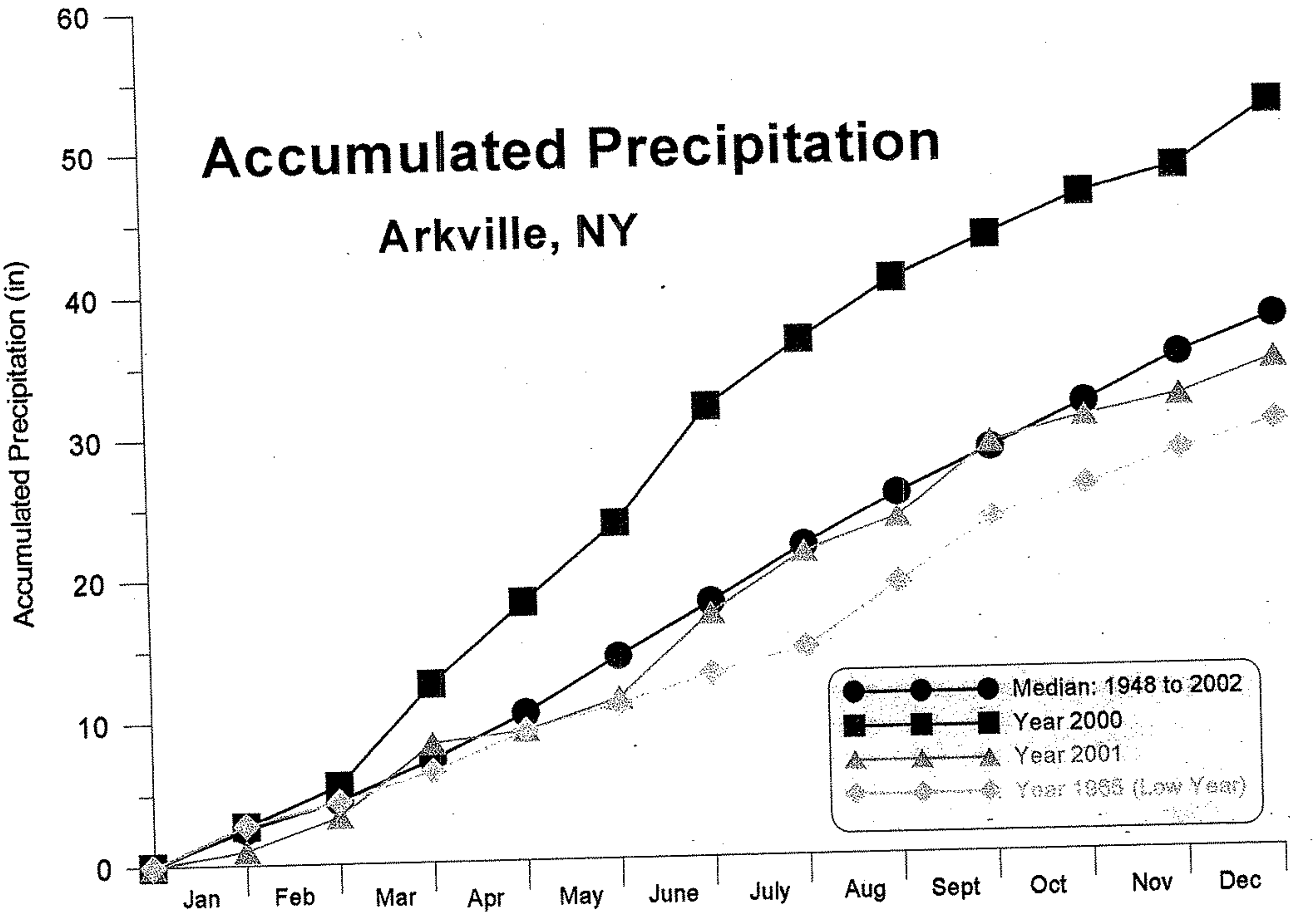
7) The Defendant, in their review of the proposed water supply permit modification, has examined and considered the Applicant's determination that there will be sufficient water for continued Pine Hill water usage after the Applicant removes the Silo A and Crystal Spring water sources from the hamlet's water supply system for private commercial use. Silo A was constructed to behead Crystal Spring and is the second most productive spring within the hamlet of Pine Hill's water district. The term "modification" does not adequately reflect the intent of the permit application - that is to remove a significant portion of the hamlet's water supply system for private usage and personal gain.

8) Newkirk, Marx, and Goldstein, in their letter of June 26, 2002, raise the substantive and significant issue of water availability under "dry" conditions (e.g., p. 3). The Defendant, in determining that a permit hearing was not necessary, relied on the project Applicant's statement that:

> *"Alpha Geoscience continued to monitor Bonnie View Springs throughout the calendar year 2001. During that time, a drought watch and later warning was issued by DEC ... Throughout the monitoring period, Bonnie View Springs continued to be the water source for the PHWC and continued to produce more than adequate quantity of water."*

As pointed out in material submitted with the application, a drought warning is only the second of four sequentially more severe drought levels that may be issued. The drought advisory rating system goes from watch, warning, emergency, to disaster. The Defendant, in reviewing the Applicant's material, should have recognized that it was not prudent to accept the adequacy of Bonnie View Springs based on a stated one-year, second level, drought condition. Statements such as that provided by the Applicant above required rigorous assessment of historic drought conditions by the Applicant and by DEC. It is scientifically unsound to remove a significant component of the hamlet of Pine Hill's water supply from use based on limited assessment.

9) As noted in 8) above, Newkirk, Marx, and Goldstein, in their letter of June 26, 2002, raise the substantive and significant issue of water availability under "dry" conditions. The Defendant should have recognized that reference to one-year of water data during a second level drought advisory was not sufficient to demonstrate the adequacy of the Bonnie View Springs during level three or level four drought conditions. In the absence of nearby long-term aquifer data, precipitation records can be used to provide a reasonable approximation of likely groundwater/spring conditions since precipitation recharges the groundwater flow system. Instead of relying on a limited, non-rigorous, statement of spring water adequacy, the Defendant should have reviewed readily available historic precipitation data or required the Applicant to do so. Figure 1, for example, examines fifty-four years of precipitation data collected at the Arkville weather station, situated some seven miles west of Pine Hill. This weather station is at an elevation of 1310 feet vs. the similar elevation of Bonnie View Springs at about 1550 ft. msl. This plot shows the accumulated monthly precipitation for the years 2000 and 2001 compared to the monthly median precipitation from 1948 to present and the year 1965, the lowest precipitation year since 1948.



HydroQuest 11/8/02

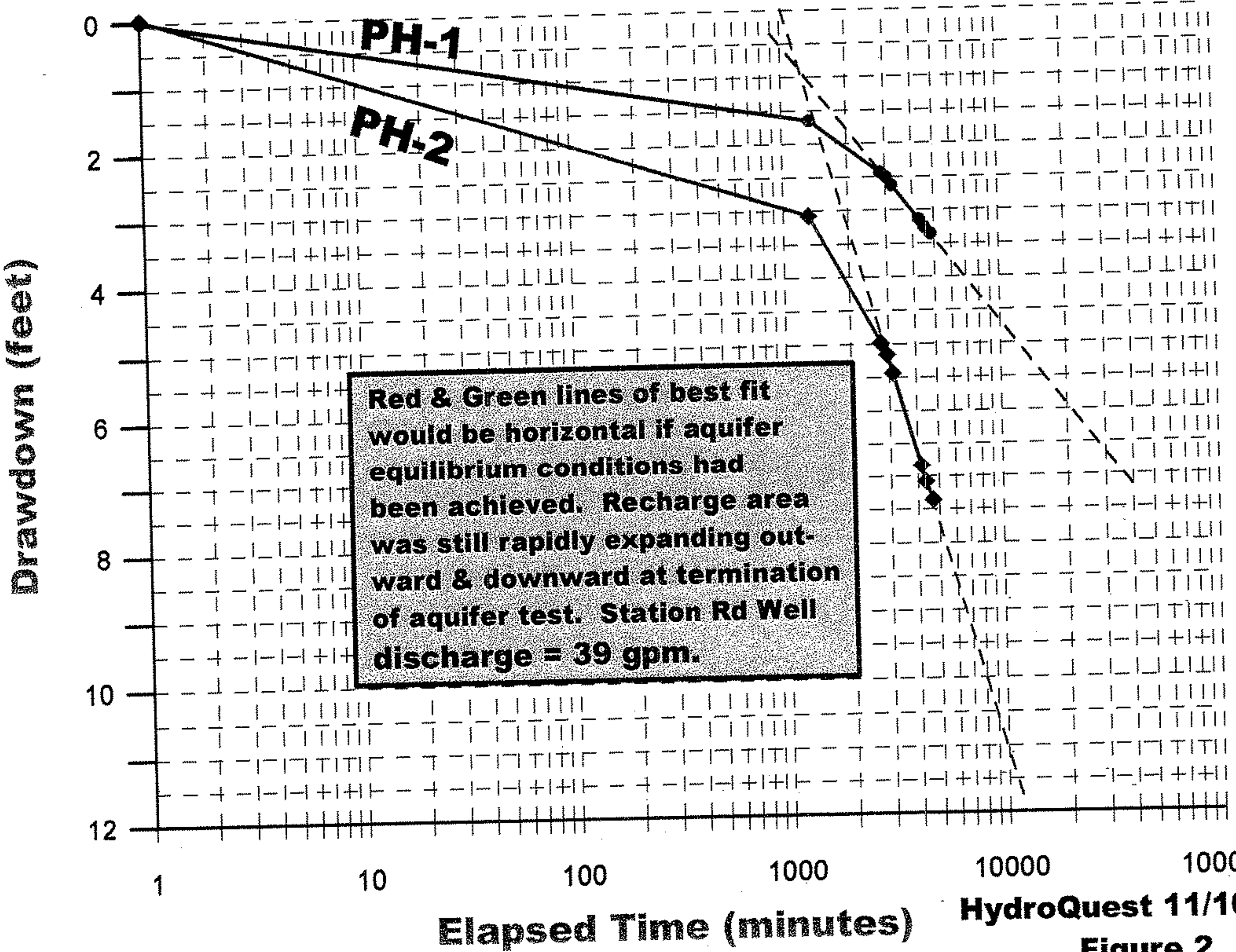
Figure 1

10) Figure 1 shows that the accumulated precipitation in 2001 for the Pine Hill vicinity was not appreciably less than the amount that is constructed from the historical median. In fact, at the end of September 2001 the accumulation was nearly identical to the median (28.87 inches vs. the accumulated median of 28.45). Furthermore, the year 2001 started with a significant moisture surplus since the year 2000 experienced the second highest total precipitation in the fifty-four year record. Both 1999 and 1998 were also above normal for the period starting in 1948. Thus the actual measurements do not support significant drought conditions for 2001. For perspective, the plot for 1965 illustrates how a truly low precipitation period appears on the graph. It is entirely possible that level three or level four drought conditions (such as probably occurred in 1965) may significantly reduce the water availability from Bonnie View Springs. In this likely event, Pine Hill may wish to supplement Bonnie View Spring water with Silo A water. Conditions such as this are undoubtedly why the hamlet of Pine Hill has multiple water sources. They may not always be needed, but when they are - they're critical. Clearly, substantiative and significant issues were not taken into account by the Defendant which, if ignored, will result in the imposition of significant conditions on the Pine Hill water supply.

11) The Defendant has raised the issue of potentially insufficient water resources should any alteration of the historic Pine Hill water supply system occur. Newkirk, Marx, and Goldstein, in their letter of June 26, 2002, comment on this substantive and significant issue. The Defendant, in reviewing the Applicant's data, relied on the Applicant's data analysis and conclusions. One such area includes the assessment of the aquifer tapped by the Station Road Well. This well is proposed in lieu of the Silo A/Crystal Spring water source as Mr. Gitter plans to use the Silo A water for his Crossroads Ventures project. The Station Road Well was pumped with a discharge of 39 gallons per minute for 79.25 hours (3.3 days). During this test, the aquifer was drawn down some 112.9 feet and had only 80 feet of remaining aquifer left before the aquifer would have been largely dewatered. At the termination of the test, the aquifer's specific capacity (i.e., yield per unit of drawdown) was steadily decreasing and the aquifer was being exploited further and further outward from the pumping well in an effort to deliver water to the Station Road Well at a rate equal to the discharge/pumping rate. Equilibrium conditions (i.e., when recharge within the zone of influence of the pumping well equals the rate of discharge of the well) were not achieved, thus this proposed water source is not capable of sustaining a discharge of 39 gpm. This should have been evident to the Defendant from the Applicant's report, from the steeply plummeting semi-log time drawdown graphs of the pumping well, and from the drawdown data collected in observation wells (e.g., PH-1 and PH-2) during the pumping test. The Applicant's observation well drawdown data, collected from wells PH-1 and PH-2 at a distance of some 1,800 feet from the pumping well, (as illustrated in Figure 2) graphically shows the data the Defendant evaluated. If the aquifer could provide adequate recharge water to maintain the Station Road Well's discharge of 39 gpm, the latter part of the two plots, through which lines of best fit are drawn, would be horizontal, not steeply sloping. In the absence of additional aquifer test data and aquifer testing during severe drought conditions, these steep slopes throw any long-term yield projections into question. The Applicant's data indicates that the aquifer tapped by the Station Road Well will not be able to continuously provide groundwater at 39 gpm. The aquifer never achieved a hydrogeologically stable equilibrium condition.

12) The Defendant should also have noted that the aquifer was slow to recover to its initial static water level (approximately 6 days), thus it may not be capable of providing a reliable, long-term, continuous water source - especially when it will be needed most. This already questionable hydrogeologic situation may be further compounded when considering that the higher yielding portions of fractures that provide groundwater typically anneal or become narrower with depth. Thus, reduced water availability commonly associated with increasingly deeper aquifer recharge may result in aquifer dewatering in a much shorter time than projected by the Applicant. The Defendant's evaluation of this data should have signaled the need for further hydrogeologic analysis, particularly in light of the Applicant's plan to remove a key water source from the Pine Hill water supply system. The Station Road Well may not be a reasonable substitute backup water source for the Silo A/Crystal Spring water source that the hamlet of Pine Hill has historically relied upon. The recharge area tributary to Silo A may be significantly larger than the recharge area tributary to the Station Road Well. There is no hydrologically or economically sound reason to remove Silo A water from the hamlet of Pine Hill's water distribution system. There is no benefit to the hamlet in doing this, only

Observation Well Drawdown
Associated With Station Road Well Aquifer Test



Red & Green lines of best fit would be horizontal if aquifer equilibrium conditions had been achieved. Recharge area was still rapidly expanding outward & downward at termination of aquifer test. Station Rd Well discharge = 39 gpm.

HydroQuest 11/10/02

Figure 2

the risk of jeopardizing the viability of the present and future water supply system. *I recommend against any significant water withdrawal from wells and springs within the limits of the historic Pine Hill water supply system by outside users (other than private homeowner wells) because potentially overlapping aquifer recharge areas may result in the loss of control of much needed groundwater resources.* These substantive and significant issues were raised during the comment process and should be addressed in a public hearing.

13) In reviewing the Pine Hill Water Company's permit modification, the Defendant was aware that aquifer testing had documented that the Station Road Well, Pine Hill well # 1, Pine Hill well # 2, and a private well were hydraulically connected. These hydraulically connected water sources that share a common recharge area have not been fully evaluated relative to their combined yield. Drawing from one may significantly impact the other's yield potential. While this situation was discussed, it is incomplete and requires further hydrogeologic assessment. I recommend that a public adjudicatory hearing format be used to fully assess the potential groundwater availability and related impacts from wells simultaneously tapping the same aquifer. This substantive and significant issue was addressed by Newkirk, Marx, and Goldstein in their letter of June 26, 2002 (p. 3).

Conclusions

14) Substantive and significant issues were raised during the comment process. The Defendant's decision to not grant a public hearing has placed the hamlet of Pine Hill's current and future water needs (and growth potential) in jeopardy. In approving the Pine Hill Water Company's proposed water supply permit modification without the benefit of a public hearing, the Defendant effectively and unilaterally determined that 1) removal of the hamlet's Silo B and Crystal Spring water source would still allow for a sufficient water supply for the present-day Pine Hill hamlet in times of drought, 2) that it is a sound hydrogeologic practice to subdivide a Town's water resources for private commercial gain, and 3) that little or no future growth should occur in the hamlet of Pine Hill (as a key water source would be removed from the hamlet's control). Yet, clearly, Pine Hill's historic water demands required the addition and integration of a series springs and reservoirs to meet drought and high demand water needs. The Defendant is not in a position to certify that, once granted, the requested permit modification will leave the hamlet of Pine Hill with an adequate water supply capable of meeting present and future water demands during periods of drought.

15) In my professional judgment, the Defendant failed to adequately address substantive and significant issues relating to the application as raised by members of the public. Resolution of the issues raised may have resulted in denial of the permit. Furthermore, the application is much further reaching than simply a permit modification. If approved, this "modification" has a high likelihood of thwarting future residential, commercial, and economic growth in Pine Hill. Permit approval will result in Pine Hill relinquishing control of a key component of the hamlet's water supply system. A hearing should have been held. It is not advisable to separate out any portion of a hamlet's water supply system, especially when considering that a second private party will then have control for private, commercial, gain. I recommend that the court require the Defendant to A) either hold an adjudicatory public hearing on the permit application, or B) review all material submitted by all parties to date and deny the application based on its being hydrologically unsound.

PAUL A. RUBIN
Hydrogeologist
HydroQuest

Sworn to before me this

11th day of November, 2002.

Notary Public

202 Battery Avenue
Brooklyn, NY 11209
April 15, 2004

Mr. Alexander Ciesluk
Deputy Regional Permit Director
NY DEC Region 3
21 South Putt Corners Rd.
New Paltz, NY 12561-1696

Re: Public Comment on: DEIS For Belleayre Resort At Catskill Park

Dear Mr. Ciesluk:

I would like to offer comments on the aforementioned DEIS. I have previously provided written comment to this office re Public Water Supply Permit Modification #3-5150-00365/0001, which is intrinsically related to this DEIS. In addition, I have publicly commented at the January 20 hearing held in Boiceville. I am an environmental engineer (BS Mechanical Engineering, MS Environmental Science) with several years of experience in municipal water and wastewater treatment.

My comments specifically relate to sections of the DEIS which deal with water supply. I first discovered fundamental discrepancies in data used to support the WSA modification of WSA 5889, which proposed the removal of Crystal Spring (Silo A) from the Pine Hill Water Company's Assets. Flawed data was discovered in the Spring and Stream Flow Measurement Study (Flow Study) performed by Alpha Geoscience between January 2000 and December 2001. The Flow Study document is referenced extensively throughout both the WSA modification and the DEIS and used in numerous sections of the DEIS as a cornerstone to subsequent engineering analysis. As I have pointed out previously, it contains blatant discrepancies, and otherwise questionable data. From my perspective as an engineer who handles and analyzes water data on a daily basis, the entire study is disputable and I do not feel comfortable with any subsequent calculations, estimations, or conclusions that are based on its data.

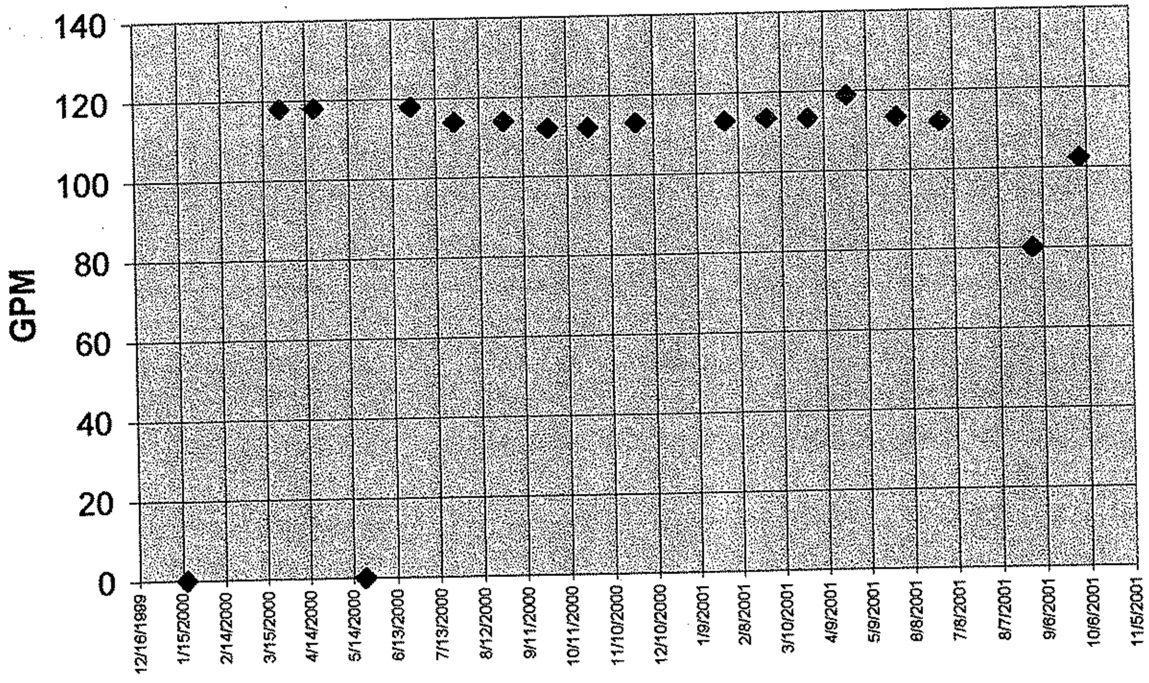
I have attached two versions of the Alpha Geoscience Flow Study for your convenience. These copies were taken directly from the DEIS and are designated as Version 1 and Version 2. Note that rows A,B,C,D,H,I,L,P,Q,R,S,T,U,V, and W of both versions are highlighted to demonstrate significant deviations in values between the two. A closer analysis reveals that nearly all Version 1 values in these rows are 2.5 times higher than those in Version 2. I find the uniformity and selectivity of these discrepancies highly suspicious. What is most troublesome is that either version has been used (by design or by oversight) to support the WSA modification and the DEIS. The Flow Study has appeared no less than 3 times in supporting documents for the WSA and no less than 5 times in the DEIS. The following table lists the order of appearances to demonstrate the extent in which the Flow Study was utilized. Note the arbitrary use of either version.

Occurrences of Alpha Geoscience Stream and Flow Study

	LOCATION	VERSION
2002 WSA MODIFICATION APPLICATION	6/6/01 DELEWARE ENGINEERING LETTER TO DEAN PALEN	1
	EXHIBIT 1 - 2/28/02 ENGINEERS REPORT	2
	EXHIBIT 5	2
DEIS	VOL. 2-APPENDIX 2.1-BIG INDIAN PLATEAU WATER SUPPLY.pdf P25	1
	VOL. 2-APPENDIX 2.2-WILDACRES RESORT WATER SUPPLY.pdf P49	2
	VOL. 3-APPENDIX 7-BIG INDIAN PLATEAU WATER SUPPLY D.pdf P4	2
	VOL. 3-APPENDIX 7-BIG INDIAN PLATEAU WATER SUPPLY G.pdf P27	2
	VOL. 3-APPENDIX 7-WILDACRES RESORT WATER SUPPLY C.pdf P4	2

Not only are there conflicting data between Version 1 and Version 2, there are significant contradictory values for critical data when compared to other supporting documentation in the DEIS. Data from Line E, "Pine Hill Water Supply Meter" has been used extensively in calculations of water usage and spring flow. I was initially suspicious of the Line E data, as it did not represent inherent variation in water usage typical of small water systems. Furthermore, the occurrence of zero flow on January 18, and May 22 did not make sense for a water supply under constant use. The following figure is graphical presentation of the Line E data. This graph covers nearly two years of readings, though you will note an unusual lack of seasonal or monthly variation in flow.

PINE HILL WATER SUPPLY METER

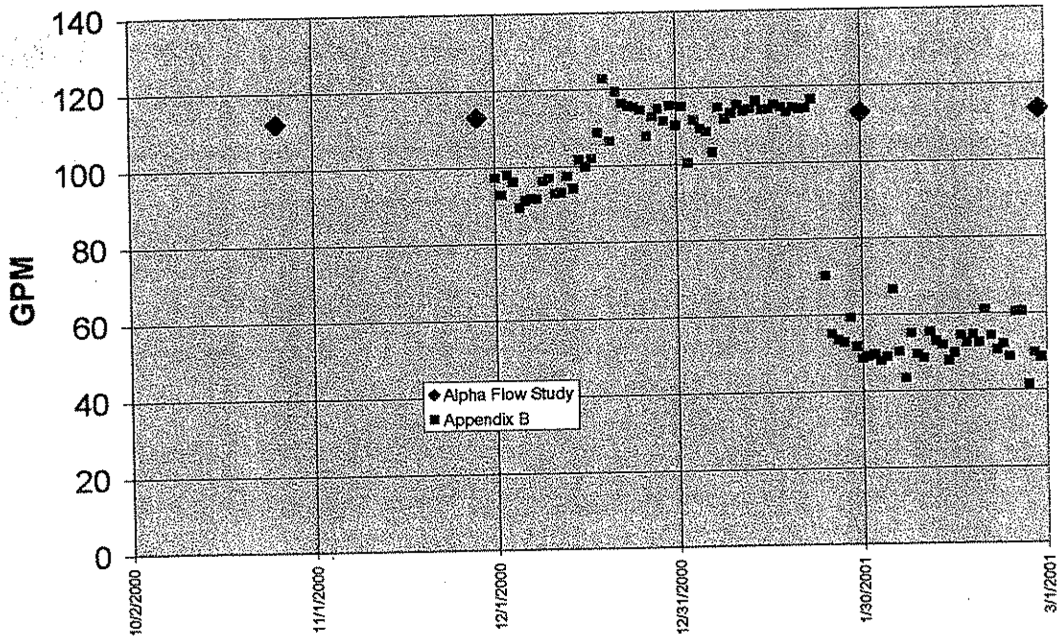


My suspicion was confirmed by the data presented in **Volume 3- Appendix 7 Big Indian Water Supply B.** This section includes in its Appendix B, day to day water flows for the Pine Hill Supply Meter between Dec 1, 2000 and Feb 28, 2001. This clearly contradicts the Alpha Flow Study as follows:

	Alpha Flow Study (Version 1 or 2)	**Appendix B**
12/27/00	Not Measured	162000 gpd (112.5 gpm)
1/30/2001	113 gpm	69600 gpd (**48.3 gpm**)
2/28/2001	113.5 gpm	69500 gpd (**48.3 gpm**)

Appendix B also indicates that major leaks to the system were repaired on 1/23/2001 and the Appendix B data reflects the subsequent drop in daily flow. The Alpha Flow Study data does not reflect any such shift in flow; instead, it presents consistent flow between 113 and 119 gpm even after the 1/2001 repairs. I have plotted the Appendix B data along with the corresponding Flow Study data in the graph below to exemplify this point. Note the normal variability in the day-to-day flows from Appendix B in contrast with Alpha Flow Study data.

PINE HILL WATER SUPPLY METER



Mr. Ciesluk, I trust that the information I have presented thus far clearly discloses the Alpha Flow Study as unreliable. I have demonstrated this with the developer's own contradictory data. I would like to follow this up with direct implications resulting from the use of this flawed data in the context of the WSA and DEIS.

A new Water Supply Permit was granted on September 12, 2002 based on the April, 2001 WSA application. The flawed Flow Study however is the primary support of this application. The crux of the application is the critical Bonnie View Spring production. The calculations used in section 3.2 to determine the average monthly flow of the Bonnie View Spring are based on Version 1 of the Flow Study which contains the "inflated' values. Thus the 393,120 gpd production estimation is likely a gross over-estimate as opposed to a "conservative" flow as cited in the application. Recall that this estimation was derived using September 2000 data, which was reputedly the low flow month.

*Average Monthly Flow = 0.7 * Bonnie View Flow = 0.7(H-C+D+F+E)*

Using Version 1 data:

Average Monthly Flow =0.7(368-114+24+0+112) = 273gpm=393,120 gpd*

The developer, with his own supporting documentation of the WSA contradicts this critical calculation. The Engineer's Report (Section 2.1.1) supporting the WSA cites *August 2001* as the low flow month and arbitrarily uses Version 2 data this time. Using the above formula and the August 2001 data from Version 2 we have:

Average Monthly Flow =0.7(45-30+5+0+80) = 70gpm=100,800 gpd*

However, the Engineer's report cites this calculated value as *87* gpm (not 70 gpm = 100,800 gpd which results from the formula above) – they do not show their calculation, so it can only be assumed that a basic arithmetic error was made. This is not the only arithmetic error discovered in this section of the Engineer's report. The Engineer's report then cites the average flow over the two-year period as 134 gpm. Punching in the numbers supplied in "Table 1B, Average Flows Spring and Stream Flow Measurements" from the WSA, we have:

Average Flow =0.7(558-373+30+99+5) = 223 gpm* (<u>not</u> 134 gpm)

In the context of the WSA, I have now demonstrated flawed data, contradicting data, and arithmetic error. It is in my opinion that a true account of the Bonnie View Spring production during low flow month could not have possibly been represented accurately in the WSA. Nonetheless, the WSA was granted which relinquished the Silo A water supply source from the Pine Hill Water Company's list of assets and allowed its use as a water supply source for the developer's Big Indian Plateau project.

As previously stated, the implications of the Flow Study are far-reaching. Below is a partial list of DEIS sections which directly refer to the Flow Study along with the manner in which the data was used.

Volume 2- Appendix 2.1 Big Indian Water Supply – Used in the determination of Silo A and Silo B production capacity.

Volume 3- Appendix 7 Big Indian Water Supply – Used in the determination of Silo A Spring, Upper Spring, Silo B Spring, Railroad Spring production capacities.
Volume 3- Appendix 7 Big Indian Water Supply B – The decision of the Department of Health Public Service Commission (PSC) was based largely on a 273 gpm production capacity of the Bonnie View Springs as determined by Alpha using Version 1 data. However, the developer includes Version 2 as supporting documentation in the appendix for this section, which directly contradicts the referenced flows for Bonnie View Springs cited in the Service Investigation of the Pine Hill Water Company, Case 01-W-0803. We now understand that Version 1 data contained "overstated" flows for the Bonnie View Springs. These exaggerated flows supported the Pine Hill Water Company's position to have the Pine Hill Water District Coalition's petition denied. At the time, the Version 1 data may have been all that the PSC had been provided and they likely took it in good faith as reliable. As a result, the Water Coalition's request for a separate evidentiary hearing was in fact denied based on the overstated values of Version 1.
Volume 3- Appendix 7 Big Indian Water Supply G – There are extensive references to the Flow Study in this Surface and Groundwater Assessment. This includes, but is not limited to Silo A Spring Flow to meet Potable requirements, Spring use impacts on stream flow, comparisons with climatologic data, Crystal Spring Brook Comparisons, etc.

Based on my review of the Water Supply sections of the DEIS and discrepancies found within the Flow Study, I conclude the following:

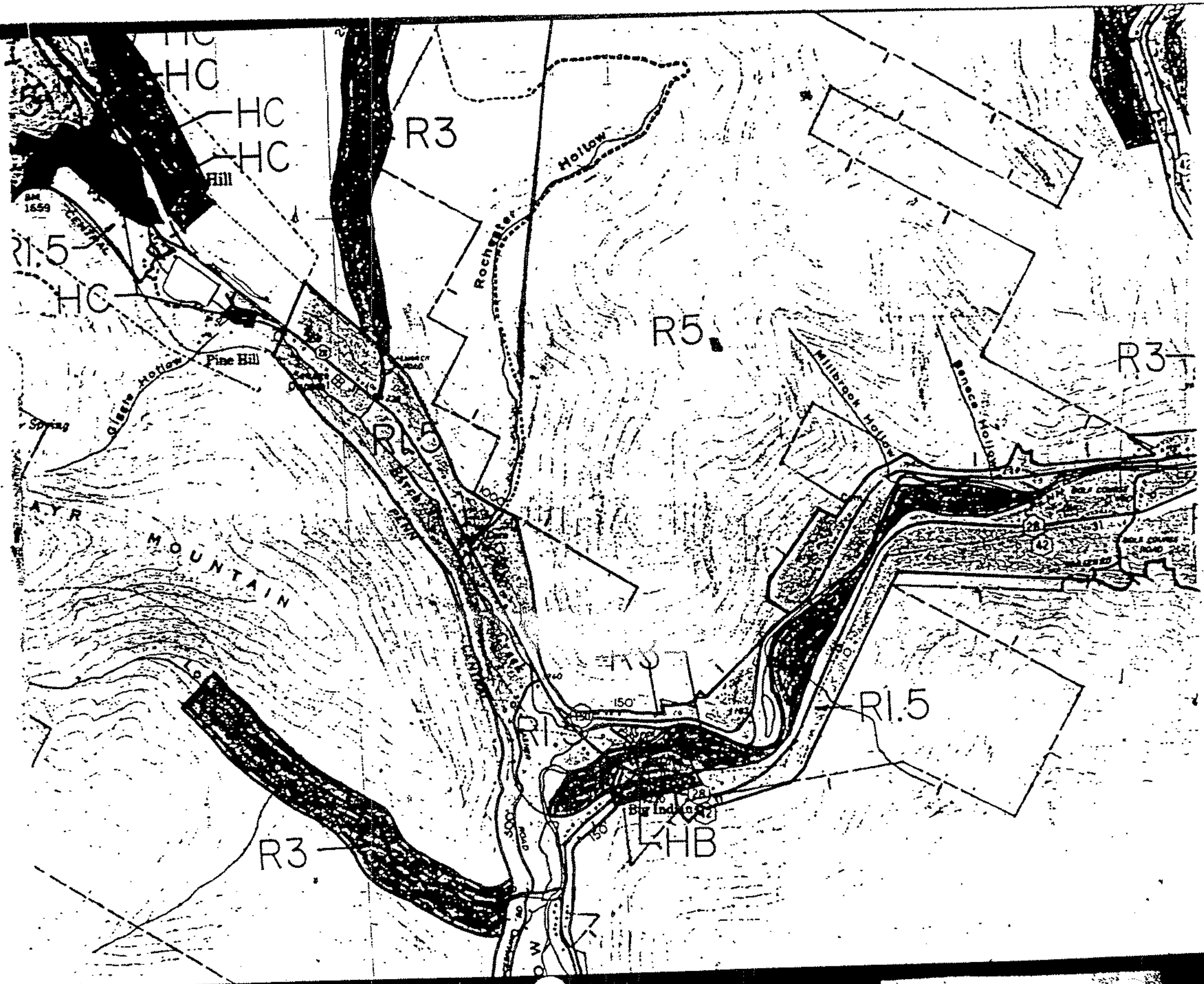
- Data contained within the Flow Study is unreliable. Due to the number of discrepancies between Version 1 and Version 2 (50% of all data), the entire Flow Study should be deemed invalid.
- Critical data such as flows from the Bonnie View Spring and Crystal Spring are among the directly flawed data. Other critical data such as and Silo A flows are flawed by association. Neither should not be used to support claims in the DEIS.
- New flow studies are required to validate DEIS claims.
- The significant discrepancies found in my review of just two of the nine DEIS volumes suggest the possibility that other significant errors abound within the context of this DEIS.

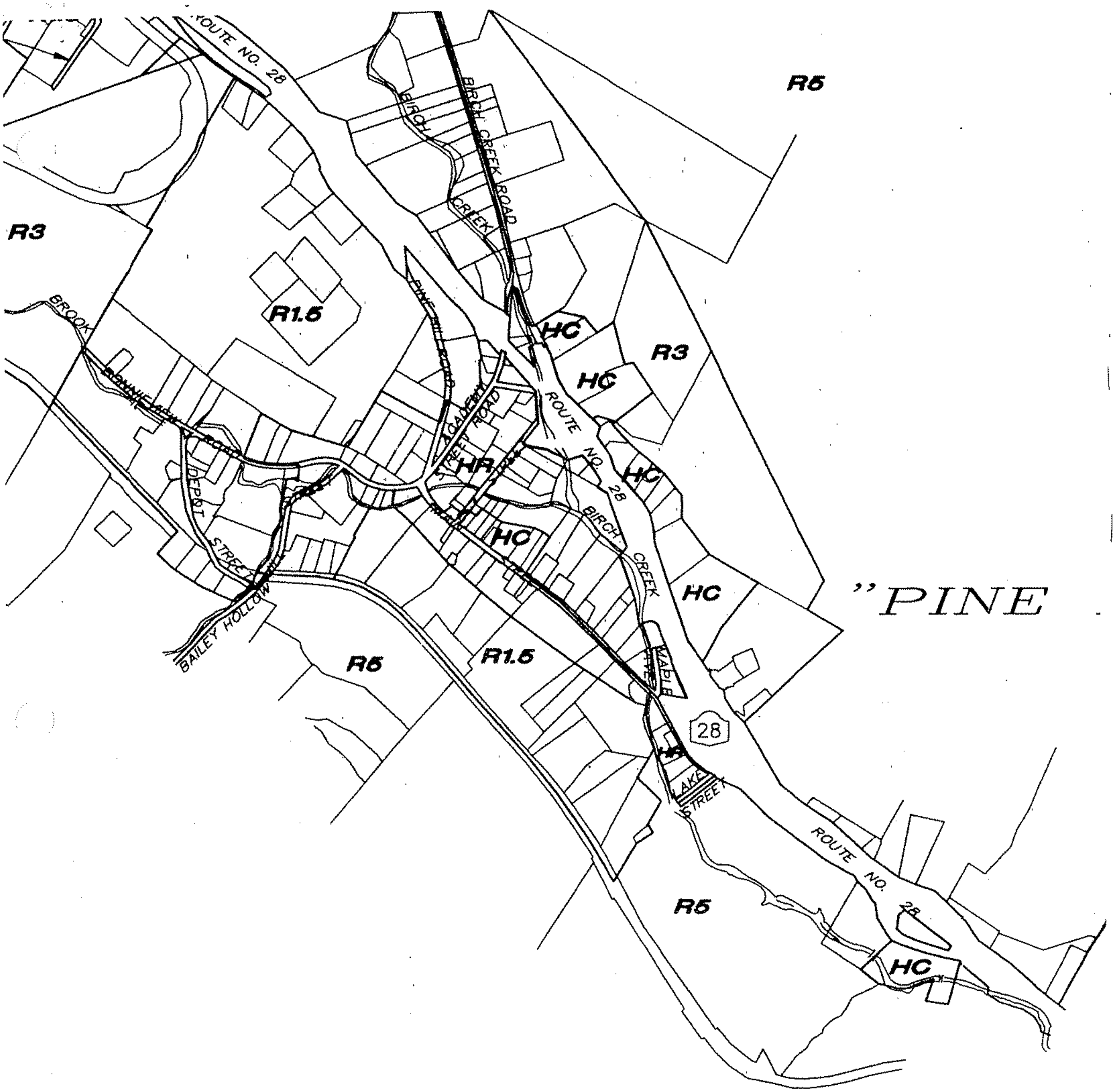
I thank you for your time in reviewing my comments.

Very Sincerely,

J. Andrew Habib
Environmental Engineer
Consultant to Pine Hill Water Coalition District

Official
Map, Town of Shandaken





TOWN OF SHANDAKEN ZONING MAP

"PINE HILL"

SCALE 1" = 400'

DATED : OCTOBER 10, 1990

Map supplied by
the Pine Hill Water
Company (Dean Gitter)
in reference to
WSA #10181

65

CPC Ex 65

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DRAFT
Environmental Impact Statement

Appendix 9

Construction Phase Stormwater Quantity Management Plan

WITH

Attachment 1 August 2003 Construction Retention Basin Dewatering Plan

The Belleayre Resort at Catskill Park

RUNOFF BY SCS TR-20 METHOD: TYPE II 24-HOUR RAINFALL= 6.00 IN, SCS U.H.

RUNOFF SPAN = 10-20 HRS, dt= .10 HRS, 101 POINTS

SUBCAT NUMBER	AREA (ACRE)	Tc (MIN)	--GROUND COVERS (%CN)--	WGT'D CN	C	PEAK (CFS)	Tpeak (HRS)	VOL (AF)
211	3.00	1.8	100%91 → Bare soil forever	91	-	23.29	11.86	1.07
212	3.30	2.8	100%91	91	-	26.36	11.87	1.17
213	4.86	1.9	100%91	91	-	37.88	11.86	1.73
214	3.00	3.9	100%91	91	-	23.96	11.88	1.07
221	5.00	5.1	100%91	91	-	38.72	11.89	1.78
222	3.70	1.8	100%91	91	-	28.72	11.86	1.32
223	1.60	3.1	100%91	91	-	12.82	11.88	.57
224	3.80	4.1	100%91	91	-	30.25	11.88	1.35
231	3.30	2.0	100%91	91	-	25.82	11.86	1.17
232	3.30	3.9	100%91	91	-	26.35	11.88	1.17
233	2.50	4.8	80%91 20%70	87	-	18.39	11.89	.83
234	4.20	2.4	100%91	91	-	33.28	11.87	1.49
241	3.83	2.4	3%98 5%74 38%70 54%91	82	-	26.15	11.87	1.14
242	9.03	3.9	2%98 4%74 38%70 55%91	82	-	61.80	11.89	2.70
243	5.78	2.4	69%91 5%74 3%98 22%70	86	-	42.54	11.87	1.88
251	5.50	4.5	73%91 2%98 4%74 22%70	86	-	40.13	11.89	1.79
252	5.60	2.9	84%91 2%98 4%74 11%70	88	-	42.96	11.87	1.89
253	6.00	2.0	3%98 5%74 13%70 78%91	88	-	45.03	11.86	2.03
261	6.70	2.3	66%91 3%98 6%74 25%70	85	-	48.32	11.87	2.14
262	7.60	4.6	57%91 3%98 4%74 37%70	83	-	52.17	11.89	2.32
263	6.60	3.6	79%91 2%98 2%74 18%70	87	-	49.85	11.88	2.19

```
                                                                      Page 4
Data for BIG INDIAN PLATEAU - PHASE 2 CONNSTRUCTION DUP1
         TYPE II 24-HOUR RAINFALL= 6.00 IN                            6 Aug 03
Prepared by {enter your company name here}
HydroCAD 5.11  000439  (c) 1986-1999 Applied Microcomputer Systems

                        POND ROUTING BY STOR-IND METHOD

                                            ------ PEAK FLOW -------  ---Qout---
POND  START   FLOOD   PEAK    PEAK     Qin    Qout   Qpri   Qsec   ATTEN. LAG
NO.   ELEV.   ELEV.   ELEV.   STORAGE  (CFS)  (CFS)  (CFS)  (CFS)   (%)  (MIN)
      (FT)    (FT)    (FT)    (AF)

211   2304.0  2310.0  2308.9   1.07    23.29   0.00                 100   0.0
212   2312.9  2316.0  2314.0   1.17    26.36   0.00                 100   0.0
213   2271.0  2275.5  2275.4   1.73    37.88   0.00                 100   0.0
214   2264.0  2270.0  2269.4   1.07    23.96   0.00                 100   0.0
221   2294.0  2301.0  2299.0   1.78    38.72   0.00                 100   0.0
222   2294.0  2300.0  2299.1   1.31    28.72   0.00                 100   0.0
223   2284.0  2290.0  2288.0    .57    12.82   0.00                 100   0.0
224   2199.0  2205.0  2204.8   1.35    30.25   0.00                 100   0.0
231   2144.0  2150.0  2149.6   1.17    25.82   0.00                 100   0.0
232   2114.0  2120.0  2119.9   1.17    26.35   0.00                 100   0.0
233   2109.0  2115.0  2114.7    .83    18.39   0.00                 100   0.0
234   2064.0  2071.0  2069.8   1.49    33.28   0.00                 100   0.0
241   2109.0  2116.0  2114.9   1.14    26.15   0.00                 100   0.0
242   2064.0  2071.0  2069.9   2.69    61.80   0.00                 100   0.0
243   2169.0  2180.0  2179.8   1.88    42.54   0.00   - Discharge?  100   0.0
251   1937.0  1950.0  1950.0   2.92   127.5   71.14                  44   8.1
253   1946.5  1956.0  1954.8   3.27    66.45   0.00                 100   0.0
261   2189.0  2196.0  2194.9   2.13    48.32   0.00                 100   0.0
262   2139.0  2145.0  2144.8   2.32    52.17   0.00                 100   0.0
263   2068.0  2075.0  2074.9   2.19    49.85   0.00                 100   0.0
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Toxicity of acidified chitosan for cultured rainbow trout (*Oncorhynchus mykiss*)

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Accepted 7 November 1999

Abstract

Chitosan is a deacetylation product of chitin. It is used as a flocculent for sewage and brewery wastes, and as a chelator of heavy metals. In aquaculture, chitosan has been used as an immunostimulant for protection against bacterial diseases in fish, for controlled release of vaccines, and as a diet supplement. Chitosan has generally been considered to be nontoxic to animals, but when it was dissolved in acetic acid and added to a culture system at 1.0 ppm to remove organic solids, we found acute toxicity to rainbow trout (*Oncorhynchus mykiss*). In controlled experiments to determine the extent of toxicity, we found that trout died after several hours exposure to 0.75 ppm and died in 24 h after exposure to 0.075 ppm. Exposure to 0.038 ppm resulted in mortality after 6 days exposure, while exposure to 0.019 ppm resulted in no mortality after 14 days exposure. Histological examination of gills, skin, muscle, and internal organs indicated significant and consistent pathological changes only in gills. Lifting of lamellar epithelium, hypertrophy and hyperplasia of lamellar epithelial cells occurred in trout exposed to 0.019 and 0.038 ppm. In trout exposed to 0.75 or 0.075 ppm chitosan, large areas of lamellar fusion were observed. These results show that soluble acidified chitosan is highly toxic to rainbow trout even at low concentrations.

Keywords: Chitosan; Rainbow trout; Toxicity; Pathology

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PII: S0044-8486(99)00359-2

1. Introduction

Chitin is second only to cellulose as the most plentiful natural polymer. Along with its deacetylation product chitosan, chitin is manufactured commercially from the outer shell of crustaceans, particularly crabs and shrimp. The vast quantities of available shellfish wastes easily supply the chitosan needed for many applications. Most chitosan is used as a nontoxic cationic flocculent in treatment of wastes from sewage, sludge, breweries, etc., and as a chelator of heavy and radioactive metals (Sandford, 1989). Chitosan has also been found to be useful as a flocculent for several species of algae (Nigam et al., 1980; Morales et al., 1985; Lubian, 1989). It is being evaluated in human medicine for wound dressings, hemostatic agents, drug delivery systems, and as a cholesterol reducing agent. Agricultural applications include coatings for seeds, fruit preservation, as a fungistat and as a flocculent for recovering proteinaceous wastes (Sandford, 1989; Elson, 1996). In aquaculture, chitosan has been used as an immunostimulant to enhance protection of salmonids against bacterial disease (Anderson and Siwicki, 1994; Siwicki et al., 1994) and, combined with alginate, for controlled release of proteins such as bacterins (Polk et al., 1994), and as a diet supplement (Kono et al., 1987).

When incorporated as a food additive, free chitosan has been reported to be nontoxic to mice fed at 10 g/kg of body weight (Arai et al., 1968). However, when fed at 20 g/kg as chitosan acetate, 40% of test mice died while no mortality occurred in mice fed the same level of free chitosan or chitosan formate (Arai et al., 1968). Kono et al. (1987) reported that diets supplemented with 10% free chitosan did not stimulate growth rates in three species of marine fish nor were there any toxic effects. When 5% chitosan was added to the diet of rainbow trout (*Oncorhynchus mykiss*) as an immunostimulant there were no reports of toxic effects (Siwicki et al., 1994).

We tested chitosan as an aid in removing solids from a rainbow trout recirculation system previously described by Bullock et al. (1993). Chitosan was dissolved in 1% acetic acid and added to the system at 1.0 ppm. A severe toxic effect resulting in death was noted within several hours after addition of chitosan. Examination of affected trout showed gills were pale with excess mucus and hemorrhages. Internal organs appeared normal. Because of the previous reports of its nontoxic nature, we decided to test the toxicity of chitosan for rainbow trout under controlled conditions.

2. Materials and methods

2.1. *Toxicity testing*

Toxicity tests were conducted in 57-l round tanks supplied with 2 l/min of 11.5°C spring water. The flow rate of spring water was maintained by allowing water to overflow a 4-l container, which maintained a constant head pressure, and introducing water into tanks by means of plastic tubing from the 4-l container. Hose clamps were used to set the flow rate at 2 l/min to each tank. Water delivery rate was determined daily for each tank. Dry standard grade chitosan was obtained from Vanson, Redmond, WA and a 1.0% solution was prepared in 1.0% acetic acid. A masterflex peristaltic pump (Cole Palmer Instrument, Burling, IL) set at 0.22 ml/min was used to deliver a calculated 1 ppm chitosan to the experimental tanks. Test levels below 1 ppm were obtained by diluting the 1% chitosan solution and keeping the pump delivery constant. In order to obtain actual chitosan levels rather than calculated levels, we attempted to quantify the 1 ppm chitosan in springwater delivered by the peristaltic pump. When the pH of springwater was raised to precipitate chitosan, the calcium and magnesium in the springwater also precipitated. However, incoming chitosan concentration was quantified by turning on the peristaltic pump for 1 min, which was calculated to deliver 2-mg chitosan, and collecting the chitosan sample in 50-ml deionized water. Chitosan was precipitated from deionized water by raising the pH of the sample to 10 using 1.0 normal NaOH. After stirring for 4 h, the sample was filtered onto an 8-μm filter (Millipore, Redford, MA) previously dried at 60°C to a constant weight. The filtered sample was dried at 60°C and weighed to a constant weight. This procedure was repeated three times. The chitosan levels selected for testing were 1.0, 0.1, 0.05, and 0.025 ppm. However, as will be discussed later, the quantification studies showed that only 75% of the calculated level of chitosan were delivered by the peristaltic pump. Therefore, actual test levels were 0.75, 0.075, 0.038, and 0.019 ppm.

Rainbow trout with an average weight of 120.5 g were used in all tests. In preliminary trials using 0.75, 0.075, 0.038, and 0.019 ppm chitosan plus a 1% acetic acid control, and a nontreated rainbow trout control, a single 57-l tank containing 15 rainbow trout was used for each test level and controls (total of six tanks). In subsequent tests with 0.038 and 0.019 ppm chitosan, triplicate tanks, each containing 15 trout, were used for each concentration. Preliminary trials were carried out up to 7 days while later trials with the 0.038 and 0.019 ppm levels were carried out for 14 days.

2.2. Histopathology

In all tests, three to five rainbow trout were taken for histological examination from each exposure level, acetic acid, and nontreated controls. In preliminary trials, surviving fish were sampled at 24 h from the 0.75 ppm treatment tank and day 4 from the 0.075 ppm, because of acute toxicity. Samples from the 1.0 ppm acetic acid control and nontreated control were taken on day 7. In trials with the 0.038 and 0.019 ppm chitosan treatments, samples were taken on day 14. Pieces of gill, muscle, heart, spleen, liver, kidney, and intestine were removed from each trout, and fixed in 10% formalin or Deitrich's fixative. They were processed routinely for histology, sectioned at 5 μm and stained with hematoxylin and eosin (H&E).

3. Results

3.1. Toxicity tests

Daily determination of water flow to experimental tanks was consistently within 2% of the 2 l/min. The actual concentration of pump delivery per minute as quantified by precipitation of chitosan was found to be 1.5 ppm, which is 75% of predicted value. The actual concentration exposure levels to trout were 0.75, 0.075, 0.038, and 0.019 ppm.

In the initial 7-day exposure, chitosan was acutely toxic at 0.75 and 0.075 ppm concentrations. Twelve of 15 trout died within 24 h at 0.75 ppm, and six trout died within 24 h at 0.075 ppm, and 11 died within 3 days. During the 7-day trial, only one trout died on day 7 at the 0.038 ppm concentration, and none died at the 0.019 ppm concentration. No toxicity was noted in trout exposed to 1.0% acetic acid or in nontreated control trout. During the 14-day experiment, trout exposed to 0.038 ppm began dying on day 6 in one tank and on day 8 in the other two tanks. Mortality continued during the 14-day study period with a total of nine, seven, and five trouts dying in the three tanks. No trout died in the three tanks exposed to 0.019 ppm.

3.2. Histopathology

The only consistent histopathological changes were observed in gill tissue. Gill tissues of fish sampled from the nontreated control and the acetic acid control were

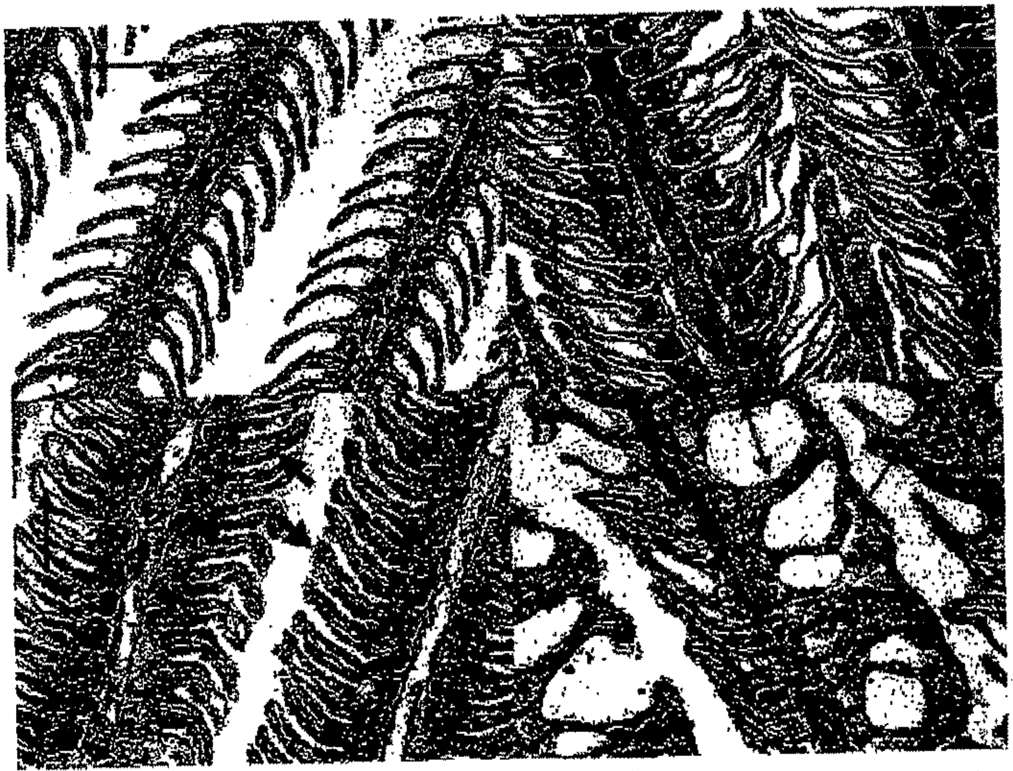

Fig. 1. Histological sections of gill tissues of rainbow trout. (A) Control gill tissue, with filaments consisting of thin capillaries covered by flattened epithelial cells. (B) Trout exposed to 0.019 ppm chitosan. The epithelium is lifted off the basement membrane. Edematous fluid is often evident (arrows). (C) Trout exposed to 0.038 ppm chitosan. Epithelial lifting (long arrow) in some areas. Thickening of the lamellae due to hypertrophy of epithelial cells (short arrows) and proliferation of mucous cells (clear cells within lamellar epithelium) are present. (D) Trout exposed to 0.075 ppm chitosan. Large areas of adjacent lamellae are fused (single-headed arrow), and often forming cyst-like structures (double-headed arrow) throughout the gill. H&E stain, scale bar equals 100 μm.

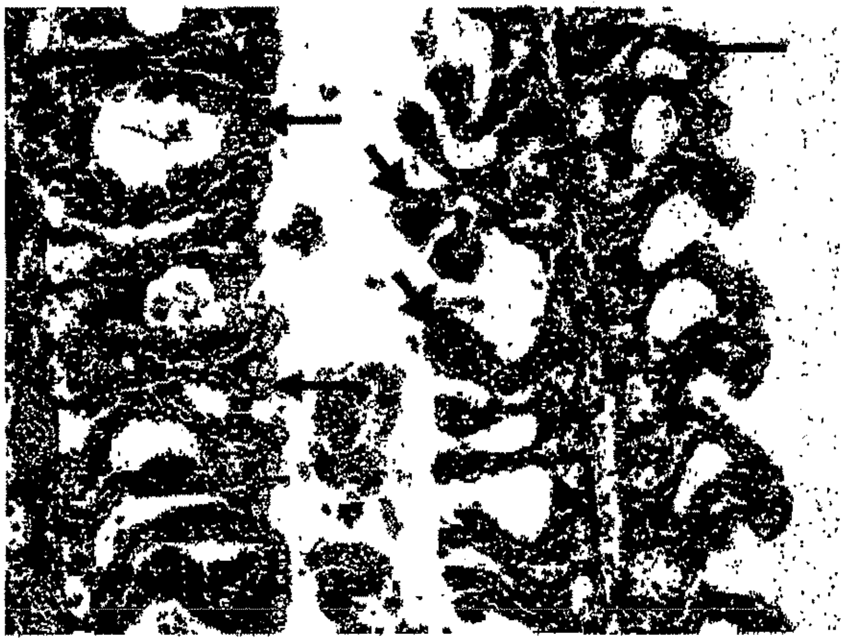

Fig. 2. Section of gill tissue from rainbow trout exposed to 0.75 ppm chitosan. Adjacent lamellae are often fused by proliferation of mucous cells (thin arrows). Tips of the lamellae are engorged with red blood cells (thick arrows). H&E stain, scale bar equals 100 μm.

normal with blood spaces of the lamellae obvious and uniform in size. They were covered by the lamellar epithelium, a single layer of flattened cells (Fig. 1A). Although no mortality was observed in fish exposed to 0.019 ppm chitosan, epithelial lifting, often with edematous fluid between the basement membrane and epithelium, was observed in all fish sampled at the end of the 14-day exposure period (Fig. 1B). In a fish exposed to 0.038 ppm chitosan and surviving for 14 days, epithelial lifting, as well as hypertrophy of epithelial cells were noted, giving the lamellae a thickened appearance. Hyperplasia of epithelial cells, particularly mucous cells, contributed to the thickened appearance (Fig. 1C). These changes were present in all fish sampled, although severity differed among individual fish. Trout exposed to 0.75 ppm for 24 h and 0.075 ppm for 4 days had severe gill lesions. Large areas of secondary lamellae were fused. A common observation was fusion of the tips of lamellae (lamellar synechiae) leading to cyst-like formations throughout the gill (Fig. 1D). In the group exposed to 0.75 ppm for 24 h, mucous cell proliferation and/or hypertrophy was obvious with the mucous cells forming a bridge between adjacent lamellae. Tips of lamellae were often rounded and filled with red blood cells (Fig. 2). Again, all fishes, which survived to these periods, had similar lesions, although severity differed among individuals.

4. Discussion

Advantages of chitosan use in aquaculture have already been demonstrated. A single injection of 100 μg in a 100-g trout gave protection against a bath challenge with

Aeromonas salmonicida for 14 days (Anderson and Siwicki, 1994). Microencapsulation of proteins such as bovine serum albumin or *Vibrio* bacteria in chitosan-alginate microcapsules facilitated controlled release of these proteins and provides a simple inexpensive method for oral delivery of vaccines (Polk et al., 1994). Incorporation of 10% chitosan into diets fed to three species of marine fish did not enhance growth, but produced no toxic effect to the fish (Kono et al., 1987).

However, as a water additive to facilitate solids removal in recirculating culture systems, chitosan exhibited dose-dependent toxic effects. Death of rainbow trout seems to be related to the gill lesions described and severity was dose-dependent. The toxicity was due to the acidified chitosan and not the acetic acid solvent because trout exposed to 1.0% acetic acid showed no gill abnormalities. Although we found chitosan acidified in acetic acid to be highly toxic to rainbow trout, toxicity data (Technical Data Sheet Sea Klear Chitosan Toxicity Data 11/8/96, provided by Vanson, Redmond, WA) showed that chitosan dissolved in malic acid was virtually nontoxic to fathead minnows (*Pimephales promelas*). The median lethal concentration was 590 ppm and the no effect concentration was 250 ppm. These differences in toxicity may be explained by species differences in tolerance or form of chitosan used for testing.

Most gill lesions observed at the light microscopic level are considered nonspecific (Eller, 1975; Mallatt, 1985). It is recognized that higher resolution transmission electron microscopy is required to recognize specific changes (i.e., mechanism of toxicity) within gill epithelial cells (Mallatt et al., 1995). Hence, we cannot determine the exact mechanism of chitosan toxicity. However, the lesions are similar to previously reported irritant/toxicant-responses and some hypotheses about mechanisms can be made. The lifting of the branchial epithelium off the basement membrane, accompanied by edema, as we saw in chronic sublethal exposures, was the most commonly reported lesion in a statistical review of gill changes induced by toxicants and other irritants (Mallatt, 1985). It has been reported as a chronic sublethal response to a variety of waterborne compounds, including suspended wood debris (Magor, 1988), and as a sublethal or lethal response to a variety of contaminants (Mallatt, 1985). The other more chronic and sublethal response was the hypertrophy of epithelial cells leading to the thickening of the lamellar epithelium. This was also commonly reported after both lethal and sublethal exposures to irritants/toxicants (Mallatt, 1985). More recent works have indicated that these disturbances in gill structure are invariably accompanied by a drop in blood electrolyte levels due to increased permeability of the gills to ions (Wendelaar Bonga and Lock, 1992).

The higher concentrations of chitosan were acutely toxic with most fish dying within 24 h when exposed to 0.75 ppm and within 72 h when exposed to 0.075 ppm. In these fishes, neither the epithelial lifting nor the cellular hypertrophy was obvious. Rather, there was severe fusion of the lamellae, particularly at the tips, and a proliferation/hypertrophy of mucous cells. In addition, blood flow appeared to be affected as the tips of lamellae were often swollen with red blood cells, often outside of the capillary walls. These lesions have been reported as acute responses to heavy metals such as cadmium, mercury, and copper (Ferguson, 1989). It is believed that the toxicant/irritant alters the glycoprotein in the mucous covering, affecting a negative charge of the epithelium, which favors adhesion to adjacent lamellae (Ferguson, 1989).

The lesions we observed are similar to those observed after exposure to mercury. Hypertrophy or swelling of epithelial cells (Paulose, 1989; Mallatt et al., 1995; Jagoe et al., 1996), lifting of lamellar epithelium and edema (Daoust et al., 1984), and fusion of lamellae (Paulose, 1989) have all been reported after acute or chronic exposures to mercury compounds. Mercury compounds, which have a high affinity for sulfhydryl groups, bind to cell proteins, and in this way, disrupt many cell processes (Rothstein, 1970). The mechanism for the hypertrophy of epithelial cells, edema and fusion of lamellae by mercury is proposed to be altered ion flux due to this binding (Mallatt et al., 1995; Jagoe et al., 1996). Chitosan readily adheres to mucopolysaccharides and proteins, such as those found in skin and hair (Sandford, 1989). Perhaps, its toxic mechanism is similar to mercury in that binding to the gill epithelium leads to ionic imbalances and potentially interferes with oxygen uptake. Further research is necessary to determine the exact toxic mechanism of solubilized chitosan.

Acknowledgements

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67

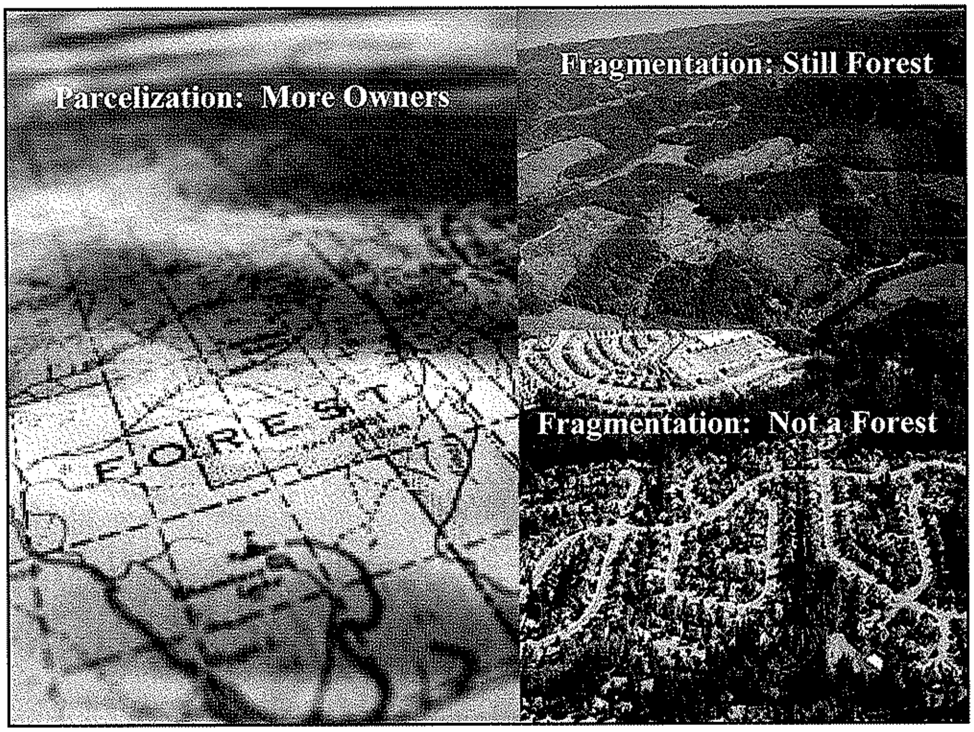
CPC Ex 67
(Need revised)

Forest Fragmentation and Land Parcelization in the Catskill Mountains: Documenting the Past & Projecting the Future Based on Empirical Relations

Issues Conference
June 10, 2004
Margaretville, NY

A joint project of:

SUNY College of Environmental Science and Forestry
Yale University School of Forestry and Environmental Studies
USDA Forest Service



Parcelization: More Owners

Fragmentation: Still Forest

Fragmentation: Not a Forest

Potential consequences: Local, Regional and Global

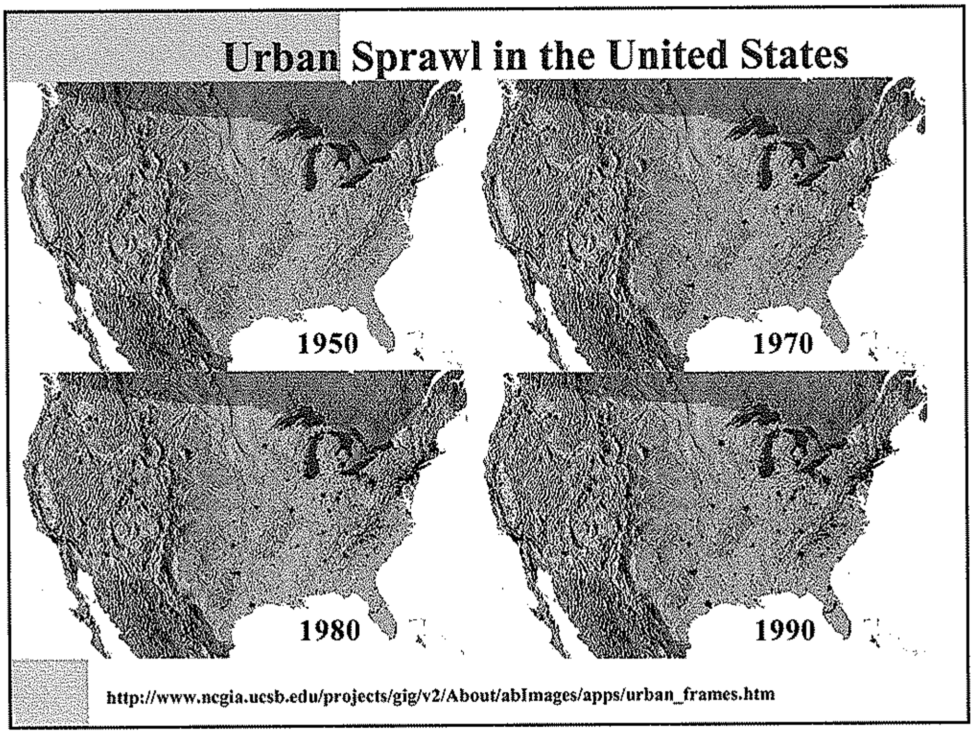
- Loss of the working forested landscape; severe economic effects
- Need to buy more timber outside the US
- Increase in runoff from impervious surfaces and in water turbidity from soil erosion
- Need for NY City to install water filtration/purification ($$$$billions????)
- Loss of wildlife habitat
- Contribution to CO_2 emissions
- Fire suppression to protect homes– build-up of combustible material

The Challenge

- By the time you see forest fragmentation, it's usually too late to do anything about it.
- Maintaining land in forest is seldom possible unless the ability of the forest to generate revenue is also maintained.
- In many areas, it will require the support of urban populations to maintain working forests.

The Challenge

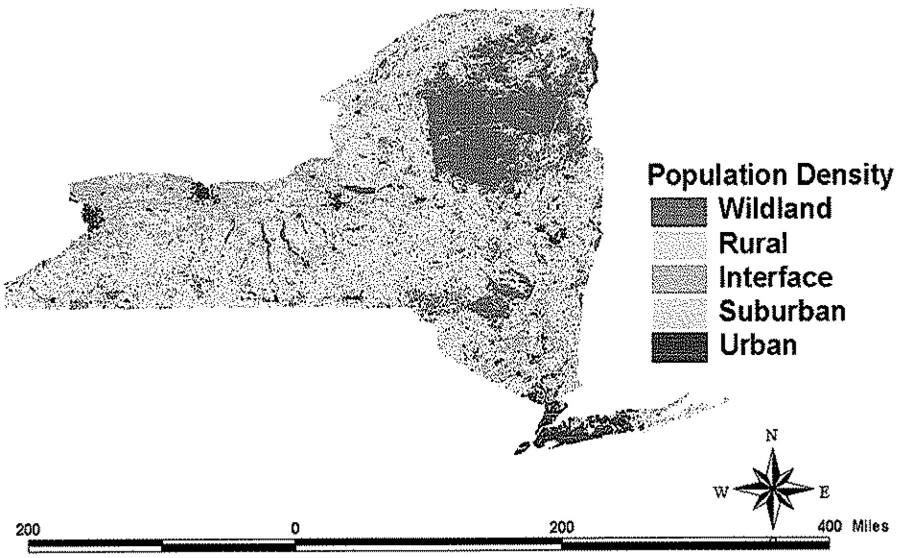
- As population grows and concentrates, working forests and farms dwindle.
- Results
  - Parcelization – smaller, less economic tracts.
  - Fragmentation – less intact forest area
- Many regions of the U.S. are approaching critical threshold densities.



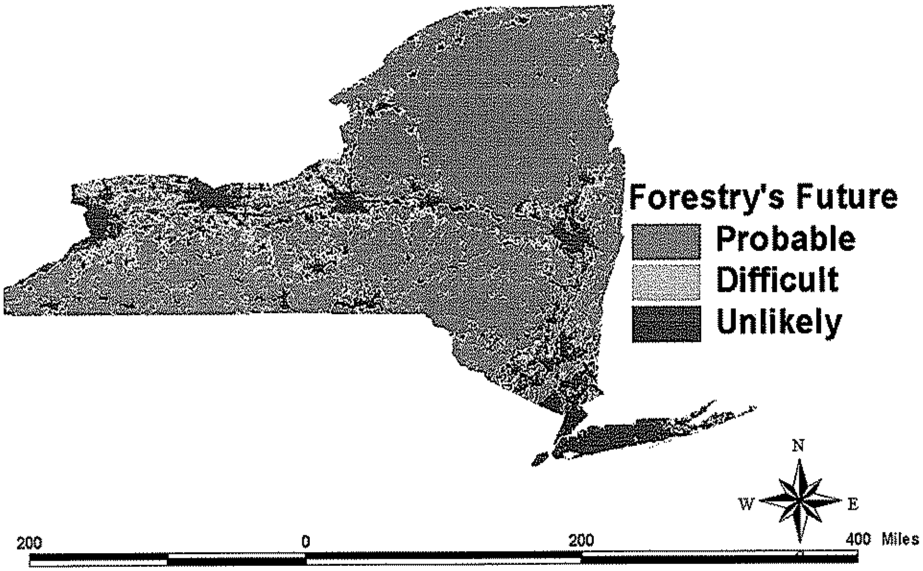
Urban Sprawl in the United States

http://www.ncgia.ucsb.edu/projects/gig/v2/About/abImages/apps/urban_frames.htm

New York



New York



The Question with respect to the proposed development

- Do areas where population is not growing rapidly still exhibit significant land use change that reduces the capacity of working lands?
- How does development that attracts non-permanent residents accelerate forest fragmentation and parcelization?

The Process – what drives parcelization?

Death Rate

Need to pay inheritance taxes

Uncertainty

Urbanization

Increased Income

Locally higher land values

Taxes

Finding the Big Sky, Close to Manhattan

By EVAN McGLINN
(New York Times, May 10, 2002)

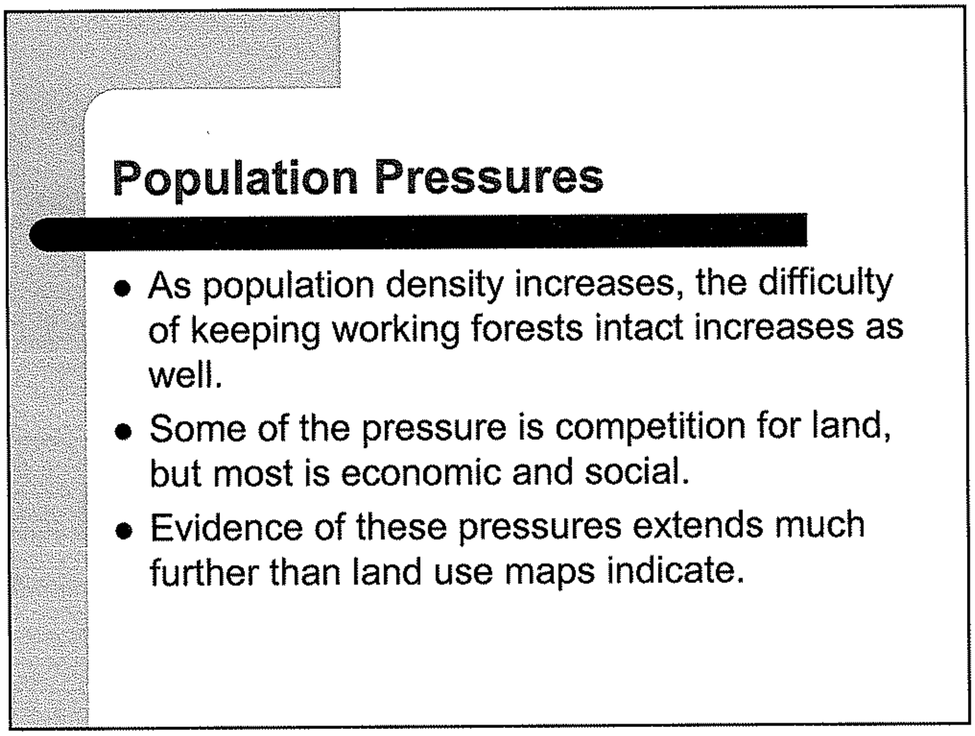
UTTER the words Delaware County at a party in Manhattan and you will likely get one of two very different reactions. People will either raise their eyebrows knowingly, and indicate they would prefer that their fellow New Yorkers never discover it. Or they will give the more typical response and ask, where's Delaware County?

John Houshmand knows. He discovered this part of the Catskills in 1991 when he was thinking about buying a ranch in Montana. "I really wanted a place that was secluded and had mountains and wildlife," he said, "but I couldn't bear the thought of only being able to go to it twice a year."

Welcome To CATSKILLS REAL ESTATE

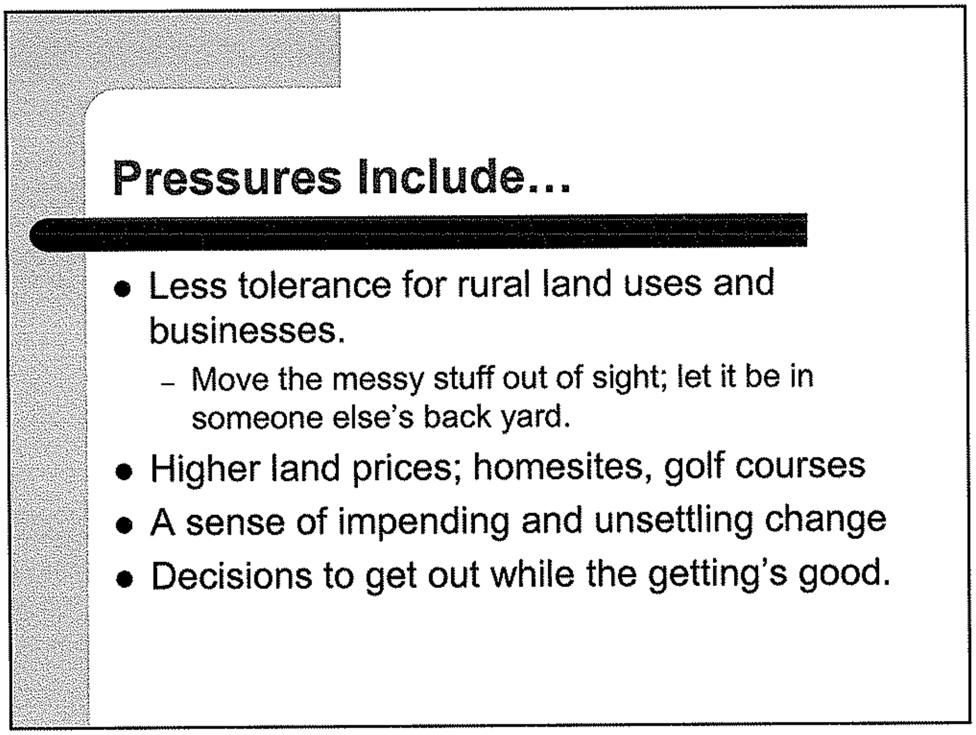
We invite you to take a virtual tour of some of the most spectacular properties currently for sale in the Catskills, Hudson Valley Region and the Adirondacks in Upstate New York. This web site is a unique showcase for private mountain top estates, charming country inns, and magnificent Hudson River homes.
http://www.catskillsrealestate.com/

.... "Trust me," he said. "Buy a home up here, and within five years, you will be living here."



Population Pressures

- As population density increases, the difficulty of keeping working forests intact increases as well.
- Some of the pressure is competition for land, but most is economic and social.
- Evidence of these pressures extends much further than land use maps indicate.



Pressures Include…

- Less tolerance for rural land uses and businesses.
  - Move the messy stuff out of sight; let it be in someone else's back yard.
- Higher land prices; homesites, golf courses
- A sense of impending and unsettling change
- Decisions to get out while the getting's good.

Land Tenure Changes

- More People Moving into Rural Areas - Sprawl
- Forests for Home Sites, not Production of Commodities
- Will Production Land Uses be Feasible in the Future?
- Changing Values – Inherited Lands
- Forest Products Industry Selling Their Lands

Impact on Forestry

- Smaller forest parcels with more neighbors:
  - Are more expensive to manage for forest products
  - Get less money for their timber
  - May find their management activities constrained
    - e.g. Prescribed fire
  - May get taxed for development values
  - Are more likely to be sold for development

Project Objectives

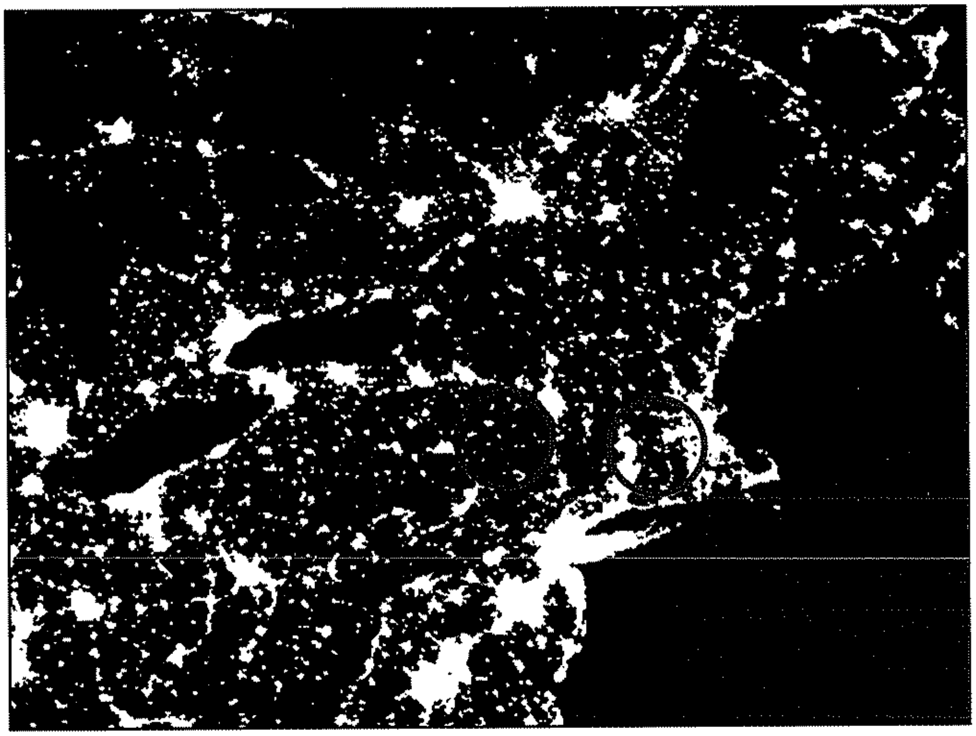
- Better understanding of forest parcelization and fragmentation processes
  - How they develop
  - What are the underlying drivers
  - How do they affect communities
- Improved forest conservation programs
  - Can we get ahead of the situation?
  - Can we sustain forest environments, economies?

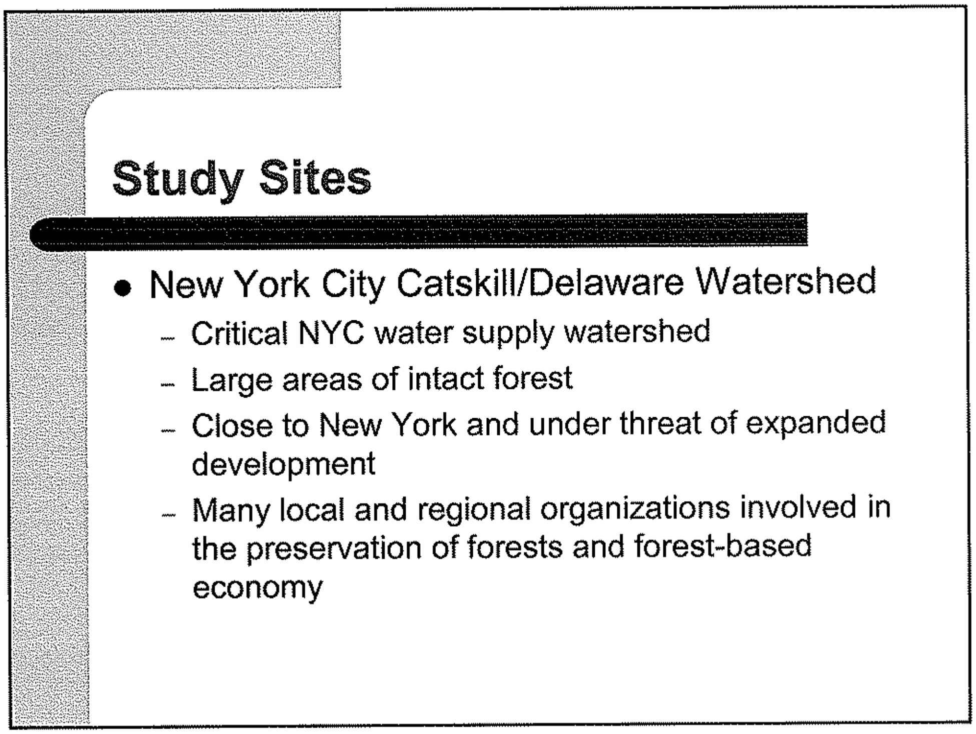
Project Methods

- Identify factors that are correlated with the past patterns of land use change
- Identify areas of intact forest where those same factors are present today
- Use a dynamic modeling tool (GEOMOD) to project possible future scenarios

Project Methods – Study sites

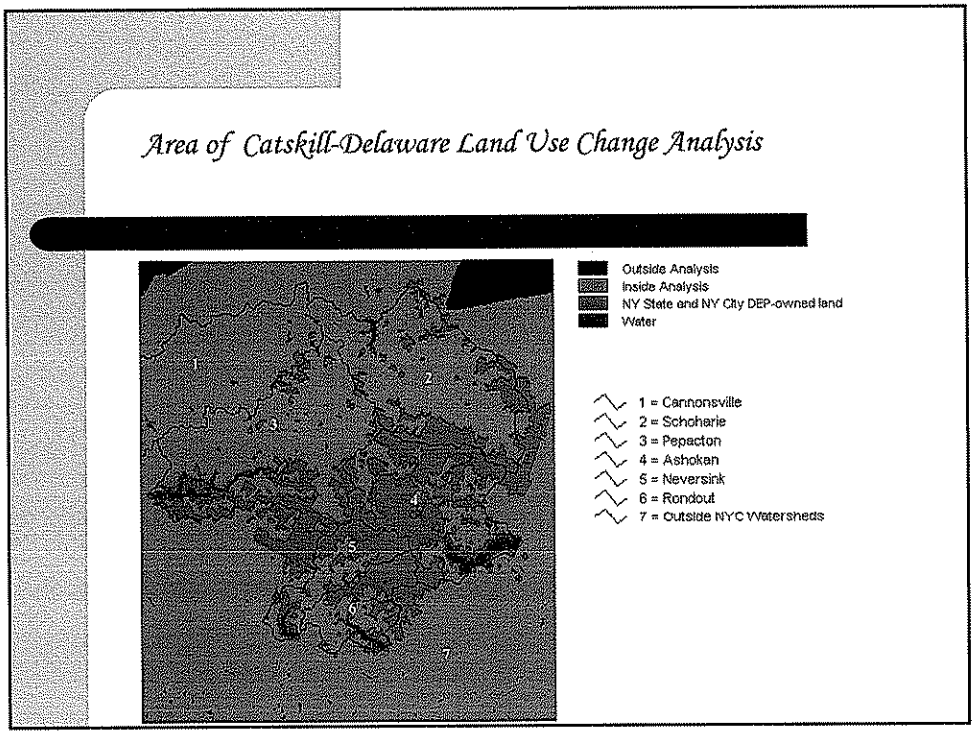
- Chose sites that have large areas of intact forest, development pressure, and an active conservation community
- Hosted community workshop to develop working hypothesis about driving factors of forest loss in the study site
- Derived a list of potential factors for analysis





Study Sites

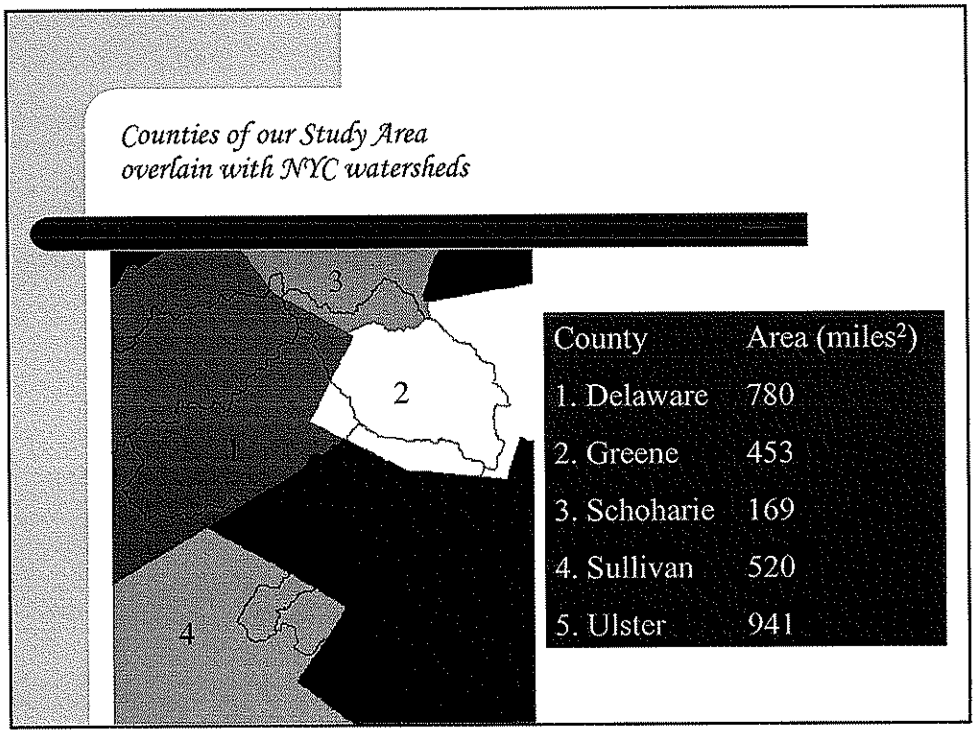
- New York City Catskill/Delaware Watershed
  - Critical NYC water supply watershed
  - Large areas of intact forest
  - Close to New York and under threat of expanded development
  - Many local and regional organizations involved in the preservation of forests and forest-based economy



Area of Catskill-Delaware Land Use Change Analysis

- ■ Outside Analysis
- ▨ Inside Analysis
- ▨ NY State and NY City DEP-owned land
- ■ Water

1 = Cannonsville
2 = Schoharie
3 = Pepacton
4 = Ashokan
5 = Neversink
6 = Rondout
7 = Outside NYC Watersheds



Counties of our Study Area overlain with NYC watersheds

County	Area (miles^2)
1. Delaware	780
2. Greene	453
3. Schoharie	169
4. Sullivan	520
5. Ulster	941

Hypotheses

- New York Catskills/Delaware Watershed
  - Parcelization is more of a current factor than fragmentation and will be hard to detect or predict
  - Forestland change is driven by distance from New York City, distance from major roads, distance from growth nodes such as ski resorts and new resort development, watershed regulations, taxes, age of landowners, and the population of permanent residents vs. housing units (i.e. second homes)

GEOMOD

a spatial and temporal GIS-based model that quantifies factors associated with land use change, and simulates the rate and pattern of land use change into the future.

was created by Dr. Charles Hall, Professor, Faculty of Environmental Forest Biology, SUNY College of Environmental Science and Forestry, Syracuse, NY and his graduate students, with funding from the the US Department of Energy, Carbon Dioxide Research Program, Atmospheric and Climatic Change Division.

What we need to build GEOMOD:

- **Rate Drivers** that may explain <u>**how much**</u> change per time step?
  1) Use of satellite imagery
  2) Use of demographic or socio/economic data
- **Pattern Drivers** that may explain <u>**where**</u> people preferred to develop the landscape

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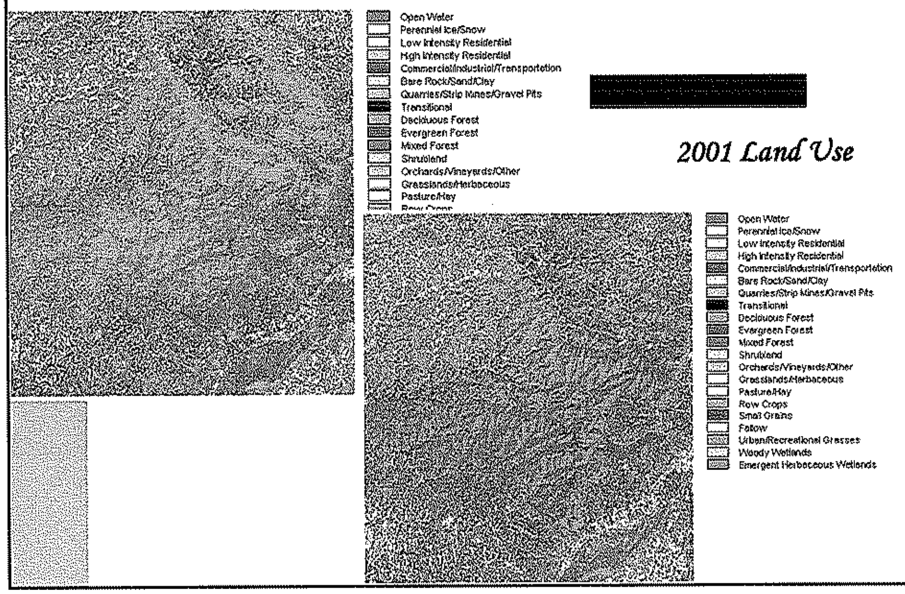
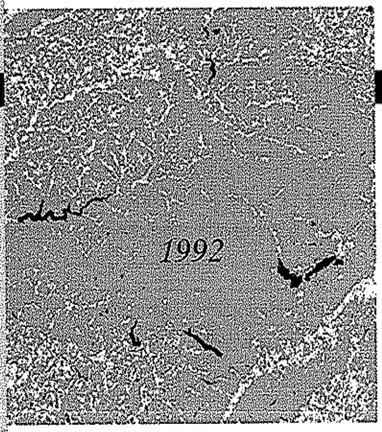
Satellite Images Tell the Story

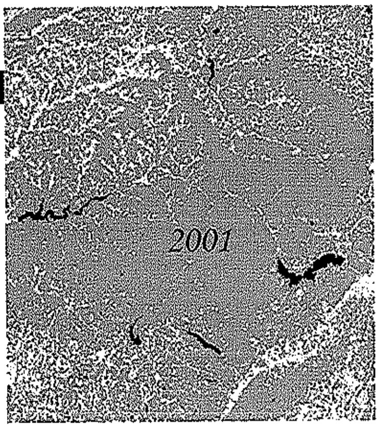
1992 Land Use

2001 Land Use



Reclassification of land uses to Forest/Non-forest





Forest includes deciduous, evergreen, & mixed forest, and woody wetlands

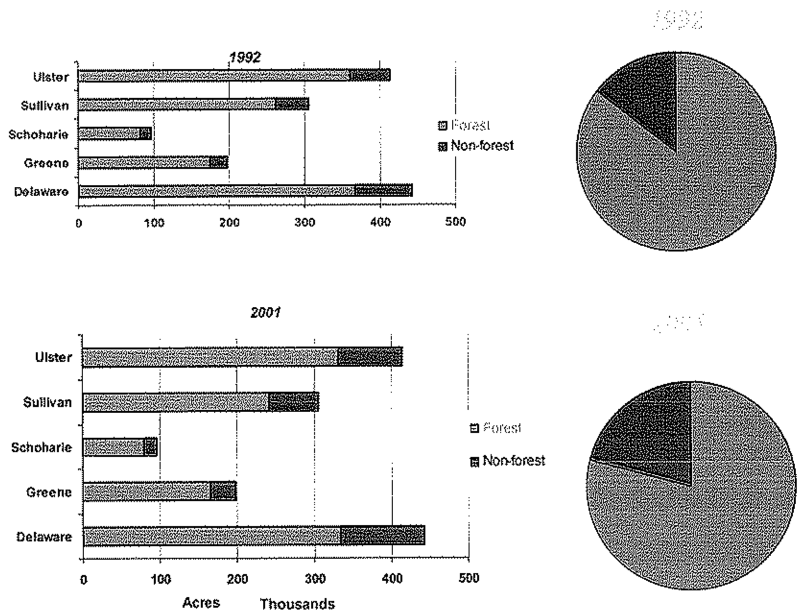
Non-forest includes low & high intensity residential, commercial, industrial, transportation, hay, pasture, row crops, urban, recreational grasses, quarries, strip mines, gravel pits

Summary of Catskill-Delaware Region Land Cover History 1992 and 2001 by County

	1992 Forest	*1992 Non-forest*	*2001 Forest*	*2001 Non-Forest*	*% Forested in 1992*	*% Forested in 2001*	*Acres of 1992 Forest Lost*	*Acres 1992 Non-forest Reforesting*	*Net Acres 'Forest' Lost*
Delaware	366425	64820	322781	108464	85%	75%	49844	6200	43645
Greene	174780	18871	161274	32376	90%	83%	17048	3543	13506
Schoharie	83071	11188	76825	17434	88%	82%	8000	1754	6247
Sullivan	262040	38350	236681	63709	87%	79%	30846	5487	25359
Ulster	360527	48002	326569	81960	88%	80%	39946	5988	33958
Total	1246843	181230	1124129	303944	87%	79%	145685	17484	122714

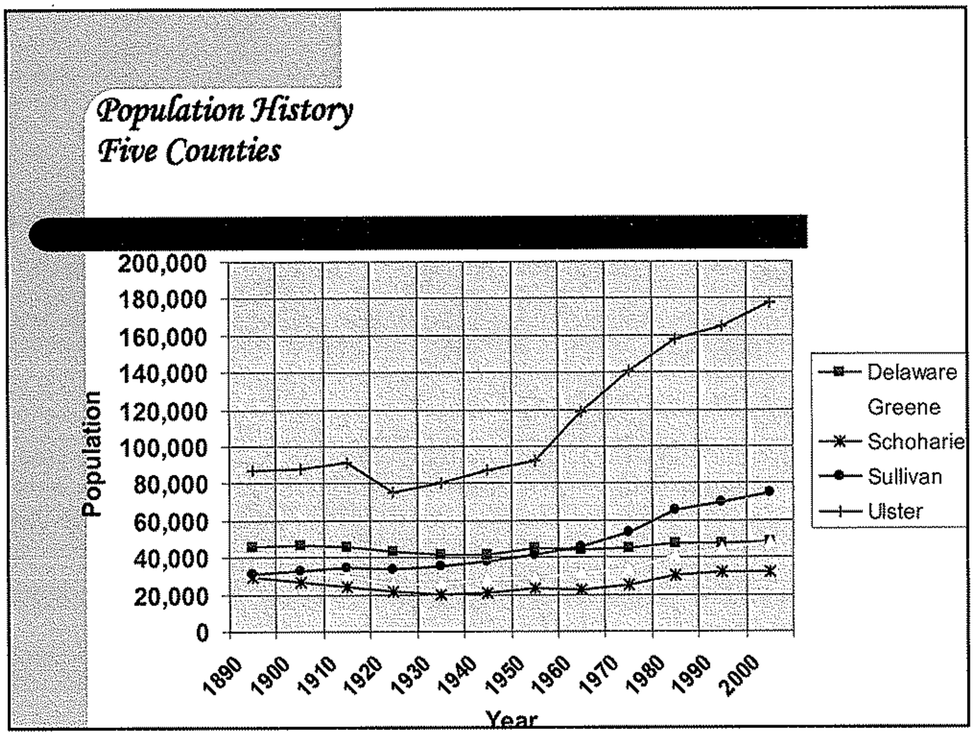
	1992	***2001***
	% Forest Including Pub. Land	***% Forest Including Pub. Land***
Delaware	85%	75%
Greene	92%	87%
Schoharie	87%	81%
Sullivan	86%	78%
Ulster	90%	85%
Total	88%	81%

Land Cover by County 1992 -2001

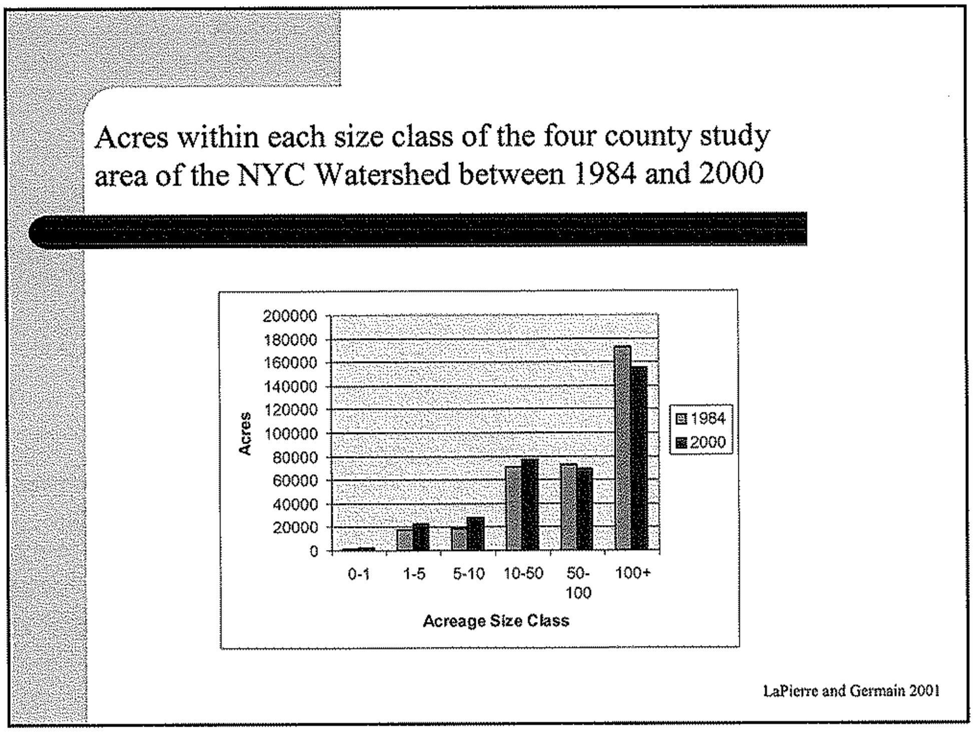


Summary of Catskill-Delaware Region Land Cover History 1992 and 2001 by NYC Watershed

	Cannons	Schoh	Pepac	Asho	Never	Rond	Total Basins	Outside NYC Watersheds	Total Area Analyzed
Proportion Pub_land/Basin	0.024	0.223	0.198	0.581	0.529	0.464	0.285	0.069	0.168
Proportion Private Land	0.973	0.768	0.779	0.369	0.446	0.502	0.693	0.920	0.790
Proportion Water	0.003	0.008	0.024	0.051	0.025	0.035	0.022	0.012	0.016
Proportion Forested in 1992	0.75	0.88	0.89	0.97	0.97	0.96	0.89	0.84	0.87
Proportion Forested in 2001	0.65	0.85	0.84	0.95	0.96	0.92	0.84	0.78	0.81
Change in Total Forest Cover	-0.10	-0.03	-0.05	-0.02	-0.01	-0.04	-0.04	-0.06	-0.05
Loss of 1992 Forest	-0.19	-0.07	-0.08	-0.03	-0.02	-0.05	-0.08	-0.11	-0.10

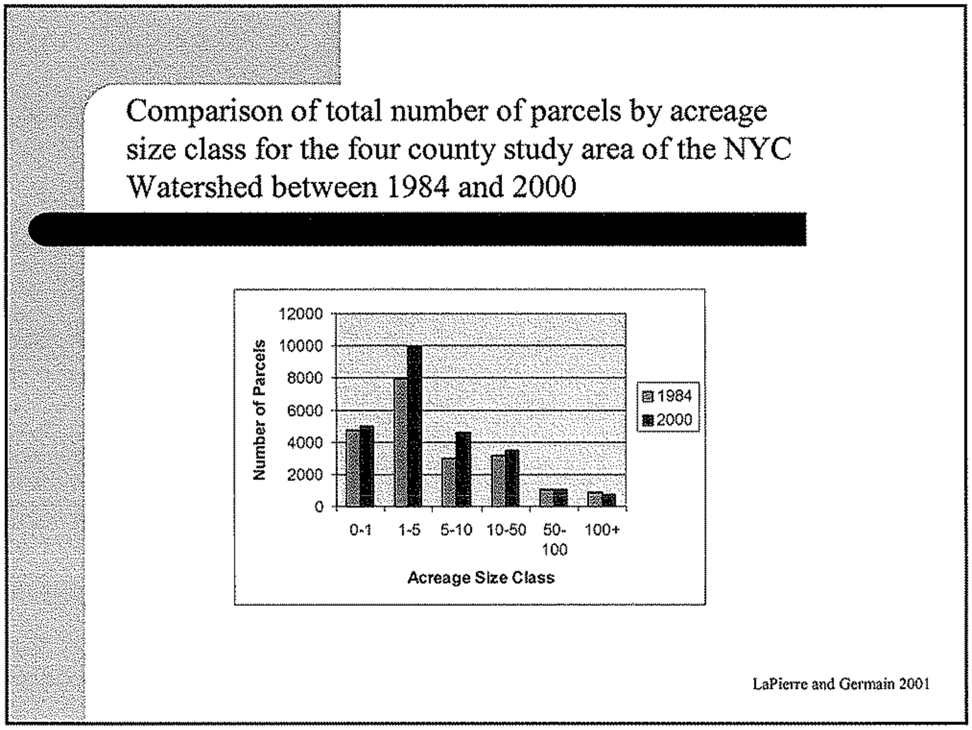


Population History Five Counties



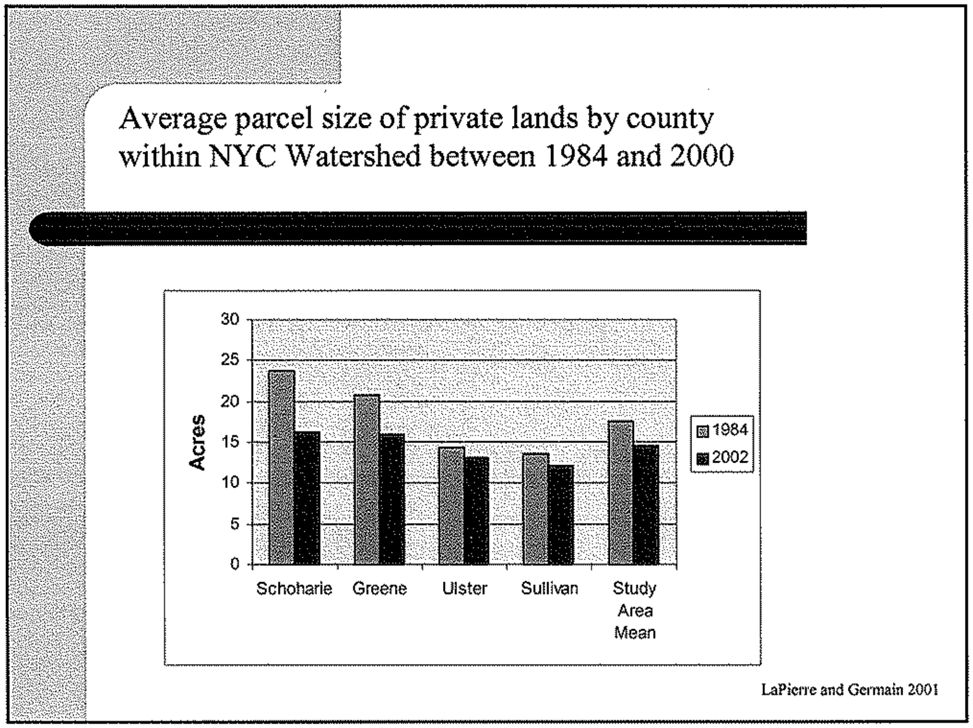
Acres within each size class of the four county study area of the NYC Watershed between 1984 and 2000

LaPierre and Germain 2001



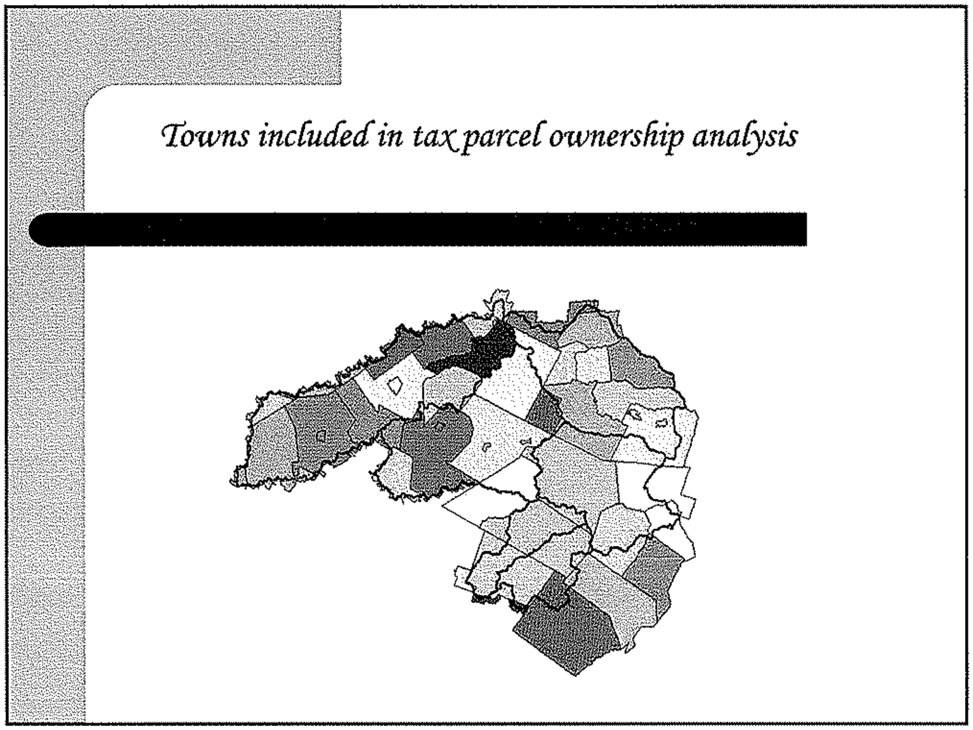
Comparison of total number of parcels by acreage size class for the four county study area of the NYC Watershed between 1984 and 2000

LaPierre and Germain 2001

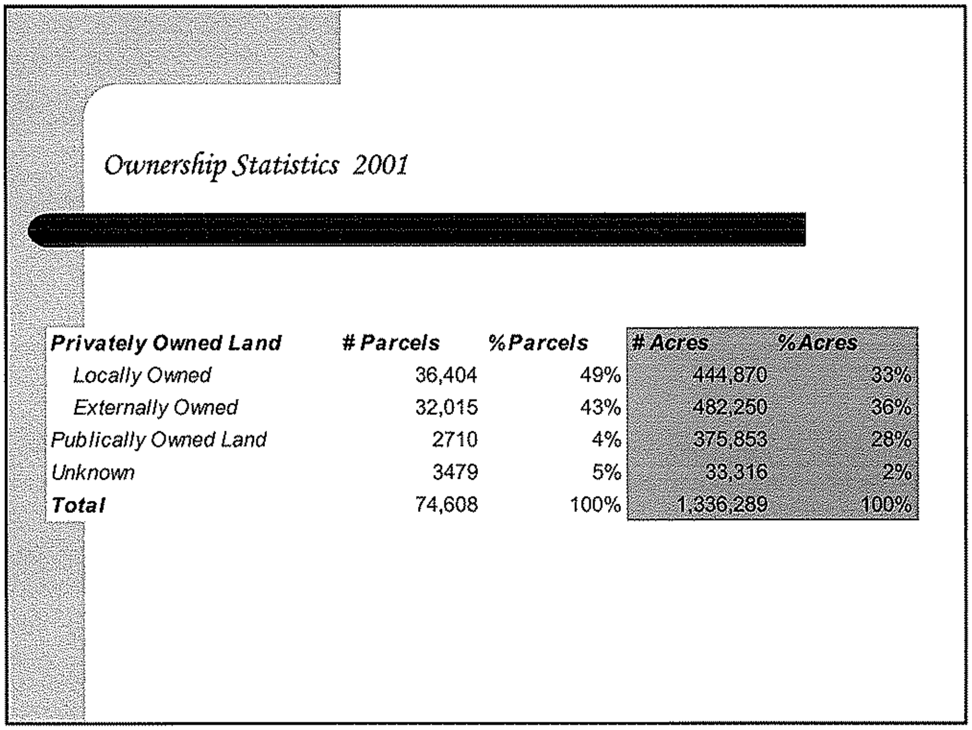


Average parcel size of private lands by county within NYC Watershed between 1984 and 2000

LaPierre and Germain 2001

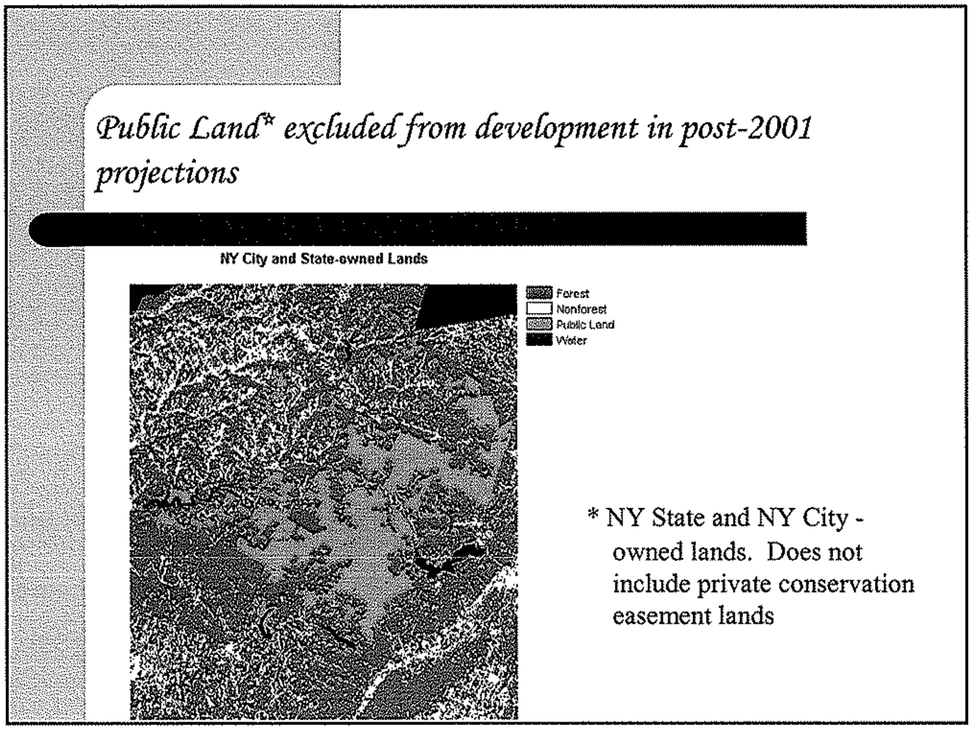


Towns included in tax parcel ownership analysis



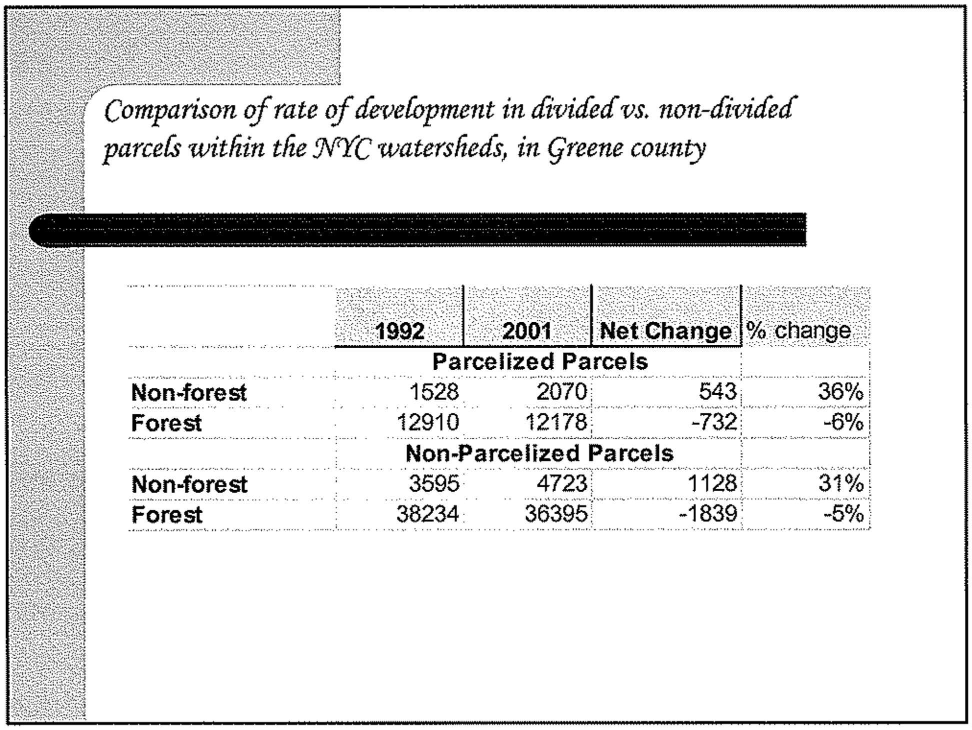
Ownership Statistics 2001

Privately Owned Land	**# Parcels**	**% Parcels**	**# Acres**	**% Acres**
Locally Owned	36,404	49%	444,870	33%
Externally Owned	32,015	43%	482,250	36%
Publically Owned Land	2710	4%	375,853	28%
Unknown	3479	5%	33,316	2%
Total	74,608	100%	1,336,289	100%



Public Land excluded from development in post-2001 projections*

* NY State and NY City - owned lands. Does not include private conservation easement lands



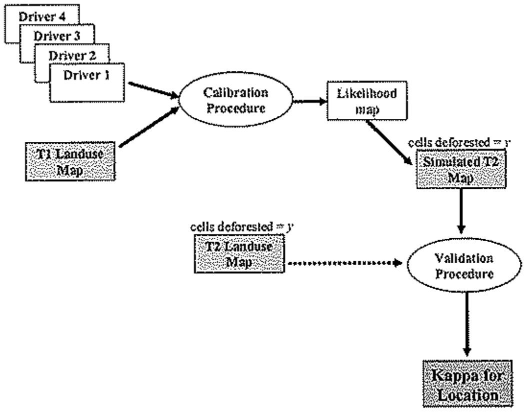
Comparison of rate of development in divided vs. non-divided parcels within the NYC watersheds, in Greene county

	1992	2001	Net Change	% change
	Parcelized Parcels			
Non-forest	1528	2070	543	36%
Forest	12910	12178	-732	-6%
	Non-Parcelized Parcels			
Non-forest	3595	4723	1128	31%
Forest	38234	36395	-1839	-5%

Final Rate Tabulation applied in model

% Forested	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Delaware	73%	72%	71%	70%	68%	67%	66%	64%	63%	62%	61%
Greene	81%	80%	79%	79%	78%	77%	76%	75%	74%	73%	72%
Schoharie	80%	79%	78%	77%	76%	75%	74%	73%	72%	71%	70%
Sullivan	77%	76%	75%	74%	72%	71%	70%	69%	68%	67%	66%
Ulster	78%	77%	76%	75%	74%	73%	72%	71%	70%	69%	68%
Total Acres	77%	76%	75%	74%	73%	71%	70%	69%	68%	67%	66%

GEOMOD – a land use change model that is both spatial and temporal, and can be validated



Driver 4

Driver 3

Driver 2

Driver 1

Calibration Procedure

Likelihood map

T1 Landuse Map

cells deforested = y

Simulated T2 Map

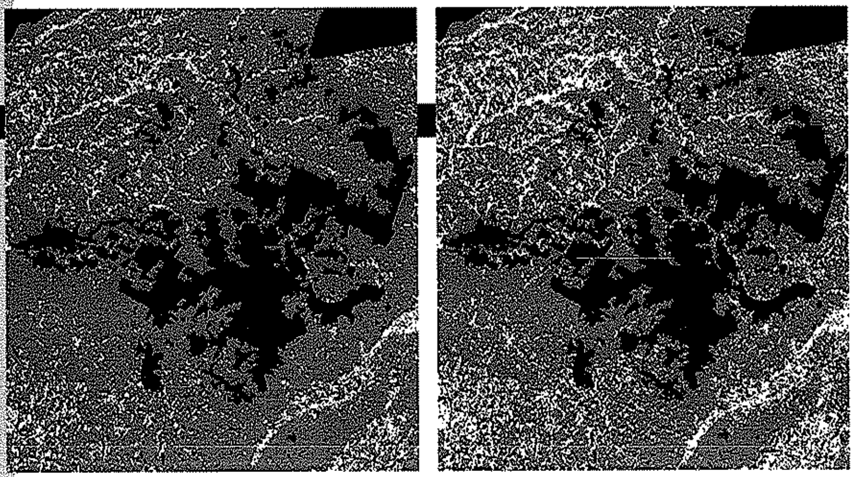
cells deforested = y

T2 Landuse Map

Validation Procedure

Kappa for Location

Maps of Final Areas Analyzed

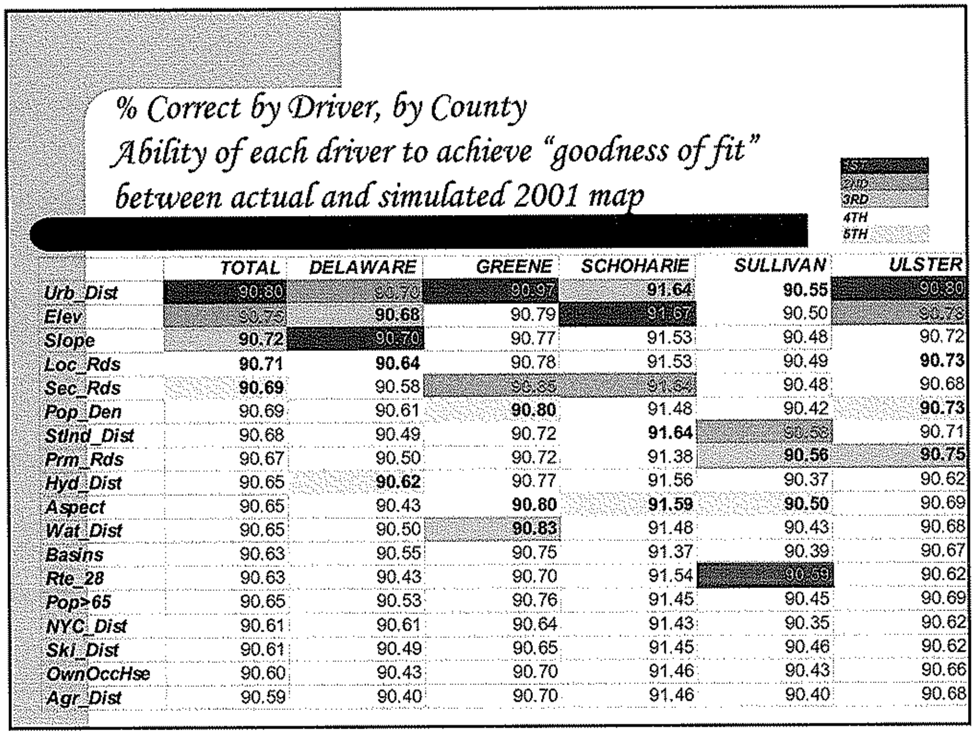


Calibration Map *Validation Map*

Black areas represent areas of water, wetlands, and NYC DEP and NY State Lands masked out, i.e. not candidates for change

Comparison of driver significance under two options – with and without the imposition of the neighborhood function

Driver	Rank	Kappa	Agree	%Correct	Driver	Rank	Kappa	Agree	%Correct
Pop_Den	1	0.5370	0.1804	84.31	***Urb_Dist***	1	**0.7285**	24.6956	90.80
Urb_Dist	2	0.5176	0.1785	83.65	***Elev***	2	**0.7271**	24.6500	90.75
Elev	3	0.5255	0.1765	83.92	***Slope***	3	**0.7263**	24.6232	90.72
Pop>65	4	0.5239	0.1759	83.86	***Loc_Rds***	4	**0.7260**	24.6124	90.71
Stlnd_Dist	5	0.5176	0.1738	83.65	***Sec_Rds***	5	**0.7255**	24.5940	90.69
Loc_Rds	6	0.5035	0.1690	83.17	***Pop_Den***	6	**0.7253**	24.5864	90.69
Agr_Dist	7	0.5021	0.1685	83.12	***Stlnd_Dist***	7	**0.7250**	24.5774	90.68
Slope	8	0.4983	0.1673	83.00	***Prm_Rds***	8	**0.7248**	24.5701	90.67
Sec_Rds	9	0.4979	0.1671	82.98	***Hyd_Dist***	9	**0.7241**	24.5482	90.65
Ski_Dist	10	0.4970	0.1668	82.95	***Aspect***	10	**0.7241**	24.5469	90.65
OwnOccHs	11	0.4939	0.1658	82.85	***Wat_Dist***	11	**0.7241**	24.5463	90.65
Prm_Rds	12	0.4901	0.1645	82.72	***Basins***	12	**0.7236**	24.5313	90.63
Wat_Dist	13	0.4885	0.1639	82.66	***Rte_28***	13	**0.7235**	24.5264	90.63
Rte_28	14	0.4854	0.1629	82.56	***Pop>65***	14	**0.7235**	24.5258	90.63
NYC_Dist	15	0.4848	0.1627	82.54	***NYC_Dist***	15	**0.7232**	24.5148	90.61
Aspect	16	0.4813	0.1615	82.42	***Ski_Dist***	16	**0.7229**	24.5100	90.61
Hyd_Dist	17	0.4812	0.1615	82.42	***OwnOccHs***	17	**0.7227**	24.5005	90.60
Basins	18	0.4787	0.1606	82.33	***Agr_Dist***	18	**0.7224**	24.4909	90.59
5DRV		0.5633	0.1893	85.27	***5DRV***		0.7319	24.8105	90.91

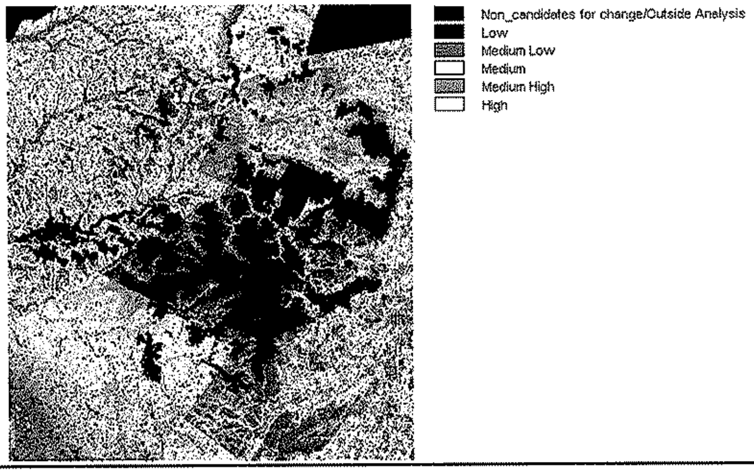


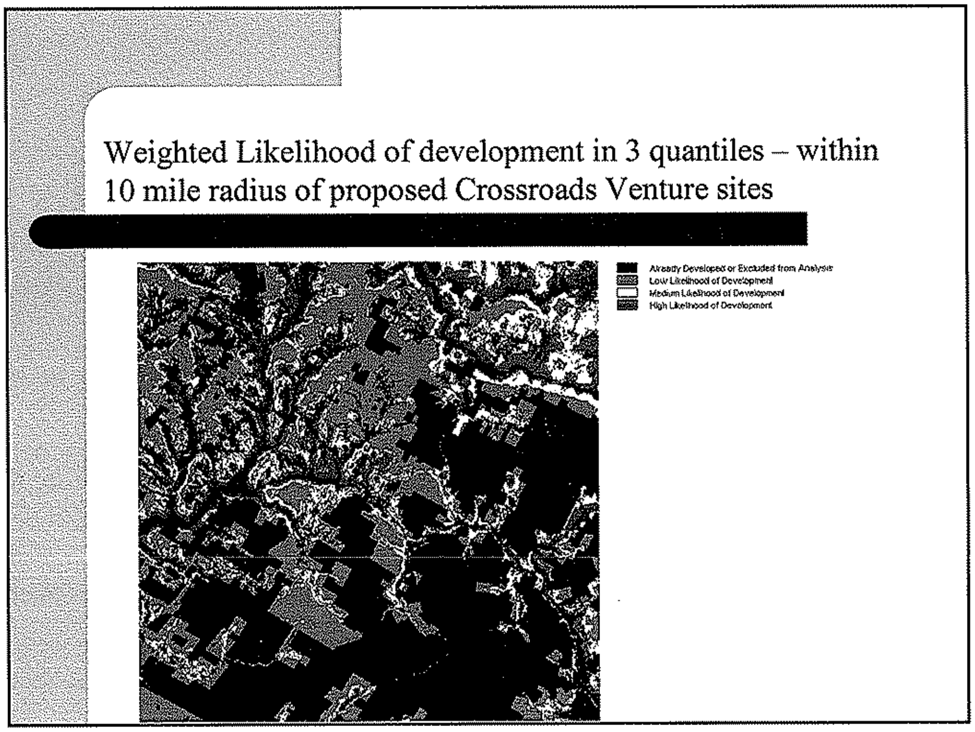
% Correct by Driver, by County
Ability of each driver to achieve "goodness of fit" between actual and simulated 2001 map

1ST
2ND
3RD
4TH
5TH

	TOTAL	DELAWARE	GREENE	SCHOHARIE	SULLIVAN	ULSTER
Urb_Dist	90.80	90.70	90.97	**91.64**	**90.55**	90.80
Elev	90.75	**90.68**	90.79	91.67	90.50	90.78
Slope	**90.72**	90.70	90.77	91.53	90.48	90.72
Loc_Rds	**90.71**	**90.64**	90.78	91.53	90.49	**90.73**
Sec_Rds	**90.69**	90.58	90.85	91.64	90.48	90.68
Pop_Den	90.69	90.61	**90.80**	91.48	90.42	**90.73**
Stlnd_Dist	90.68	90.49	90.72	**91.64**	90.58	90.71
Prm_Rds	90.67	90.50	90.72	91.38	**90.56**	**90.75**
Hyd_Dist	90.65	**90.62**	90.77	91.56	90.37	90.62
Aspect	90.65	90.43	**90.80**	**91.59**	**90.50**	90.69
Wat_Dist	90.65	90.50	**90.83**	91.48	90.43	90.68
Basins	90.63	90.55	90.75	91.37	90.39	90.67
Rte_28	90.63	90.43	90.70	91.54	90.59	90.62
Pop>65	90.65	90.53	90.76	91.45	90.45	90.69
NYC_Dist	90.61	90.61	90.64	91.43	90.35	90.62
Ski_Dist	90.61	90.49	90.65	91.45	90.46	90.62
OwnOccHse	90.60	90.43	90.70	91.46	90.43	90.66
Agr_Dist	90.59	90.40	90.70	91.46	90.40	90.68

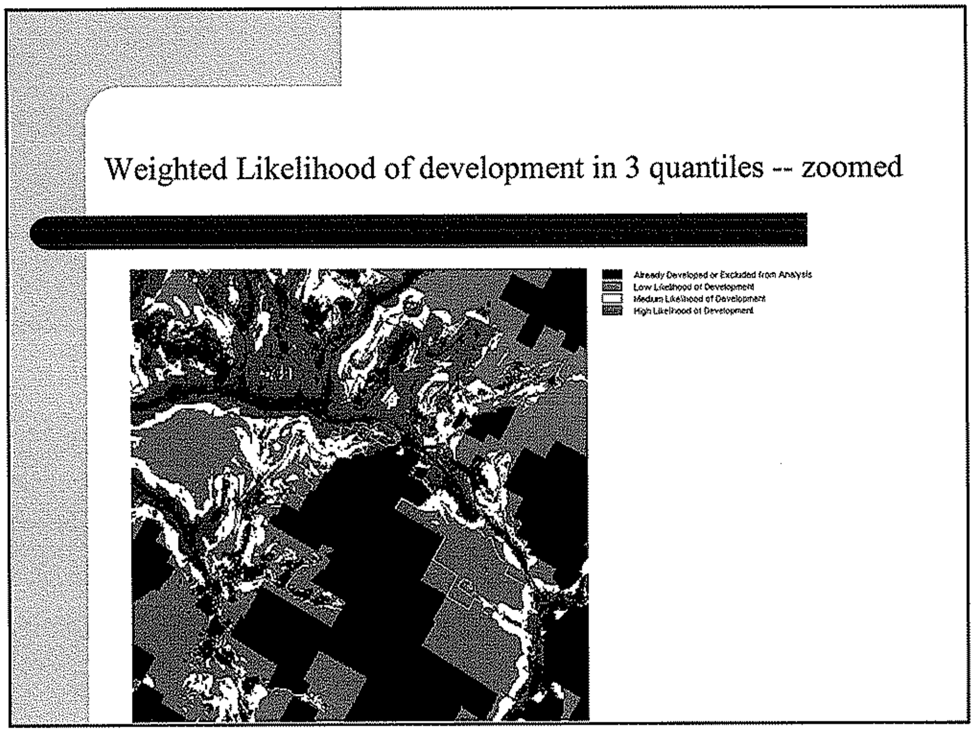
Future Likelihood for Development (ranked from low to high) by county, based on statistically-derived 'best' driver combination





Weighted Likelihood of development in 3 quantiles – within 10 mile radius of proposed Crossroads Venture sites

■ Already Developed or Excluded from Analysis
▨ Low Likelihood of Development
☐ Medium Likelihood of Development
▩ High Likelihood of Development

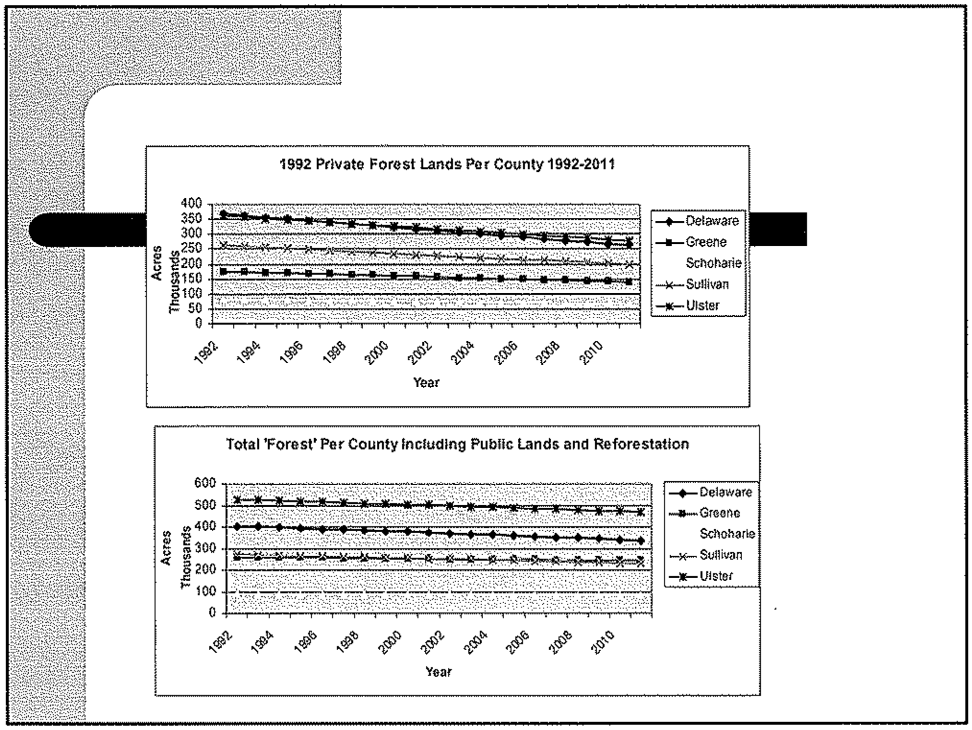


Weighted Likelihood of development in 3 quantiles -- zoomed

■ Already Developed or Excluded from Analysis
▨ Low Likelihood of Development
☐ Medium Likelihood of Development
▩ High Likelihood of Development

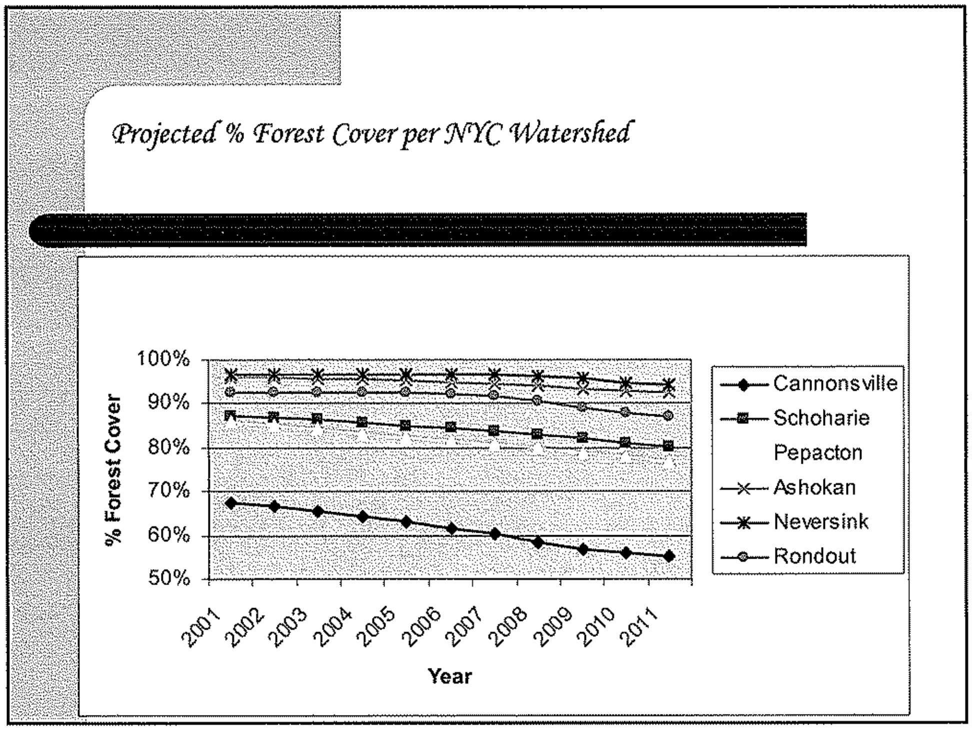
Forest Fragmentation Projections 2001 – 2011 by county

Acres Forest	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Delaware	316581	311043	305504	299966	294428	288889	283351	277813	272275	266736	261198
Greene	157731	155837	153943	152048	150154	148260	146365	144471	142577	140683	138788
Schoharie	75071	74182	73293	72404	71515	70626	69737	68849	67960	67071	66182
Sullivan	231194	227767	224339	220912	217485	214057	210630	207203	203775	200348	196920
Ulster	320581	316143	311704	307266	302828	298389	293951	289512	285074	280636	276197
Total Acres	1101158	1084971	1068784	1052596	1036409	1020222	1004035	987848	971660	955473	939286
Net (adjusted for reforestation)	1078187	1059448	1040708	1021968	1003229	984489	965750	947010	928270	909531	890791
% Forested											
Delaware	73%	72%	71%	70%	68%	67%	66%	64%	63%	62%	61%
Greene	81%	80%	79%	79%	78%	77%	76%	75%	74%	73%	72%
Schoharie	80%	79%	78%	77%	76%	75%	74%	73%	72%	71%	70%
Sullivan	77%	76%	75%	74%	72%	71%	70%	69%	68%	67%	66%
Ulster	78%	77%	76%	75%	74%	73%	72%	71%	70%	69%	68%
Total Acres	77%	76%	75%	74%	73%	71%	70%	69%	68%	67%	66%

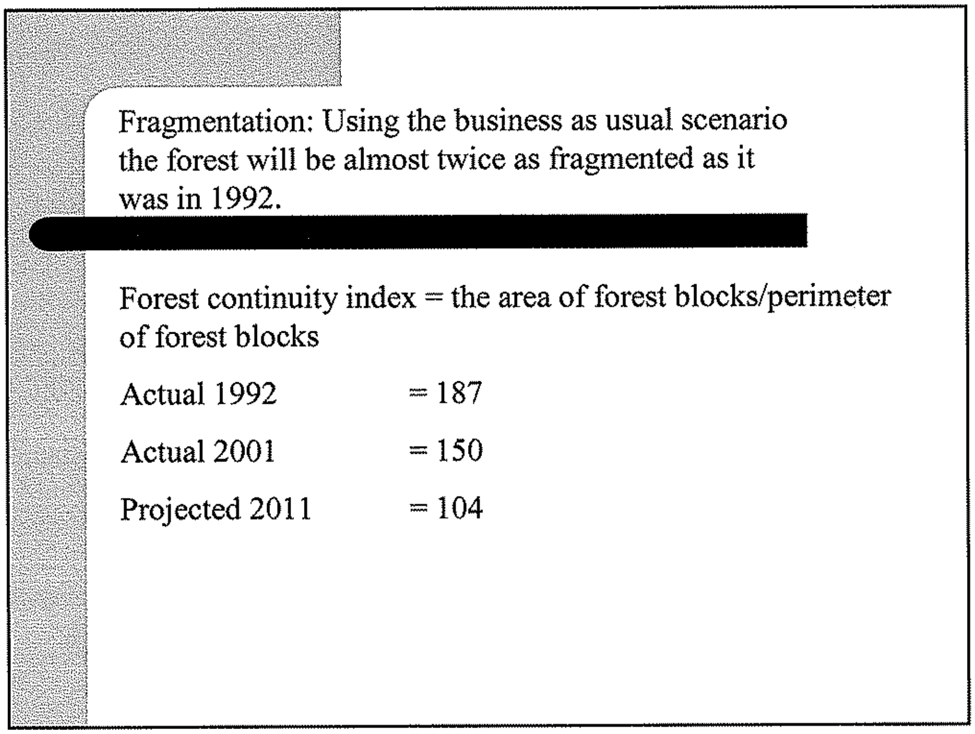


1992 Private Forest Lands Per County 1992-2011

Total 'Forest' Per County Including Public Lands and Reforestation



Projected % Forest Cover per NYC Watershed



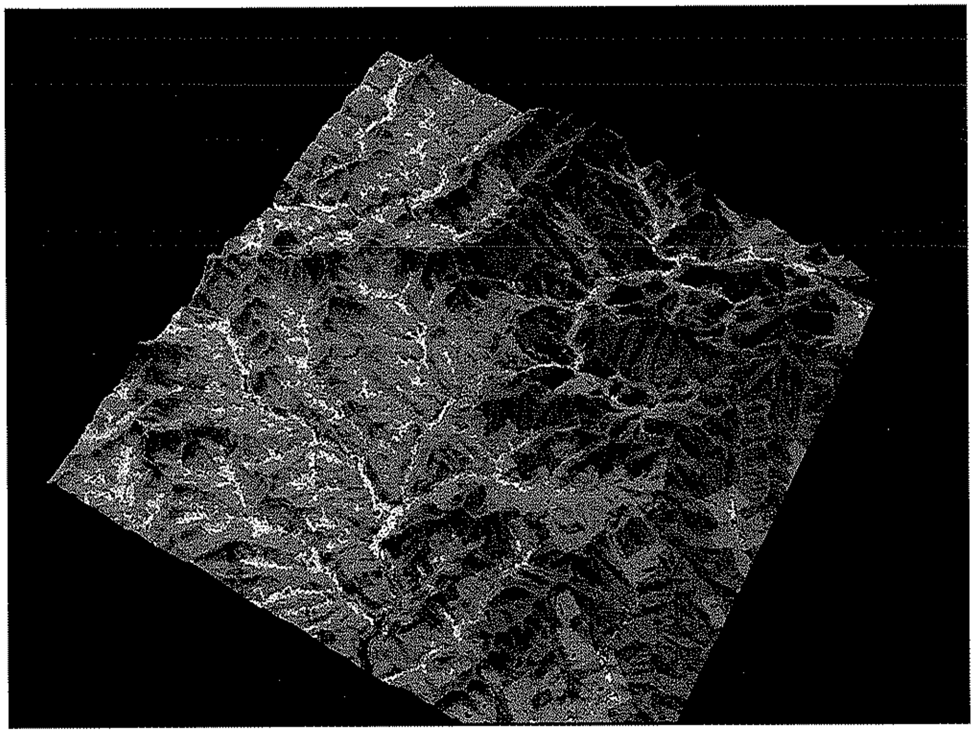
Fragmentation: Using the business as usual scenario the forest will be almost twice as fragmented as it was in 1992.

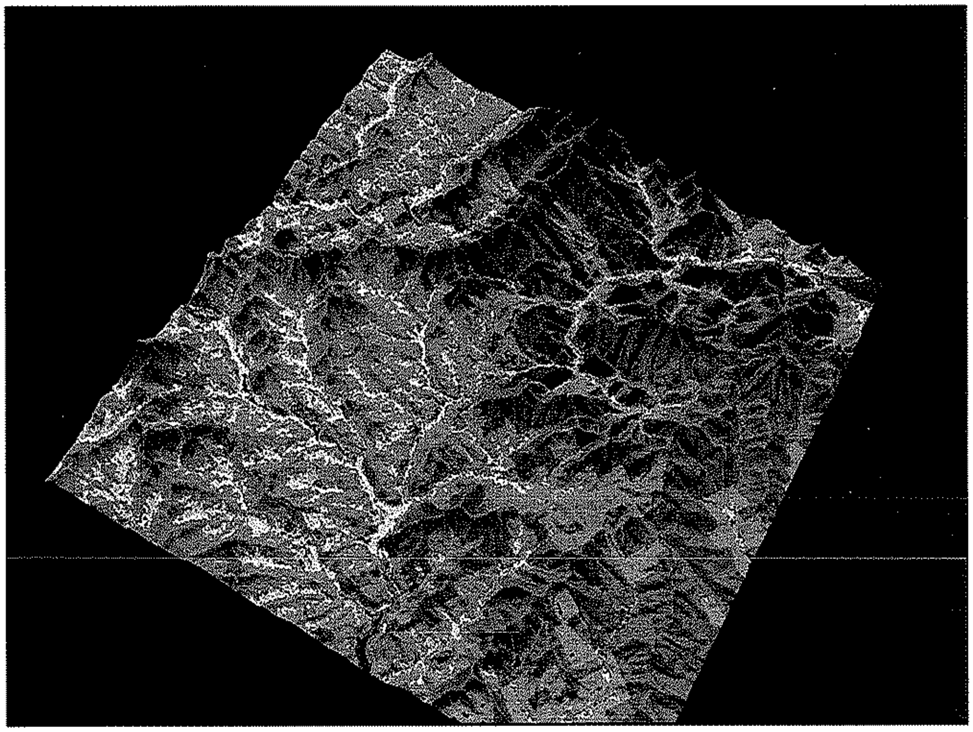
Forest continuity index = the area of forest blocks/perimeter of forest blocks

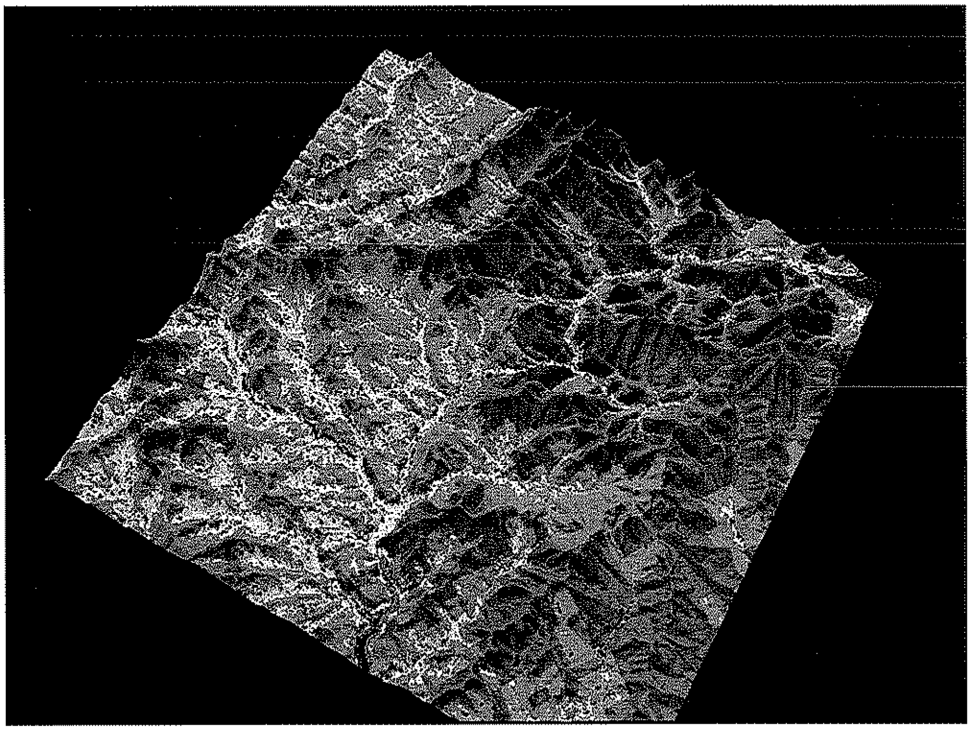
Actual 1992 = 187

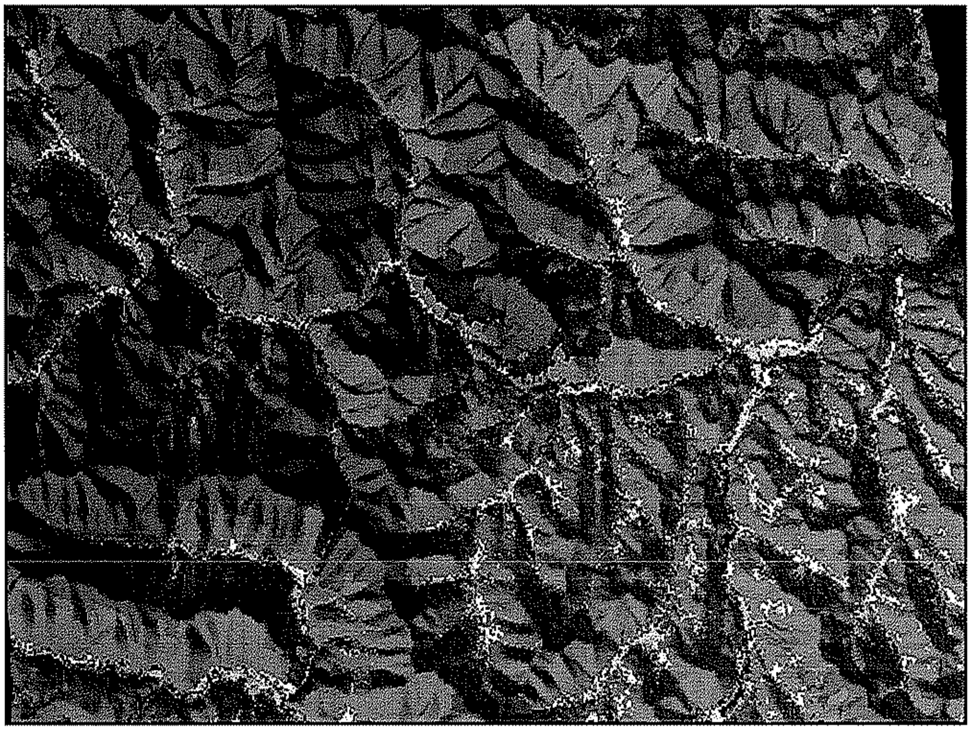
Actual 2001 = 150

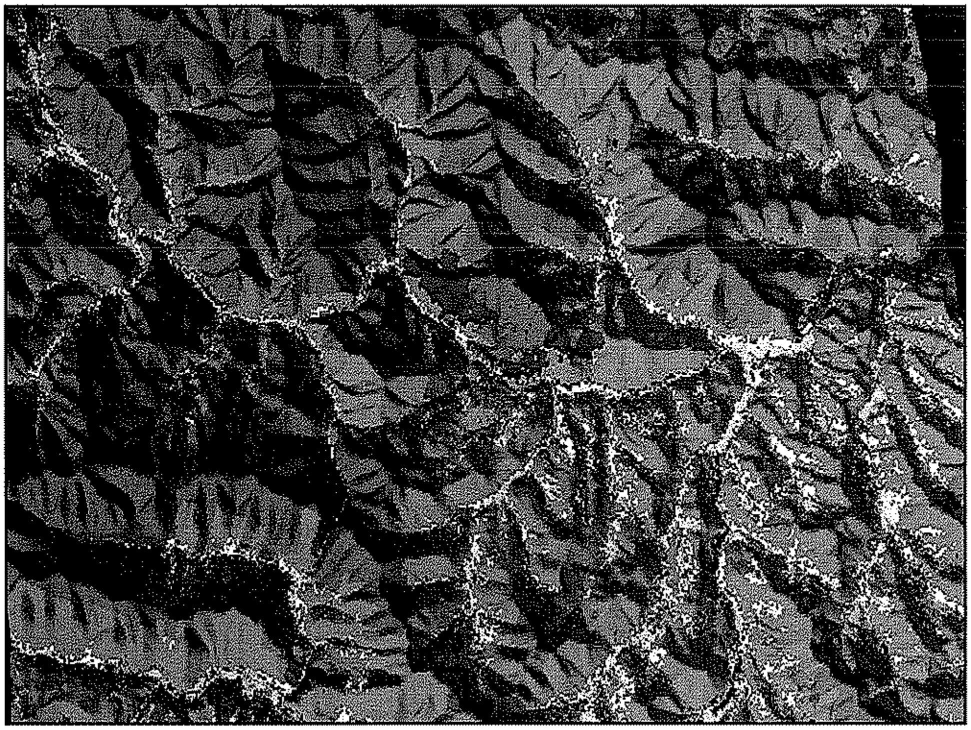
Projected 2011 = 104

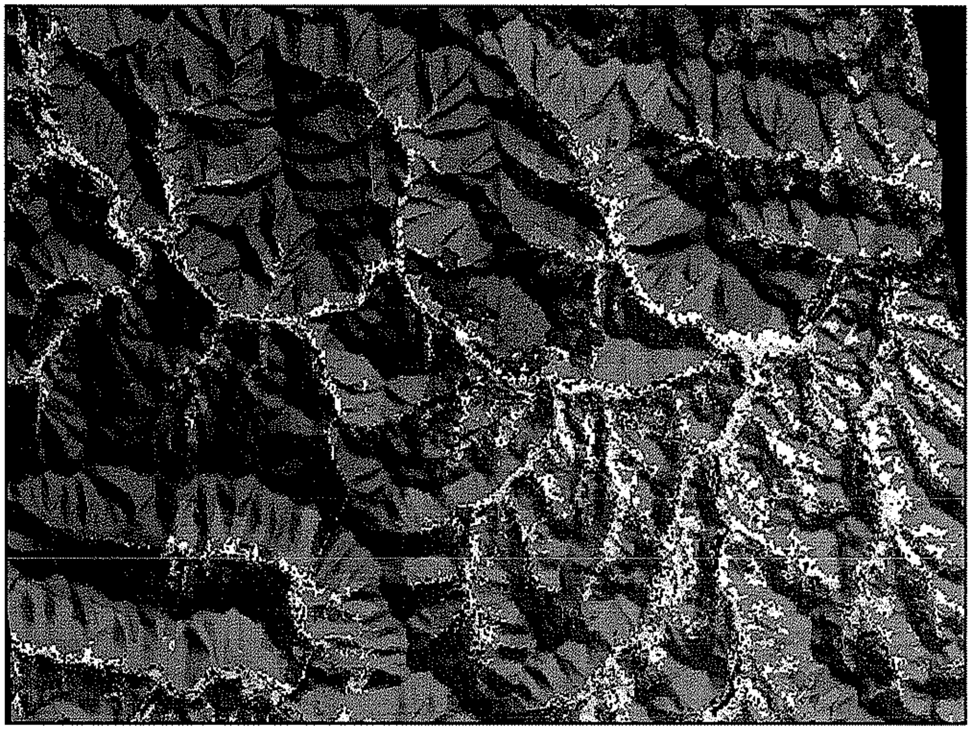


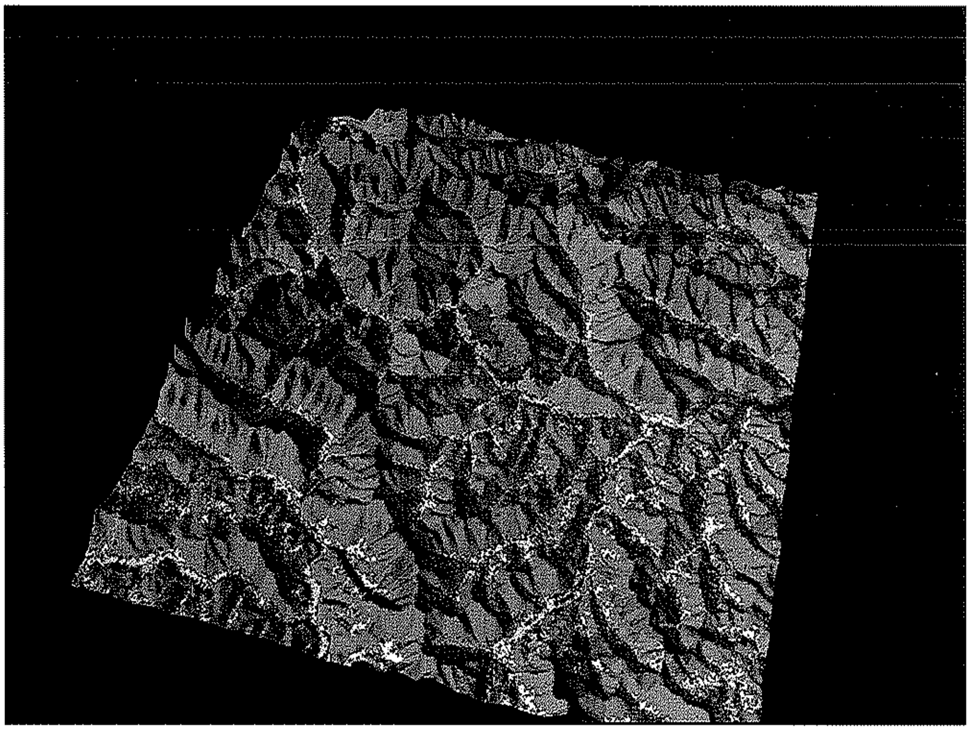


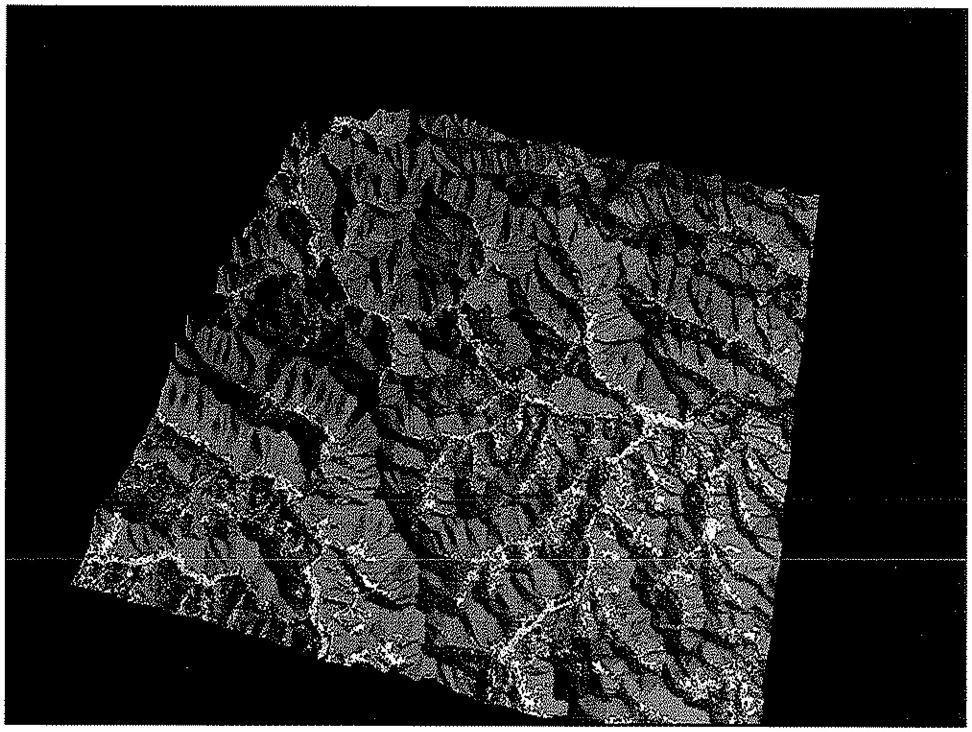


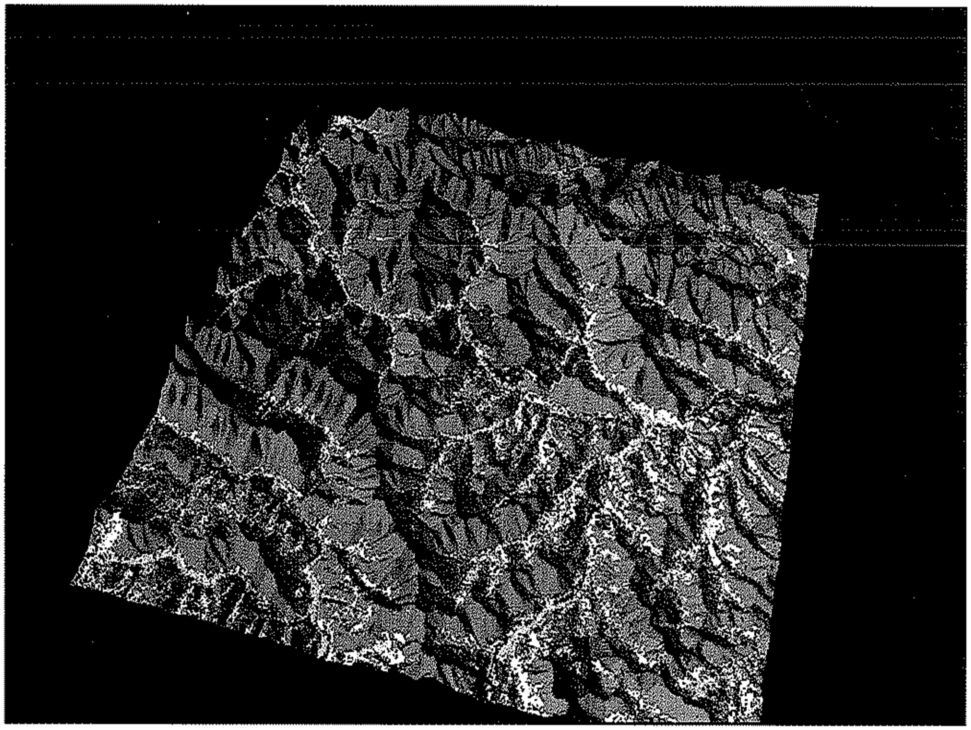


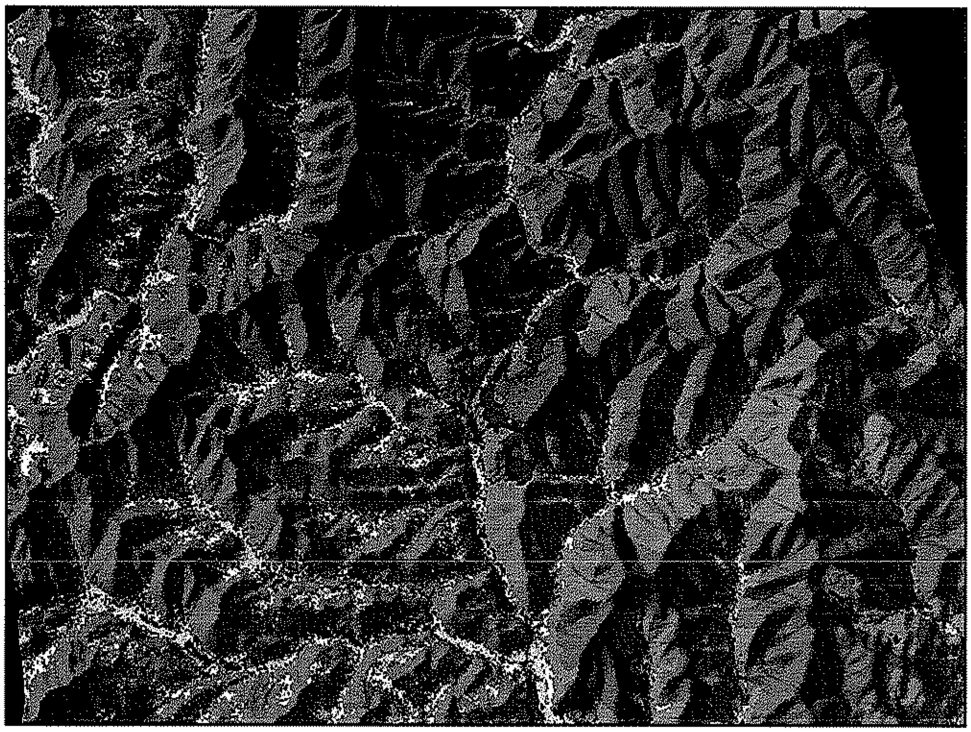


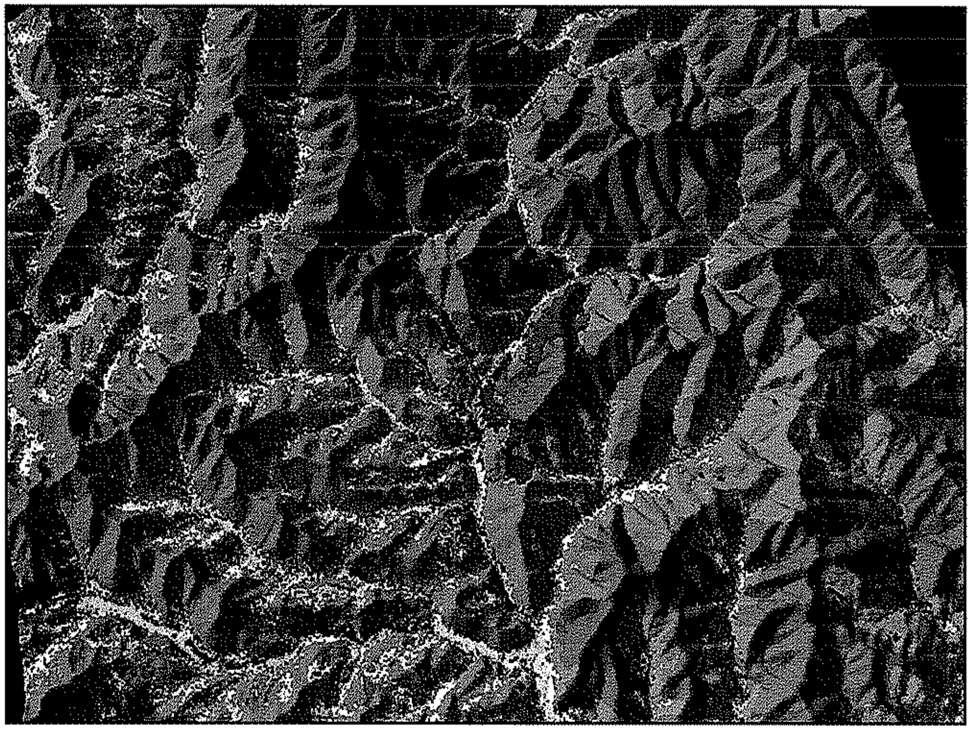


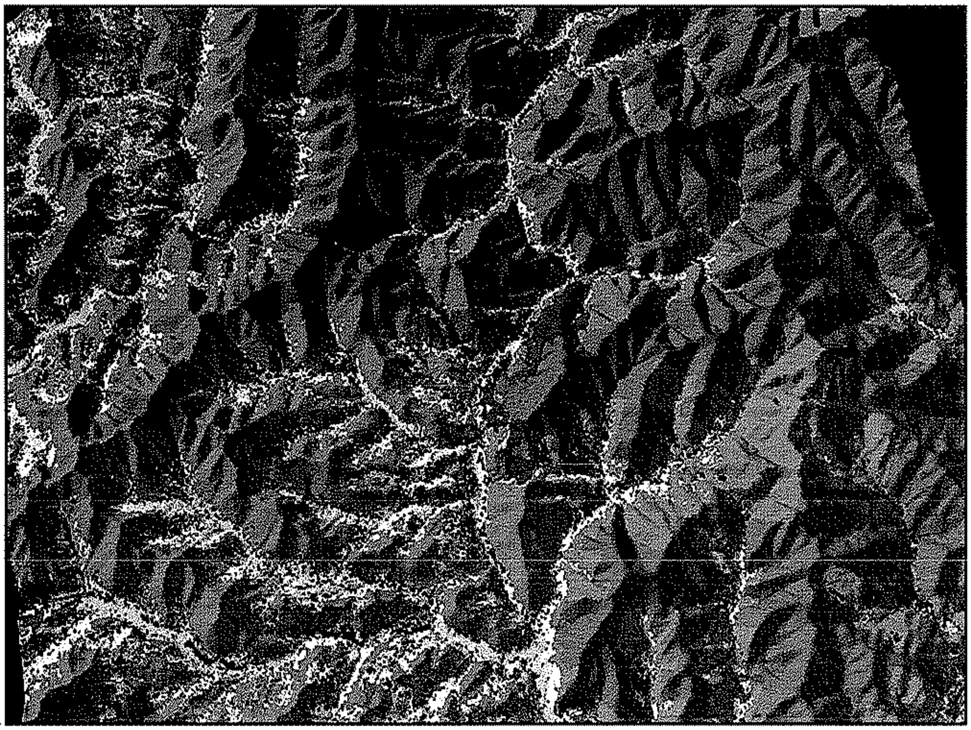












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The effects of population growth on timber management and inventories in Virginia

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bstract

panding human populations may have important effects on the availability of timber from private lands in the South. To
amine the effects of development on timber supply, we compared the density of populations and various site variables with
ert opinions on the future location of commercial timberland for a study site in Virginia. Population density is a significant
dictor of commercial timberland and resulting probability equations provide a method for adjusting timber inventories.
dings indicate that the transition between rural and urban land use occurs where population density is between 20 and 70
ple per square mile. Population effects reduce commercial inventories between 30 and 49% in the study area. © 1999
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Introduction

An expanding human population may have impor-
t implications for forest resources in the United
tes. As domestic and global populations grow, so
ws demands for resource products and natural
ings. Increasing production, in turn, may adversely
ct the environmental and aesthetic quality of for-
. At the same time, the expansion of residential and
in areas will likely reduce the amount of resources
lable for the production of goods and services
rcin, 1993; Harris and DeForest, 1993). Over time, these concurrent impacts on both timber demand and timber supply could result in increasing market scarcity and continued upward pressure on timber prices. Additionally, expanding 'urban–rural interfaces,' as they are sometimes called, may hold implications for other resource values (Shands, 1991). For example, wildlife habitat may become more fragmented and otherwise less effective as an area becomes more populated. Managing forest fuel loads may also become increasingly problematic and forest fires are likely to be more difficult to fight and more costly as population density increases.

This study examines the potential effects of population growth on timber supply. In particular, we examine how expanding populations in a part of western

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047.

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site to map their opinion of where commercial forestry would and where it would not likely be practiced in the future. They further identified those areas that would not be managed due to some special site feature (not necessarily related to population and land use pressures) such as critical species habitats, proximity to water, or buffers. These maps were drawn at a 1 : 24 000 scale and were digitized and entered as a GIS map layer.

We then tested the relationship between this expert lassification of potential commercial timberland PCT) and several factors describing the accessibility nd operability of the site and the population density f the area. That is, we posited that the probability of and (L) being labeled as PCT is given as:

$$\Pr(L = \mathrm{PCT}) = f(X_i) = 1 - F(g[X_i]) \qquad (1)$$

here F is a cumulative distribution function which epends on a function (g) of a vector of explanatory ariables (X). We assumed that F had a logistic form hich is a close approximation to the normal distribuon. The resulting 'Logit' model has the following rm:

$$\Pr(L = \mathrm{PCT}|X) = 1 - F(g[X]) = \frac{e^{-g(X)}}{1 + e^{-g(X)}} \qquad (2)$$

he vector X includes the following variables: the opulation density of the area (POP, people per square ile), site index (SI, height at age 50), slope SLOPE%), and two dummy variables that define ease access to the site (AC-EASY and AC-HARD). AC-ASY is equal to 1 where survey crews indicated that, hile roads did not exist, they could be easily built; qual to zero otherwise. AC-HARD is equal to 1 if ads were deemed difficult or very difficult to build. e null case is defined where roads to the site already ist. Taken together, these variables describe the mparative advantage of each site for various land es. To estimate the model, we define the functional m of g as follows:

$$X) = a + b_1 \underset{(-)}{\mathrm{POP}} + b_2 \underset{(-)}{\mathrm{SI}} + b_3 \underset{(-)}{\mathrm{SLOPE}} + b_4 \underset{(-)}{\mathrm{AC}}\text{-EASY} + b_5 \underset{(-)}{\mathrm{AC}}\text{-HARD} \qquad (3)$$

ere the signs in parentheses indicate our expectans regarding the effect of the referenced variable on probability of forest cover. We expect that increasing population density increases demand for nonforest land uses, that ease of operability (i.e., low slopes) also reduces the likelihood of forest cover, and that less accessible sites are more likely to be forested. We expect the effect of site index to be negative given that higher quality land may have comparative advantage for use in agriculture.

Previous studies have used similar models to examine the harvest choices of individual landowners. The earliest application (Binkley, 1981) addresses the effects of income, price; education, and costs on the decision to harvest timber. Subsequent studies (e.g., Dennis, 1990; Kuuluvainen and Salo, 1991) have used discrete choice methods to simultaneously address the decision to harvest and the quantity of the harvest. The present study is perhaps most closely related to Wear and Flamm's (1993) cross-sectional model of harvest choice in a single watershed. Their analysis uses site features (assuming constant delivered prices) to proxy for the costs of harvesting. The present study is distinct by virtue of its independent variable. The use of an expected land-use is an attempt to address long-run resource allocation.

To test this relationship, we examined the land use classification for US Forest Service permanent inventory plots located in the study area. Using these plots gave us access to several other descriptive variables and allowed us to subsequently estimate the implications of population density on standard measures of timberland area and timber inventories. We overlaid the plot locations through the GIS to assign a population density to each plot. We then screened the plots to define the subset of forest plots in private ownership without the aforementioned special features defined by local experts. We then defined L as a binary variable where those plots that were classified as PCT were assigned L=1; otherwise they were assigned L=0.

Plot observations were then used to estimate the Logit model defined by Eq. (2) using standard maximum likelihood estimation applied to individual survey plots.[1] To test for the effect of the independent

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[1] This involves constructing the likelihood function based on the probabilities defined by Eqs. (2) and (3) and solving for coefficients that yield the highest likelihood that the model generated the data. We used the statistical package LIMDEP (Greene, 1992). Techniques are described in detail in Maddala (1983).

ıble 1
›efficient estimates of the logit model defined by Eqs. (2) and). using data from Albemarle. Greene. and Nelson counties. An terisk indicates significance at the 5% level. The log likelihood tio (LLR) for testing the overall significance of the model is also ported

›efficient	Estimate	SE
tercept	0.0617	1.5803
›p	−0.0424	0.0133 *
›pe	0.0161	0.0158
te	0.2076	0.2085
:-EASY	−1.0528	0.6765
:-HARD	2.0237	2.0623
_R	30.96 *	
=94		

hroughout this paper significance was tested at =0.05). However. all other variables (slope. site dex. and access categories) have insignificant coef- :ients. We also tested the significance of population nsity by estimating the logit model without the riable and constructing the log likelihood ratio itistic for the constrained model (chi-squared dis- bution with one degree of freedom). The calculated itistic (23.362) is greater than the critical value 841), so we again reject that the variable has no 'ect.

As all other variables are insignificant. we estimated :ondensed model with only population density as an planatory variable to apply the probability model to :a and volume expansion factors using Eq. (4). For s model. the intercept was 1.9065. the population nsity coefficient was −0.0421. and both coefficients :re significant. We tested the overall significance of th the original model and the condensed model ing a log likelihood ratio test (chi-squared distribu- n. with degrees of freedom equal to the number of planatory variables). For both models we reject no planatory power (see Table 1).

To further examine the effects of population density timber production. we plotted the probability of ·est being commercial timberland as a function of pulation density. Fig. 2 shows the expected inverse ationship between population density and PCT. At a pulation density of 0. the probability of PCT is 0.82. :e probability declines as population density :reases and approaches zero as density reaches 150 people per square mile (psm). The odds of being commercial forest land are roughly 50 : 50 at a population density of 45 people psm and the probability of commercial forestry is >0.75 at ca. 20 people psm.

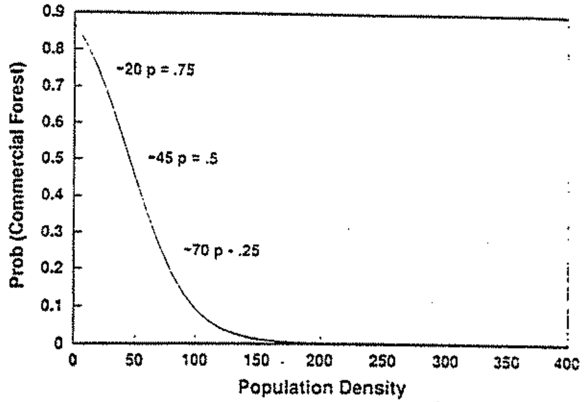

Fig. 2. The predicted probability that forest is commercial timberland as a function of population density.

The next step in the analysis was to estimate the predicted probability of commercial forestry for all survey plots in the Planning District as a whole. Fig. 3 shows the distribution of plots by probability values. Thirty percent of the plots have probability values of 0.8 or greater and 57% have probability values of 0.7 or greater. However. 25% of the plots have probability values that are <0.5. indicating a <50 : 50 chance of commercial forestry.

Area and volume expansion factors for all plots were then used to calculate the expected commercial

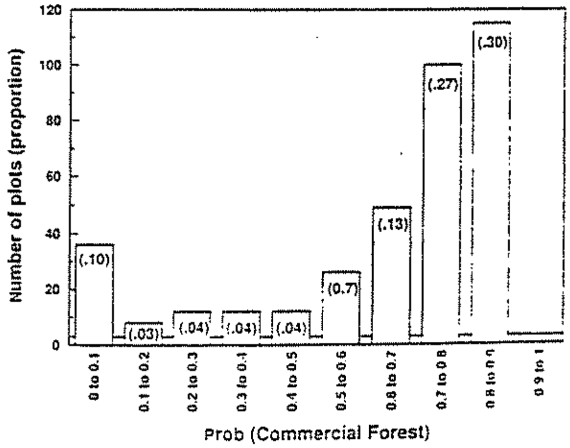

Fig. 3. Number (proportion) of inventory plots by the predicted probability that forest is commercial timberland.

able 3

rowing stock volumes in the study area for the 1991 survey. Subsequent columns show the effects of (1) removing lands in public ownership,) removing lands classified as urban, and (3) reducing availability related to increasing population density

) Pine volume

	1992 Survey	Minus public	Minus urban	Minus pop. effect
	Thousand cubic feet			
otal	300 149	289 577	257 904	154 439
lbemarle	76 035	76 035	67 394	42 217
uvanna	64 580	64 580	44 468	22 716
reene	28 301	28 301	28 301	19 395
ouisa	96 042	96 042	93 122	51 902
elson	35 191	24 619	24 619	18 209

) Other softwood volume

tal	42 038	41 570	40 748	25 994
bemarle	16 416	16 416	15 955	7 372
uvanna	467	467	467	260
eene	1 806	1 806	1 806	1 365
uisa	4 928	4 928	4 567	3 016
lson	18 421	17 953	17 953	13 981

Soft hardwood volume

tal	431 076	411 474	396 438	259 772
bemarle	119 620	119 620	119 620	81 411
vanna	40 866	40 866	28 456	20 287
eene	41 097	41 097	41 097	17 836
uisa	80 684	80 684	78 058	44 484
lson	148 809	129 207	129 207	95 755

Hard hardwood volume

al	864 177	830 395	773 794	511 489
emarle	282 528	281 634	276 830	190 825
vanna	87 864	85 143	67 772	39 780
ene	57 151	57 151	57 151	23 968
isa	189 445	189 445	155 019	94 039
son	247 189	217 022	217 022	162 877

Future population growth

Populations will likely continue to expand in the omas Jefferson Planning District. To examine the ential effects on forests we estimated the net effect t various levels of population growth might have on nmercial forest area using the methods developed e. We increased the population density for indivi- l plots and recalculated the probability of com- rcial timberland using Eq. (2). These values were n used to screen the survey data using Eq. (4).

Population growth is a spatially defined process h growth concentrated at the periphery of high density areas. We did not attempt to develop and apply a sophisticated model of urban and suburban expansion for this exercise; rather, we examined a simple model that expanded populations by an equal proportion across the entire study area. These projections therefore do not represent forecasts, but they do allow for a qualitative examination of the consequences of population growth.

Results of the population simulations are charted in Fig. 5, with timberland plotted against population (both are charted in terms of percentage change from their present values). The results show an approximately linear relationship between population growth ple, differ in areas with different topography, landownership pattern, or relative resource values?

The study also illustrates the value of linking biophysical forest inventories with social data. This linkage could be improved by recording census block identifiers for each plot in a forest survey. This would both improve the precision of subsequent analyses and allow for direct screening of inventories without linkage to a GIS. More extensive study in this area could lead to significant improvements in our understanding of timber supply from private lands and the general expression of social phenomena on forested landscapes.

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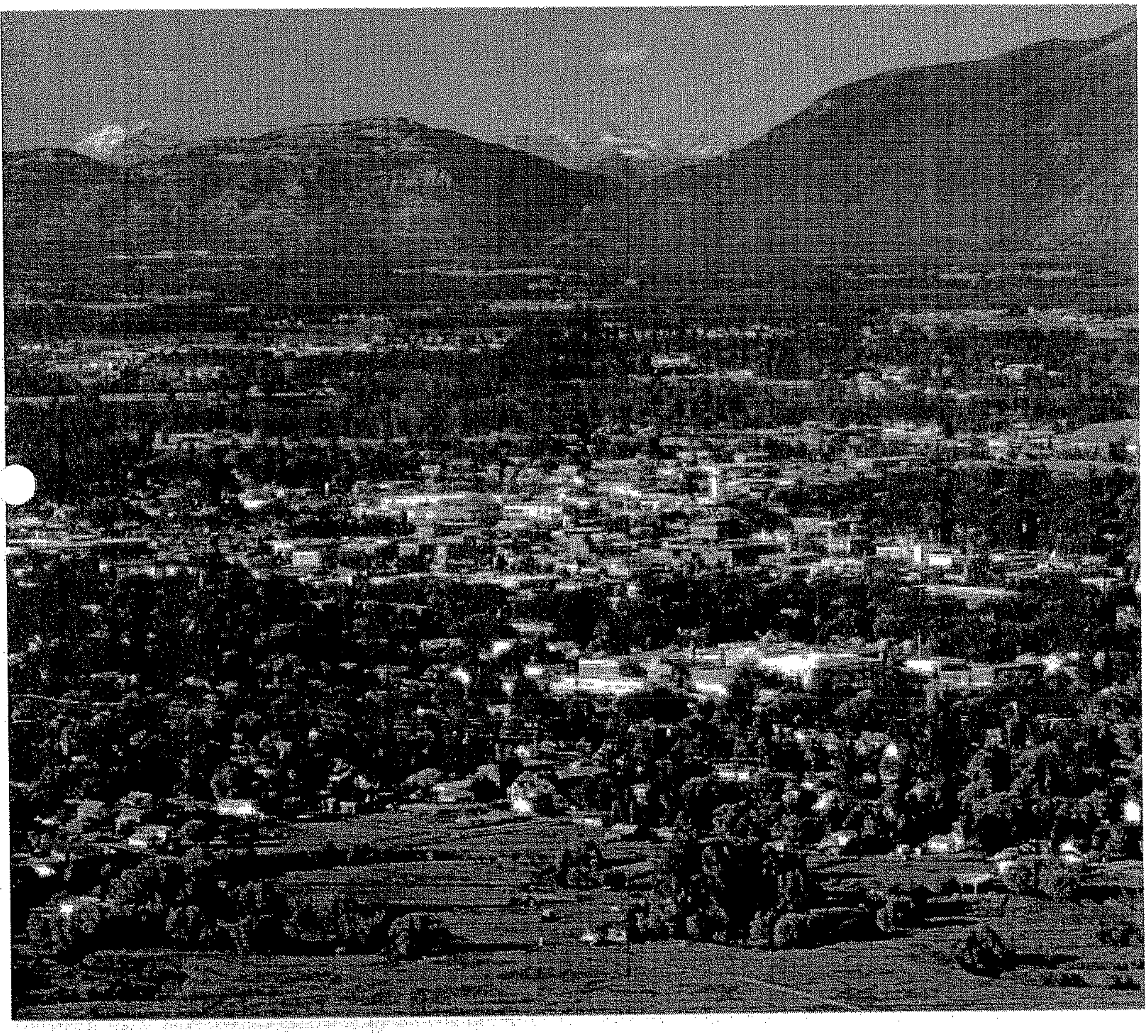
Gateway to Glacier

The Emerging Economy of Flathead County



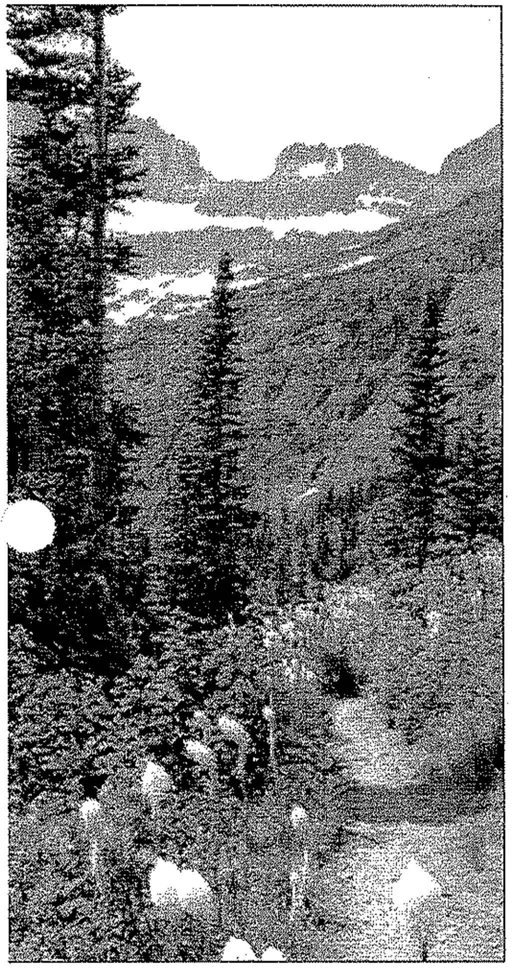
Healthy Parks,
Healthy Communities

NATIONAL PARKS CONSERVATION ASSOCIATION
Protecting Parks for Future Generations®

MAY 2003

ABOUT THIS REPORT

Gateway to Glacier: The Emerging Economy of Flathead County is a synthesis of three technical studies on Flathead County's economy conducted by researchers at The University of Montana. Unless otherwise cited, the data and other information supporting this report's findings are found in those three studies. The detailed technical studies are available to interested individuals on the Internet at *www.npca.org/healthycommunities.* Or you may order copies of the three studies for the cost of reproduction by contacting the Northern Rockies office of the NPCA, P.O. Box 824, Helena, MT 59624, or call (406) 495-1560.
E-mail: northernrockies@npca.org.



Grinnell Trail

PHOTO: LARRY STOLTE

The three studies synthesized in this report are:

- *The Flathead's Changing Economy: Assessing the Role of National Parks in the Economies of High Amenity, Non-metropolitan Regions of the West*
  LARRY D. SWANSON, Ph.D., Associate Director and head of the Regional Economy Program, O'Connor Center for the Rocky Mountain West, The University of Montana, Missoula. (2002)

  Swanson undertook an extensive economic analysis of Flathead County to 1) identify and assess key trends and patterns of change, 2) evaluate the influence of Glacier National Park on the area economy, and 3) evaluate economic trends in other national park gateway communities around the western United States. This analysis is based on an evaluation of Flathead's economic characteristics and performance relative to "peer" counties throughout the West with similar economic and demographic profiles.

- *What the People Think - Glacier National Park and Vicinity*
  NORMA NICKERSON, Ph.D., Director, Institute for Tourism and Recreation Research, The University of Montana, Missoula. (2002)

  Nickerson surveyed opinion research focusing on Flathead Valley residents, and visitors to Glacier Park and the Flathead. Her report details specific characteristics that draw residents and visitors to the area, perceptions of change in the valley's natural environment, and concerns about the future.

- *Business Perspectives on the Flathead Economy, Conservation and Glacier National Park*
  JASON LATHROP, Graduate student, The University of Montana, Missoula. (2002)

  Lathrop interviewed 80 Flathead Valley business owners and managers from a broad spectrum of business sectors. His report explores business leaders' attitudes about the Flathead's changing economy, local communities, business environment, community leadership, Glacier National Park, and conservation.

Gateway to Glacier

The Emerging Economy of Flathead County

Healthy Parks,
Healthy Communities

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Protecting Parks
for Future Generations®

The National Parks Conservation Association, established in 1919, is America's only private, nonprofit advocacy organization dedicated solely to protecting, preserving, and enhancing the U.S. National Park System for present and future generations by identifying problems and generating support to resolve them.

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Family fun on Glacier's Going-to-the-Sun Road

PHOTO: KAREN NICHOLS

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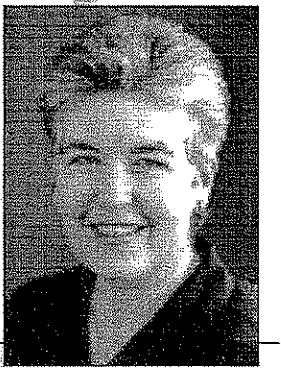
FOREWORD

Kalispell Area Chamber of Commerce

A few years ago as a representative of the business community, I had a chance to share the same table with the National Parks Conservation Association (NPCA) on the Going-to-the-Sun Road Citizens Advisory Committee. At that table we blended diverse interests and developed a mutually acceptable solution for a difficult problem. The outcome was beneficial to the community and satisfying to participants.



Now it is time for community, conservation, and business interests to come to the table again to constructively contribute to the future of our beloved Flathead Valley. *Gateway to Glacier* provides an excellent place to start our discussions. This report makes the argument that we can maintain our small-town community character, grow a healthy economy, and conserve the natural treasures of our region. I believe these are goals we all share.

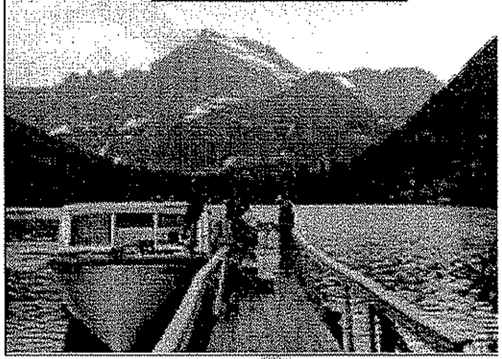


PHOTO: COURTESY GLACIER PARK BOAT COMPANY

Let's not squander our resources. Our environment, our economy, and our community are treasures we can't afford to waste. Our time, our effort, and our good will are powerful resources we must use wisely. Cooperation is essential if we are to conserve the assets we treasure while accommodating the growth that these assets inevitably bring.

Gateway to Glacier points to the opportunity that comes with change. Those of us who live in the Flathead Valley have the chance to work cooperatively to harness change, to preserve both traditional values and achieve economic rewards. It will require mutual respect, a spirit of cooperation, hard work, and leadership.

I look forward to working with all of you.

Susan D. Burch

Susan D. Burch
CHAIRMAN, KALISPELL CHAMBER OF COMMERCE
OWNER, GLACIER PARK BOAT COMPANY

15 Depot Park • Kalispell, MT 59901
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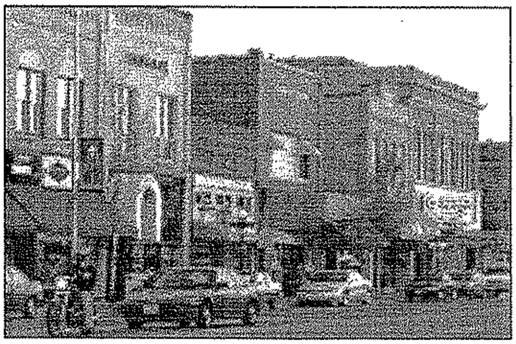
EXECUTIVE SUMMARY

While much of rural America struggles with economic decline, the economy in Montana's Flathead Valley is growing, vibrant, and diversifying. The reason is simple: Its superb quality of life pays off in tangible economic benefits. Glacier National Park and other scenic public lands, clean air and water, and a friendly, small-town character are cornerstones of this quality of life.



Main Street, Kalispell

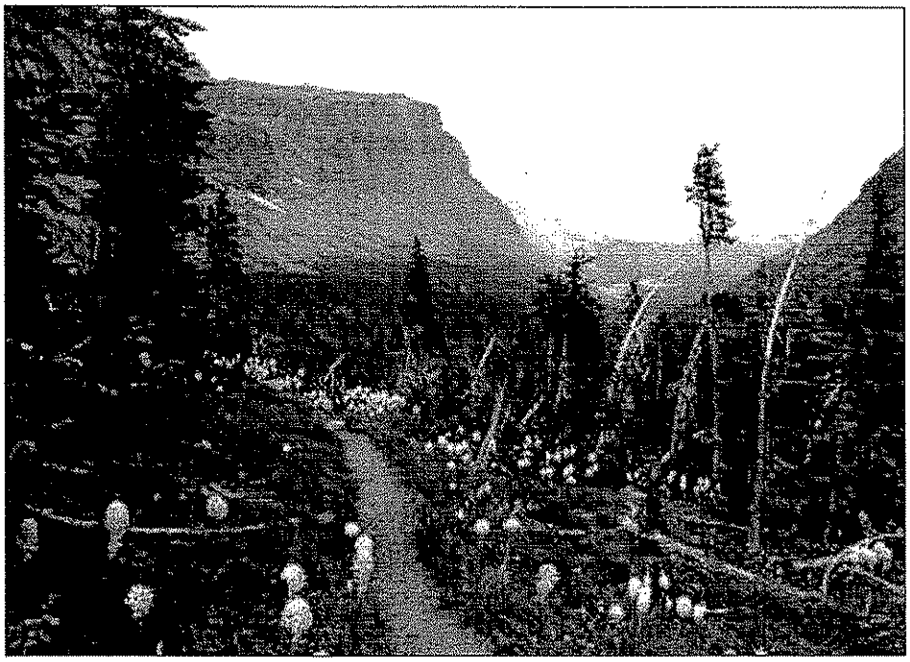
PHOTO:KAREN NICHOLS

In 2002, the National Parks Conservation Association (NPCA)—through its Northern Rockies regional offices located in Whitefish and Helena—commissioned three separate studies to explore the roots of economic vitality in Flathead County, the primary "gateway" to Glacier National Park.

Gateway to Glacier: The Emerging Economy of Flathead County synthesizes the findings of these three studies to document how the Flathead's economic vitality is directly tied to Glacier Park and the region's natural environment and small-town character. It argues that many of the valley's most attractive qualities are at risk. And it points the way toward a collaborative approach to protect these valuable assets for the future.

Some say that the Flathead has been discovered, and this is probably the plainest way to explain the changes of the past decade. The attraction of Flathead County, its communities, and the surrounding landscape is obvious to long-time residents, newcomers, and first-time visitors alike.

Many valley residents fear that this "discovery" has brought rapid change that will erode what they value most about their home. Yet in this transition are opportunities to protect the qualities and characteristics that make this a uniquely wonderful place to live—and that are at the heart of the valley's economic vitality.



Gateway to Glacier explores the challenges and the opportunities within the county's economic transition. Its key findings about the Flathead's emerging economy are briefly described in this executive summary and explored greater in the six chapters that follow.

Two Medicine Pass trail

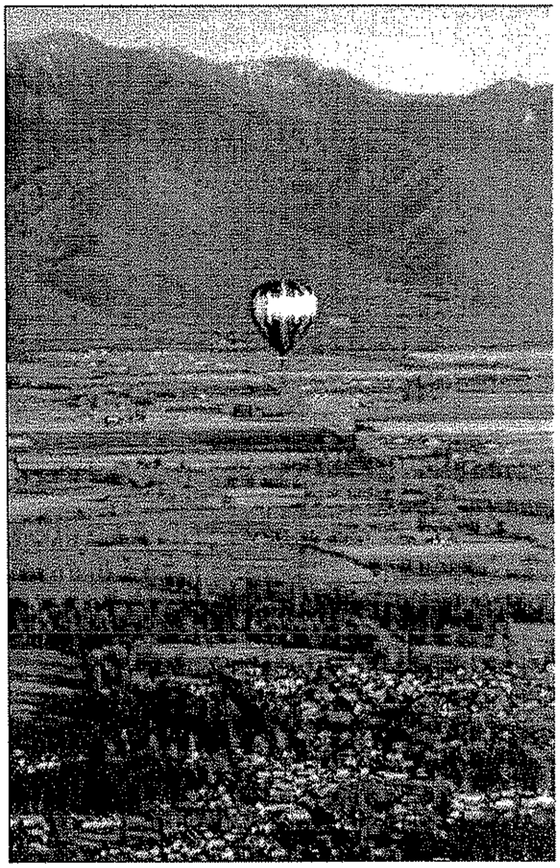
PHOTO: LARRY STOLTE

1. The Flathead County economy is vibrant, diverse, and growing.

By virtually any economic indicator, Flathead County is booming.

- In the last decade, 15,700 new jobs were created, an increase of nearly 50 percent. Dramatic increases occurred in relatively high-quality employment areas such as health care, business services, construction, and new areas of manufacturing.
- Population grew 26 percent between 1990 and 2000, led by an influx of new residents.
- Nearly 1,000 new businesses were established in the last decade, a 44 percent increase in local employers that marks a boom in entrepreneurial activity.
- Unemployment rates are the lowest in three decades.
- Per capita income rose by 13 percent in the last decade (up from nine percent in the '80s). Poverty has declined. And median income sharply increased, erasing losses in the previous decade.

The Flathead's economic vitality is largely fueled by an influx of new residents. But the numbers also tell a story of an economy in transition, more diverse and more stable than before, providing higher-paying jobs. Within this transition is the opportunity to direct economic development to sustain a vibrant economy, whether or not the population boom continues.



Soaring high over the Flathead Valley

PHOTO: KAREN NICHOLS

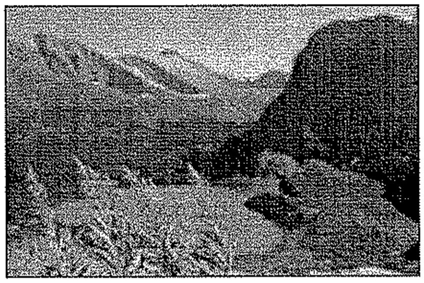
2. The quality of the Flathead Valley's spectacular natural environment is its chief economic asset.

Surveys and interviews with Flathead County residents, visitors, and business leaders confirm that the valley's chief appeal is the place itself: The small-town, friendly atmosphere, access to the outdoors and recreational opportunities, scenic beauty, clean water, wildlife, and the open, natural setting. These qualities are key economic assets because they draw people to visit, to live, and to stay in the area. Most business leaders interviewed believe they could make higher incomes elsewhere but choose to operate in Flathead County largely because of the quality of life.

Nationwide economic and technological trends have made it easier for people to live where they want. The Flathead's booming population is a sign of the area's undeniable attractiveness—and a confirmation that the quality of life is the area's chief economic asset. It is what draws people, income, jobs, and businesses here.

Grinnell Lake in the Many Glacier Valley

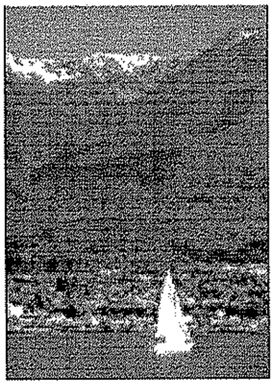
PHOTO: KAREN NICHOLS



3. Glacier National Park is an anchor for Flathead County's robust economy.

In a county blessed with a spectacular natural setting, Glacier National Park is the centerpiece. It is one of Montana's two most popular attractions for visitors, and tops the list of places local residents take out-of-town guests. The icon for nearly 200 business names and logos, Glacier also shows up on signboards for hundreds of millions of dollars of high-profile development, including a proposed mall, a performing arts center, and the redeveloped Big Mountain ski village. Glacier's appeal spans the globe, and it was voted America's best backcountry park by readers of *Backpacker* magazine. Meanwhile, Kalispell was selected in 1999 as America's "best mountain town" by *Mountain Sports & Living Magazine*, which cited its proximity to Glacier Park.

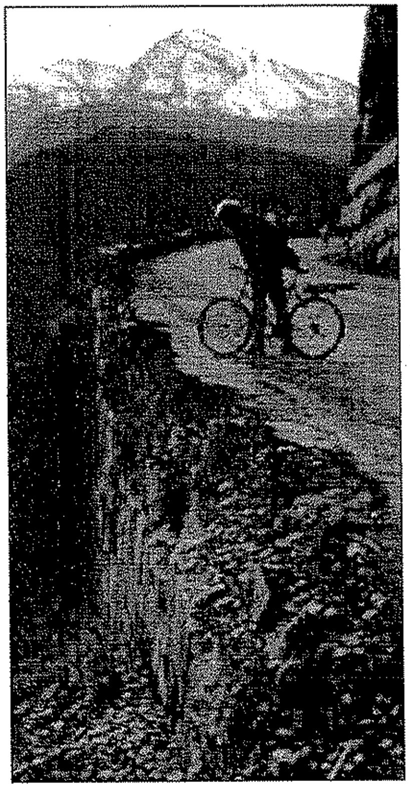
4. Proximity to national parks is an economic advantage for gateway communities such as Flathead County.



National Park gateways like Port Angeles, Washington, enjoy strong economic growth

PHOTO: VALERIE HENSCHEL

An assessment of national park gateway communities around the West shows that Flathead County's booming economy reflects a much larger pattern. Attracted by small, friendly communities and appealing landscapes, many Americans turned their attention from major metropolitan areas and traditional retirement havens during the 1990s. Rapidly growing populations in communities adjacent to national parks throughout the West suggest the special appeal of these places. This appeal has translated into economic vitality for gateway counties such as Flathead, which tend to have richer, more diverse, and more thriving economies than do similar counties that are not gateways. In these counties, tourism is but one piece of a rapidly expanding economic pie. Economic growth has been driven largely by the people who live in these gateway communities and by local businesses



Fixing Going-to-the-Sun Road and increasing funding for park operations will protect a major economic asset

PHOTO: KAREN NICHOLS

5. The Flathead Valley's most valued qualities and primary economic assets are at risk.

Many local residents believe that the valley is losing some of its special qualities, most notably its rural, small-town character, farmland, and open spaces. Returning visitors to Glacier National Park have noted declines in the condition of the natural environment, wildlife viewing opportunities, and the amount of open space. NPCA has listed Glacier as one of America's most endangered parks three times because of severe funding shortfalls, dilapidated infrastructure, and the encroachment of haphazard development on wildlife habitat outside the park.

6. Flathead communities must encourage high-quality economic growth and development.

The Flathead economy is in transition. Today's growth provides the opportunity to retool the economy so it remains strong and diverse, whether or not the population boom continues. Flathead County has enjoyed great success in creating jobs and attracting development and investment. The valley's communities must now create a clear strategy and focused initiatives to improve the well-being of Flathead residents and protect the area's most vital economic assets.

This focus will help Flathead County maintain the quality of life that old-timers, newcomers, and visitors find so appealing. High-quality economic development means maintaining water quality, wildlife habitat, an appealing landscape, and the valley's friendly small-town character. It means retaining working farms and forests, cultivating jobs with pay and benefits that can fully sustain workers and their families, and investing in a well-educated local workforce. Economic growth can be guided to support and protect the values that drive it, rather than leading inexorably to their erosion and loss.

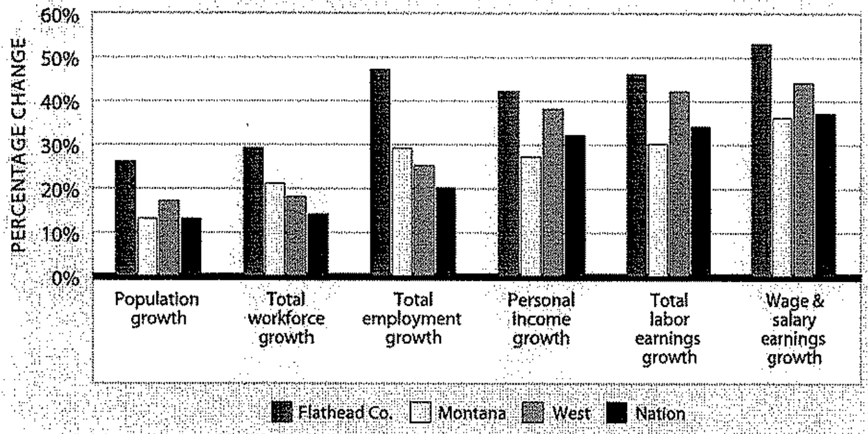


FIGURE 1.
Comparisons of Economic Growth in the '90s

Note: Total workforce refers to the total number of adults with jobs, while total employment refers to all jobs, both full- and part-time. Total labor earnings include both wage and salary earnings and self-employment income or proprietor earnings. The "West" includes the 22 contiguous states west of the Mississippi River. Dollar amounts are inflation-adjusted to 1996 dollars.
(Sources: U.S. Bureau of Labor Statistics, U.S. Department of Commerce)

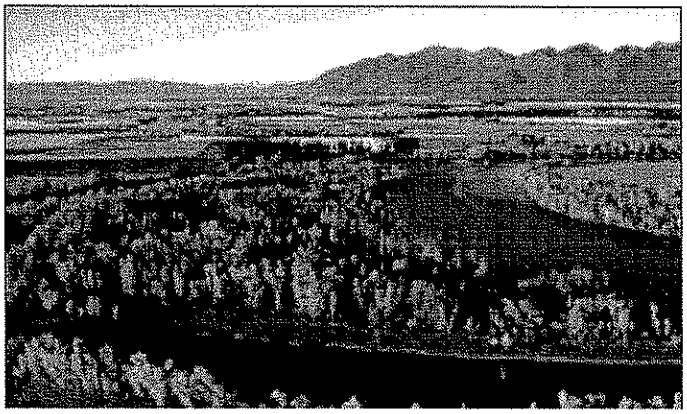
Investing in the Future

The families, businesses, and communities of Flathead County have been blessed with one of the most spectacular natural environments in North America. These natural amenities have become the area's chief economic asset. Flathead residents recognize that, along with small, friendly communities, these characteristics are largely responsible for the quality of life and economic vitality they enjoy.

This recognition can form a solid foundation for community dialogue and cooperative action to protect and enhance these fundamental assets. Partnerships of many kinds will be indispensable if Flathead residents are to guide growth to protect the values they cherish. With Glacier National Park and other public lands so directly linked to the valley's economic health, collaboration between public lands managers and communities is essential to sustain the appeal at the heart of the Flathead's economic vitality.

Glacier is a lure for outdoor enthusiasts

PHOTO: COURTESY BIG MOUNTAIN RESORT, WHITEFISH, MONTANA



Glacier National Park forms the headwaters of the Flathead River

PHOTO: KAREN NICHOLS

INTRODUCTION

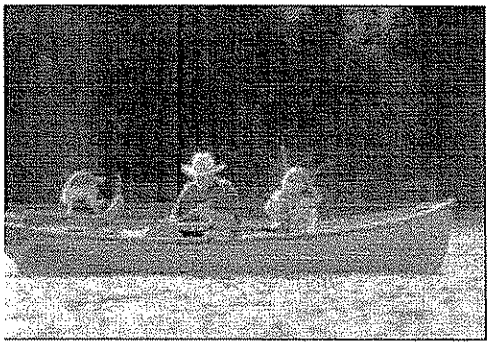
Around the turn of the 19th century, proposals to create Glacier National Park met with considerable resistance in the Flathead Valley. Opposition was deep and broad, including several Flathead County newspapers that cited lost opportunities for mining, logging, new railroad routes, oil exploration, hunting, and homesteading.

"There may be some local people who favor the park plan," wrote the *Kalispell Daily Inter Lake* in 1907, "but we know of only two." The *Inter Lake* and other local papers voiced the concerns of many Flathead residents who feared that establishing the park would take the wind out of the area's economic sails.[1]

Nearly 100 years later, it is clear that these fears were unfounded. In an October 2002 editorial, the *Daily Inter Lake* called Waterton-Glacier International Peace Park "our region's biggest economic engine."[2] As in the past, the editorial staff voiced the convictions of residents, many of whom believe that the valley's economic vitality depends in large measure upon its spectacular natural surroundings.

Floating and fishing at Glacier's Lake McDonald

PHOTO: KAREN NICHOLS



"You can't measure the mark Glacier Park has made on this community. The whole economy is tied to the park."

Carol Edgar
Executive Director,
Flathead Convention
& Visitor Bureau

In a region replete with extensive wilderness areas, national forests, lakes, streams, and mountains, Glacier National Park holds a special place. It is a landscape of exceptional beauty, known around the world and easily accessible by car, foot, and horseback. Carol Edgar, executive director of the Flathead Convention and Visitor Bureau, expressed a view common among local business leaders: "You can't measure the mark Glacier Park has made on this community. The whole economy is tied to the park."

Across the United States, there is growing recognition of the link between attractive public lands such as national parks, and the well-being of the communities that provide access to them. These "gateway communities" generally provide food, lodging, and other services for visitors. But the parks are more than simple magnets for visitors. Many gateway communities, including Flathead County, have thriving, diverse economies that are not primarily dependent upon tourism and recreation. Yet the natural appeal of these areas is at the heart of their economic success.

In 2002, NPCA—through its Northern Rockies regional offices located in Whitefish and Helena—commissioned three studies (see About This Report). These studies explore the roots of economic vitality in Flathead County, the primary gateway to Glacier. From three different angles, the studies help to illuminate important relationships among economic vitality, the natural environment, and the quality of life that is valued by both residents and visitors. These studies overwhelmingly support the assertion that the Flathead Valley's chief economic assets are its friendly communities and the natural environment, which provides recreational opportunities, a wide-open feel, clean water, wildlife, and scenic beauty. Further, the studies support the conclusion that degrading those qualities will, in the long run, slow economic progress and dampen vitality in the Flathead. They point the way toward protecting these valuable assets for the future.

This report synthesizes findings of these three studies into a wide-ranging discussion of economic transition that will help residents and leaders navigate fast-paced changes in the emerging Flathead economy.

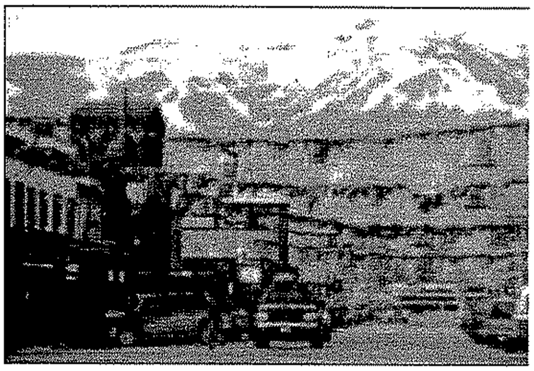
FINDING 1

The Flathead County economy is vibrant, diverse, and growing

Over the last 30 years, the Flathead County economy has changed tremendously. Industries that were once economic staples have declined in importance, and this economic restructuring has been sometimes painful and divisive. A nationwide recession in the early 1980s compounded the effects of contractions in natural resource industries such as lumber and wood products, and the valley felt the pinch.

Unlike many other rural areas still struggling with economic declines, Flathead County experienced a remarkable turnaround beginning in the late 1980s. Employment and income growth accelerated, driven in large measure by a rising tide of new residents. During the 1990s, dramatic growth occurred primarily in health care, specialized services, retail trade, and construction, more than filling the gaps left by the setbacks of the 1980s. Overall, manufacturing grew at a marginal pace, and now accounts for a much smaller share of the fast-growing economy.

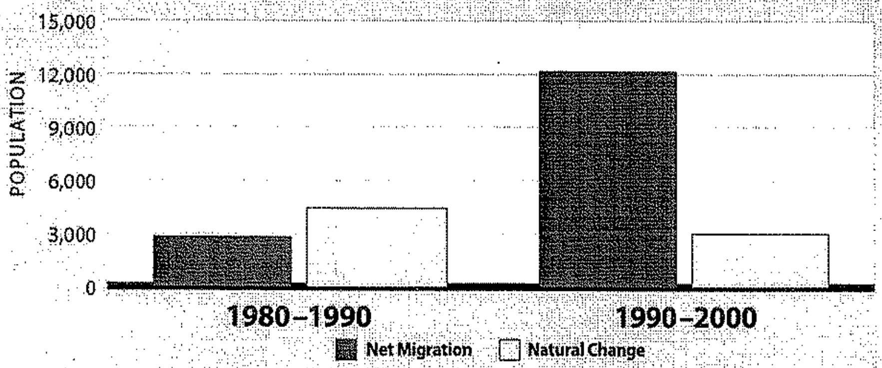
The Flathead County economy is vibrant, diverse, and growing. In many ways, the valley's economic expansion is linked to its increasing population. These new realities call for a new understanding of the roots of prosperity in the Flathead.



Whitefish enjoys a vibrant economy and a strong community identity

PHOTO: KAREN NICHOLS

FIGURE 2: **Flathead County Population Change by Major Component: 1980s vs. 1990s**



Note: *Net migration* is the difference between the number of persons moving to an area and the number moving away, and considers only persons changing their permanent residence. *Natural change* is the difference between the number of births and the number of deaths.
(Source: U.S. Census Bureau, "Components of Change")

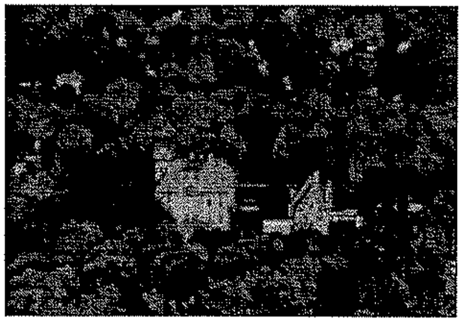
A Growing Population

In the 1990s, Flathead County's population shot up by 26 percent, nearly double the rate of growth in the '80s. The 2000 census counted 74,471 residents. A more recent July 2001 estimate places the county's population at more than 76,000.

Population growth comes in spurts in the Flathead. Growth spiked in the late 1970s and again in the mid-1980s. The early and mid-1990s brought a more sustained growth trend, and now it seems that population growth may be on the increase again. In the '70s and '80s, the "natural change" of births and deaths was the biggest influence on the rate of population growth. In contrast, population growth in the'90s was driven largely by people moving into the valley.

Flathead County Courthouse, 101 years old

PHOTO: KAREN NICHOLS



Joe Unterreiner, Kalispell

"Unlike Las Vegas, people don't move here primarily for the job opportunities. We see people attracted to this area for its outstanding natural amenities, good schools, and small-town environment. It's a beautiful place to live. Many explore starting or acquiring a business as a way of making the transition to the Flathead. Or, maybe they bring an existing business with them. We're also seeing displaced workers return to school for retraining, then decide to start a business.

So I'd say the Flathead is enjoying a high level of entrepreneurial activity right now. A lot of people are taking a risk, putting capital on the line and making an investment, because they want to live here. And these are some very creative, enterprising people who often invent a market for their products or services.

Fortunately, the Flathead is a good place to do business, especially when you look at other places around the country. We enjoy a strong business environment. And that's why you see a tremendous amount of capital at risk in the valley right now."

Joe Unterreiner
President, Kalispell
Chamber of Commerce

Who is Moving to the Flathead?

By the end of the 1990s Flathead County's population had ballooned, with the greatest growth among persons between their early 40s and mid-60s. This pattern reflects the aging population nationwide. The large and economically influential segment of "baby boomers" is now between the ages of 40 and 60. Financially established, boomers make up the bulk of the people moving to places like the Flathead Valley.

In addition to this rapidly growing population of older, working adults, the Flathead experienced a significant increase in the number of teenagers during the '90s, reflecting an influx of established families. The Flathead seems to have attracted many people who feel comfortable enough financially to live where they want, and who bring with them jobs, income, or the capital to start new businesses.

"Transportable" sources of income such as investments and transfer payments are increasingly important here. Unlike most wage earnings, these income sources move with people when they relocate. In 1977, wage income was 70 percent of all income received by individuals and households in Flathead County. Now, although labor earnings continue to grow, they account for only 60 percent of the total. Income from investments (24 percent) and transfer payments (15 percent) make up the rest. Investment income is received primarily as rent, dividends, capital gains, and interest earnings. Transfer payments are mostly from Social Security, Medicare, and Medicaid, which tend to rise with an aging population.

Business is Booming

Flathead County's rapidly growing population is an important driver of the area's economic vitality. More people and more income have translated into more business activity and continuing job growth.

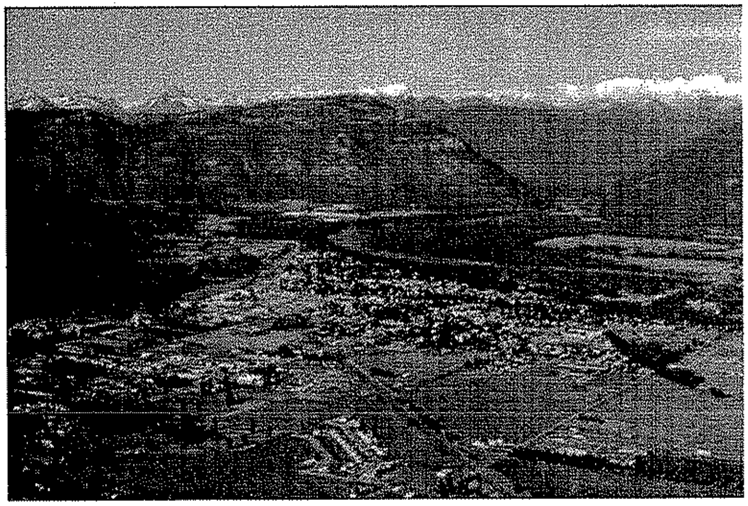
At the end of the 1990s, 980 more firms—not including sole proprietorships—were doing business in the valley than at the beginning of the decade, a 44 percent increase.[3] Employers created 15,700 new jobs during the '90s, a 47 percent increase. Per capita income and total personal income (all income received by individuals and households) grew significantly. Wage and salary labor earnings also increased at a faster rate than they did across the country and throughout the West.

Business leaders interviewed for this report generally agreed that the area's growing population has been good for the economy. A majority said that growth has brought increased prosperity to their businesses, while others described business as stable. Not a single respondent reported a decline.

Another sign of vitality in the Flathead economy is the amount of capital being invested in residential, commercial, recreational, and industrial construction projects. "All enterprise starts with risk, and right now there's a tremendous amount of capital at risk in the valley," observed Kalispell Chamber of Commerce President Joe Unterreiner. As 2003 began, the chamber calculated that more than $1 billion was being invested in major construction projects across the county.

The Flathead Valley also is becoming known for its thriving arts community. Whitefish, Kalispell, and Bigfork are three of the country's top 100 small art towns according to a 1998 book, *The 100 Best Small Art Towns in America.* Artists, musicians, and crafters directly contribute to the economy and are an indispensable element in the unique appeal of the Flathead's communities.

With Glacier as a backdrop, Columbia Falls remains an industrial hub of Flathead County PHOTO: JACK ARCHIBALD



An Economy in Transition

The Flathead economy is changing. Manufacturing—including lumber and wood products, metals, and high-tech—has become less important overall. Labor earnings and the number of manufacturing jobs rose slightly during the 1990s, but manufacturing's share of total labor earnings in the county fell from 32 percent to 18 percent between 1980 and 2000, signaling a major shift away from the area's long-standing dependence on this industry. Another mark of change is that different types of manufacturing are becoming more important in the valley. In the last decade, labor income gains in equipment manufacturing exceeded losses in wood products manufacturing by more than double.

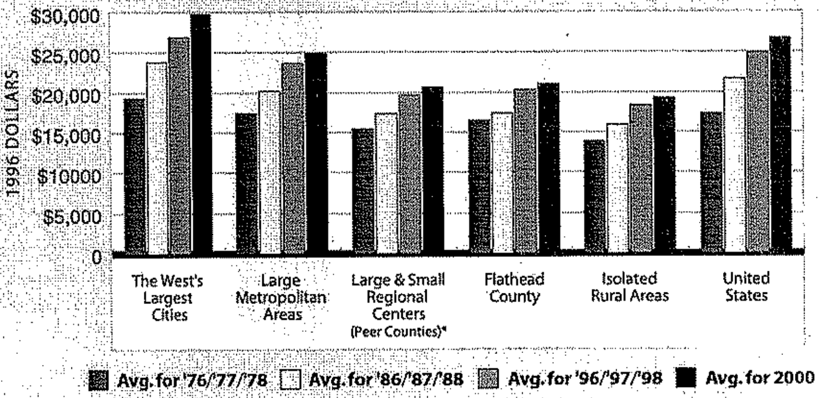
FIGURE 3. Per Capita Income: How is Flathead County Faring?

In 2000, Flathead County's per capita income was $23,142. The national average was $29,469. Does this mean that Flathead County is a "poor" area? Not necessarily.

As the chart demonstrates, per capita income levels tend to be considerably—and consistently—higher in large cities and urban areas than in rural ones. Since most people in the United States live in large cities and their surrounding areas, national per capita income is much higher than in less-populated places like Flathead County and in states, like Montana, that have no large cities.

But areas like the Flathead are starting to gain ground. Across the United States, per capita income grew most quickly in the largest cities during the 1970s and 1980s. During the 1990s, that pattern began to shift, with some of the greatest gains in per capita income happening in smaller cities.

Compared with its peers, Flathead County's per capita income is slightly above average (see chart). As per capita income growth slowed down across the United States during the late '80s and early '90s, Flathead County's economy was on the upswing. Per capita income grew more quickly here than in the rest of the country, and more quickly than the average among its peer areas. This is a sign that the current economic transition is boosting prosperity in the Flathead Valley.



Note: All figures are adjusted for inflation and translated into 1996 dollars to provide true comparisons over time. Data for the West's largest cities include the region's 28 largest cities including Los Angeles, San Francisco, Dallas-Ft. Worth, and Seattle.

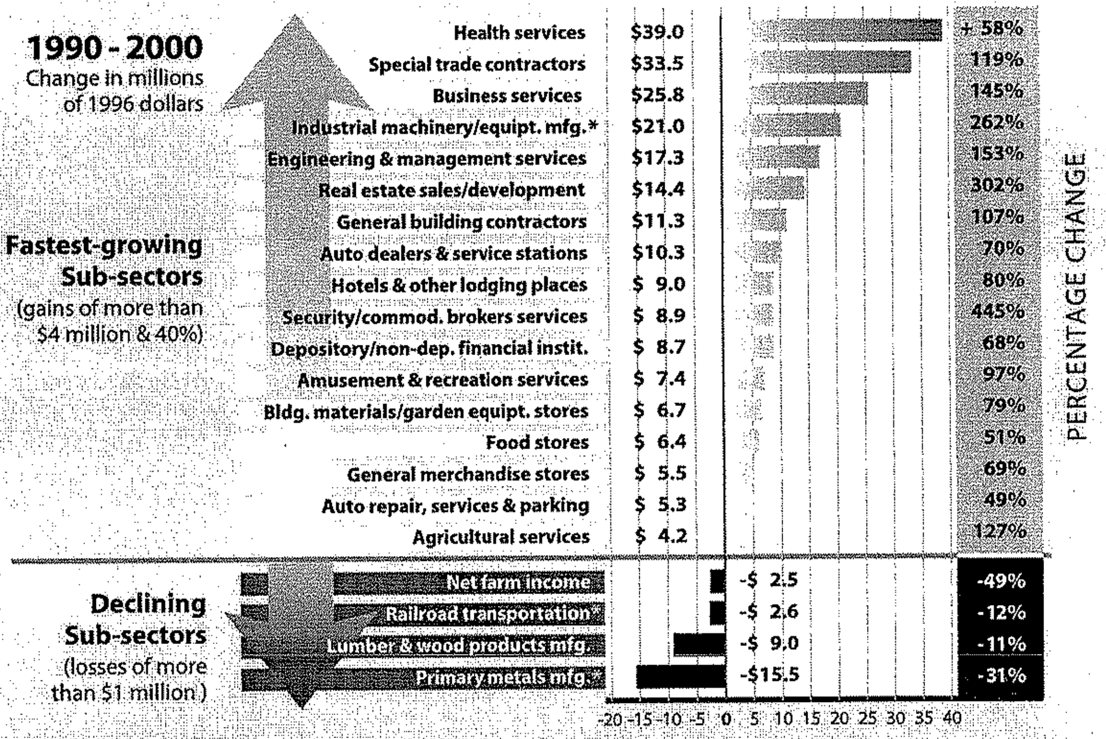
Large metropolitan areas include 28 cities the next tier down in size, including Albuquerque, Spokane, Eugene, Boise, and Yakima. Large and small regional centers are the next tier smaller in size and include larger regional centers like Sioux City, Flagstaff, Grand Junction, and Missoula, and smaller regional centers like Port Angeles, Mankato, Bozeman, and Kalispell. *Isolated rural areas* are counties having no cities greater than 10,000 population that are not near larger regional centers and cities.

	PERCENT CHANGE	
Per Capita Income Change	**77-'87**	**'87-'97**
The West's Largest Cities	+23%	+13%
Large Metropolitan Areas	+16%	+17%
Large and Small Regional Centers (Peer Counties*)	+13%	+13%
Flathead County	+ 6%	+17%
Isolated Rural Areas	+15%	+16%
United States	+25%	+15%

(Source: Swanson, *The Flathead's Changing Economy,* October 2002)

* *Peer counties* are 67 counties in the western United States with similar characteristics to Flathead County, including population size and proximity to major urban centers. All of these counties have no cities exceeding 50,000 population ('90 Census).

FIGURE 4.
Rapidly Growing and Declining Sub-sectors in Flathead County



Note:
- Change in these sub-sectors is measured in terms of labor earnings received by sub-sector workers, in inflation-adjusted 1996 dollars.
- Estimates for 1990 are 3-year averages for '89, '90, and '91, while estimates for 2000 are 2-year averages using '99 and '00 data from the U.S. Department of Commerce.

(Source: Swanson, *The Flathead's Changing Economy*)

* Sub-sector change estimated because some data were suppressed or not available.

The primary source of new jobs and labor income has been a rapid expansion in the services, retail trade, construction, and F.I.R.E. (finance, insurance, and real estate) sectors, particularly in areas directly influenced by the expanding population. During the 1990s, these sectors accounted for more than 70 percent of the labor earnings growth in the valley.

During the 1980s, services and retail trade alone accounted for 85 percent of the new jobs created in Flathead County, causing many to be concerned about quality jobs and the area's future. The '90s, however, were marked by strong growth in other sectors, which held job growth in services and retail trade to around 57 percent of all employment growth. These other growing sectors provide balance and diversity in the overall economy, lending stability and resilience.

In the service sector, growth during the '90s has been particularly strong in sub-sectors that typically offer many high-quality jobs: Health care, engineering and management services, and business services such as computer programming, data processing, advertising, credit reporting, and printing.

The Flathead's popularity among visitors and part-time residents also adds vitality. In terms of labor earnings, two of the fastest-growing sub-sectors in the '90s are strongly related to tourism: Hotels and lodging places (#9 fastest-growing sub-sector) and amusement and recreation services (#12). In many trade and service sectors, labor earnings have grown faster than area population and income, suggesting the growing influence of part-time residents who spend time and money in the area. In the construction sector, for example, disproportionate growth in labor earnings indicates a boom in second-home building, a trend that is otherwise difficult to document.

Swimmers enjoy the sparkling waters of Flathead Lake

PHOTO: KAREN NICHOLS

Tourism continues to be a stable and growing industry in Flathead County, but some measures of tourism activity suggest it may make up a shrinking piece of the rapidly growing economic pie. While part-time residents play an expanding role in the economy, non-resident tourist spending seems to have declined in relative importance in the 1990s. For example, while labor earnings in the Flathead economy grew nearly 50 percent in the past decade, lodging revenue for Flathead establishments grew by only 29 percent, as reflected in bed tax receipts. This difference suggests that much of the Flathead's economic expansion is taking place outside what is commonly thought of as tourism.

Signs of Qualitative Growth

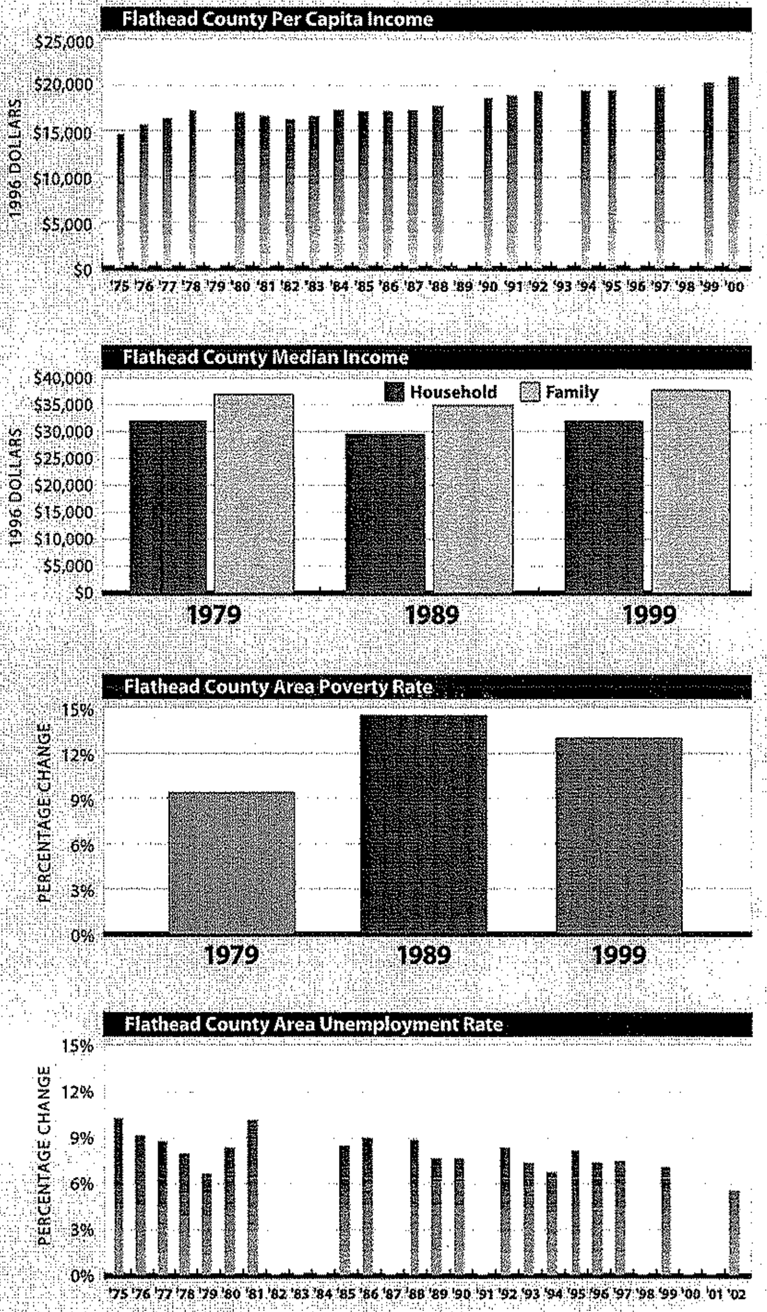
Flathead County has been experiencing rapid "quantitative" growth. More people, more jobs, and more income have helped ease the valley's economic transition. Growth has provided alternatives to extractive industries and traditional manufacturing, which are also declining in economic importance throughout the United States.

However, quantitative growth does not automatically translate into improvements that enhance prosperity and well-being for area residents. In the valley, fortunately, evidence exists of "qualitative" growth. While the 1980s brought economic setbacks in Flathead County, these declines reversed in the 1990s, with gains in per capita income and median income and declining rates of poverty and unemployment.

FIGURE 5.

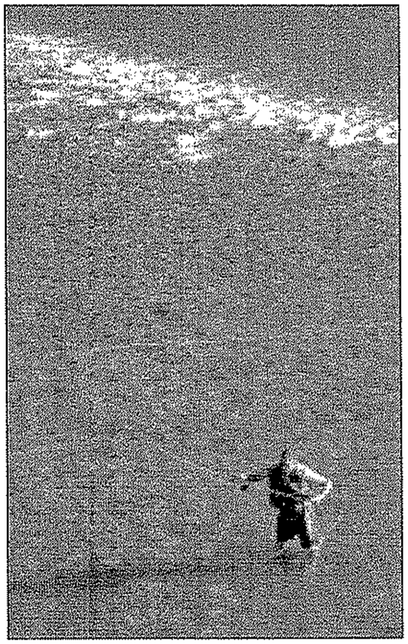
Recent Improvements in Economic Well-being in Flathead County

By nearly all measures, the quality of economic life in the Flathead is improving. Per capita income is steadily rising, median income is recovering after losses in the '80s, poverty is falling after rising in the previous decade, and unemployment is at a 30-year low.



(Source: U.S. Bureau of Economic Analysis, Census Bureau, and Bureau of Labor Statistics)

FINDING 2



Flyfishing on the North Fork of the Flathead River

PHOTO:KAREN NICHOLS

The quality of the Flathead Valley's spectacular environment is its chief economic asset

Changes in Flathead County's economy, driven by the area's growing popularity with new residents and visitors, invite a new interpretation of the valley's most important economic assets. The qualities that attract newcomers and visitors are the same ones that long-time residents most value about the Flathead Valley.

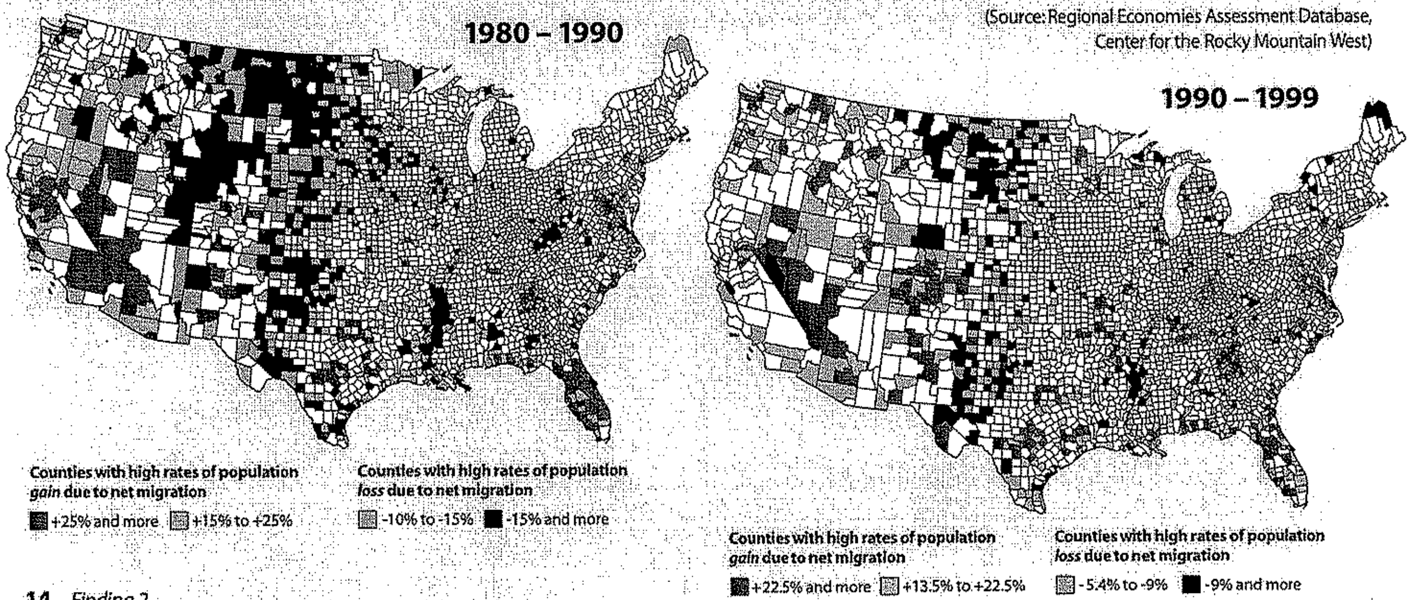
Changing Migration Patterns

Increasingly free to choose where they want to live, many people pursue the quality of life found outside of major metropolitan areas and traditional retirement havens. During the 1990s, patterns of migration shifted nationwide, reflecting this trend.

During the 1980s, the Plains region and parts of the Rocky Mountain West lost population as many people moved away. By contrast, in the West, California, Nevada, Arizona, and a handful of major metropolitan areas attracted new residents. In the East, Florida was the main magnet for people moving to a new area. In the '90s however, this pattern of concentrated population growth shifted. Population gains through migration are now much more dispersed.

During the 1990s in the Rocky Mountain West, a dramatic increase in new residents marked a sea change in migration patterns. Like the Flathead, many of the high-growth areas in the West are non-metropolitan, with relatively small population centers. Throughout the region, national park gateway communities like Flathead County are focal points for growth. More and more, people make decisions about where to live based in large part on the presence of natural "amenities"—appealing qualities or characteristics that add value—such as spectacular scenery, accessible public lands, and clean air and water.

FIGURE 6. **Population Change Through Migration in the U.S.: 1980s vs. 1990s**



(Source: Regional Economies Assessment Database, Center for the Rocky Mountain West)

The Flathead's Key Assets

In surveys and interviews, visitors, new residents, and lifelong community members identify a common core of qualities that attract them to the Flathead Valley. For these people, the valley's unique appeal lies in the small-town character of the communities and the quality of the natural environment. Visitors and residents alike are drawn by the friendly atmosphere, rural feel, clean water, wide-open spaces, wildlife, scenic beauty, and outdoor recreation opportunities.[4]

While visitors are important to the economy, valley residents are at the heart of the Flathead's economic vitality. The valley's natural and recreational amenities play a large part in attracting new residents and businesses while maintaining the loyalty of long-time residents. In a recent survey of Montanans, Kalispell residents expressed a higher degree of attachment to their hometown than do most Montanans.[5]

Most business people in the Flathead Valley say they are drawn here primarily by the quality of the community and surrounding landscape. Most of the business owners and managers interviewed for this report believe they could make more money elsewhere. They see themselves trading greater income opportunities for the quality of life they value so highly.

Of the 80 business leaders interviewed for this report, 13 were native to the Flathead. Most of the others had moved to the Flathead Valley for reasons that centered on lifestyle, outdoor recreation, scenic beauty, and family.

The Flathead Valley's natural and recreational amenities are well appreciated across the country. A 2001 study asked Internet users to identify the images that come to mind when describing a Montana vacation. The top three vote getters—natural beauty and scenery, mountains, and national parks—describe the Flathead Valley perfectly.[6] In 1999, *Mountain Sports & Living Magazine* selected Kalispell as America's "best mountain town," citing its proximity to Glacier Park and its "quaint, laid-back business district."

In today's economy, jobs and income tend to follow people, rather than the other way around. Flathead County's ability to attract and maintain the loyalty of full-time residents, as well as visitors, is critical. The character of the local communities and beauty of surrounding landscapes are the county's most important assets.

The New Economy: Where Jobs and Income Follow People

Behind the growing number of new Flathead residents and businesses are some nationwide trends that make it easier for people to choose where they live.

- The U.S. economy overall is less dependent on jobs in manufacturing and other large industries tied to a particular location. The shift to a more service-oriented economy has made business more mobile. Nationwide, job growth has been focused over the past decade in small firms, which have greater flexibility in location.
- Investment income is a larger share of overall personal income. Thirty years ago, 80 percent of the U.S. income base was labor earnings. Now, in many places, less than 60 percent of personal income comes from wages and salaries. The rest comes from investments and transfer payments, which are more transportable than wage income, giving people more freedom to live where they want.
- Improvements in information technology have fundamentally changed how business is conducted. These advances make it possible to work from home offices or run global businesses from remote locations.

Tom Krustangel, Whitefish

"I don't know that anyone can adequately explain what led them to Montana. There is a magic here. I know the first time I set eyes on Glacier Park, I was absolutely awestruck. I had never seen anything so magnificent in all my life. I vowed right then and there to come back and sure enough. It took a few years, but now I have a successful business and I'm right where I want to be.

I love this valley. I love the people in it. I'd hate for us to look like Anytown, USA, with garbled, jumbled zoning. There is a character to this area that I hope we're smart enough to preserve. We as Americans have a bias to look at short-term profit rather than long-term growth, but I think there's a will here to keep our valley special."

Tom Krustangel
Owner, Montana Tom's Chocolate

The Wildest Assets

Visitors and residents share a deep appreciation of the wildlife inhabiting the valley and surrounding mountains. The majority of residents believe that large predators such as grizzly bears, mountain lions, and wolves play an important role in the natural systems they occupy.[7]

Hunting, fishing, and wildlife watching are popular pastimes among people who live in the valley. According to John Fraley at the Montana Department of Fish, Wildlife and Parks, "Northwest Montana has the highest rate of hunting and fishing by both men and women in the entire United States outside of Alaska." Some 40 percent of Northwest Montanans hunt, nearly six times the national average. Sixty percent fish, which is more than triple the national average. And nearly half of those surveyed say they go out to view or photograph wildlife.[8]

Among visitors who spend at least one night in Flathead County, wildlife watching ranks as the most popular activity Fifty-three percent of overnight visitors surveyed noted this as something they did during their stay. Other popular activities included nature photography (44 percent), day hiking (43 percent), and camping (29 percent).[9]

> "In Colorado a lot of the natural areas have been kind of taken over by sort of a trendiness. It's like Rocky Disneyland or something. And Montana is like Montana. It's a real deal place. There's still a sense of a real daily life, not a kind of a recreation tourist daily life."
>
> **–Minnesota man vacationing in Montana**
>
> (The Montana Vacation Experience, Institute for Tourism and Recreation Research, 2002)

Biologist Chuck Jonkel leads another bear watching field trip

PHOTO: KAREN NICHOLS

Figure 7.

Bears in the Backcountry: User Attitude Survey

In the summer of 2001, researchers surveyed nearly 1,600 Glacier Park backcountry users about their attitudes toward grizzly bears.[10] The survey included day hikers and overnight backpackers, all of whom had walked at least a half mile from the trailhead. Their responses suggest that Glacier visitors place a high value on grizzly bears—and understand the vital role these animals play in maintaining ecological balance, both within and outside the park.

	Strongly Agree	Agree	Neutral/No Opinion	Disagree	Strongly Disagree
To me, the grizzly bear symbolizes the beauty and wonder of nature.		●			
In my opinion, the grizzly bear is essential for keeping other plants and animal species in proper balance with nature.		●			
I would very much like to see a grizzly bear in the wild.		●			
Grizzly bears should be eliminated in areas outside of national parks.				●	
If oil, natural gas, or minerals were discovered in grizzly bear habitat, the resource should be extracted even if it harms bears.				●	

Glacier's Grizzlies

Joan Grote, who directs the Mars-Stout call center for the Flathead Convention and Visitor Bureau, knows what people are looking for when they visit this area. Running through the top attractions for visitors, Grote ended her list by noting, "And of course, everyone wants to see a bear."

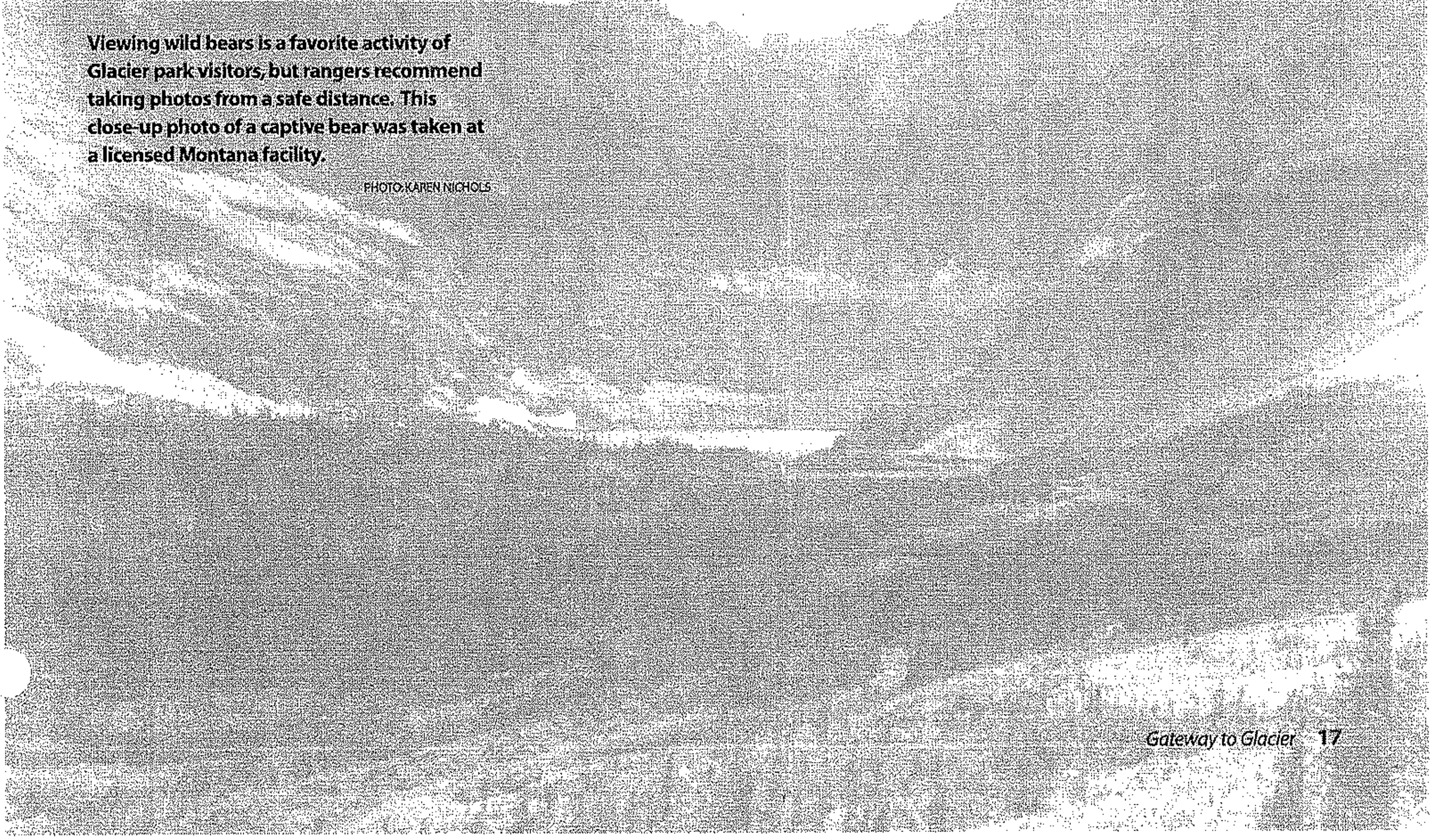
In reality, Flathead residents and visitors alike seem to have a healthy respect for the great bear. Some believe that seeing a grizzly in the wild would be a peak outdoor experience for them. On the other hand, many people are glad to know the great bear is around, but would rather not encounter one in the woods. Among both camps, however, there is widespread agreement that grizzlies are a key element of the natural systems they occupy. Seen or unseen, grizzlies are an important part of the Glacier experience—a sign of wildness and ecological integrity.

Viewing wild bears is a favorite activity of Glacier park visitors, but rangers recommend taking photos from a safe distance. This close-up photo of a captive bear was taken at a licensed Montana facility.

PHOTO:KAREN NICHOLS

Iceberg Lake cirque

PHOTO:NPCA



Glacier National Park is an anchor for Flathead County's robust economy

In the late 1800s and early 1900s, prospectors searched for everything from gold to copper to oil in what we know today as Glacier National Park. Countless prospectors and speculators believed they would make their fortunes there. Hundreds of mining and oil claims were staked out, but the hoped-for booms turned to bust.

The real "gold" in Glacier was protected on April 11, 1910, when President Taft signed the bill creating Glacier National Park. The mountains, forests, wildlife, and clean waters were protected for posterity. With an initial appropriation of $15,000, crews prepared a few roadways and trails for the first season of visitors, and the park rapidly became a popular destination for travelers.[11]

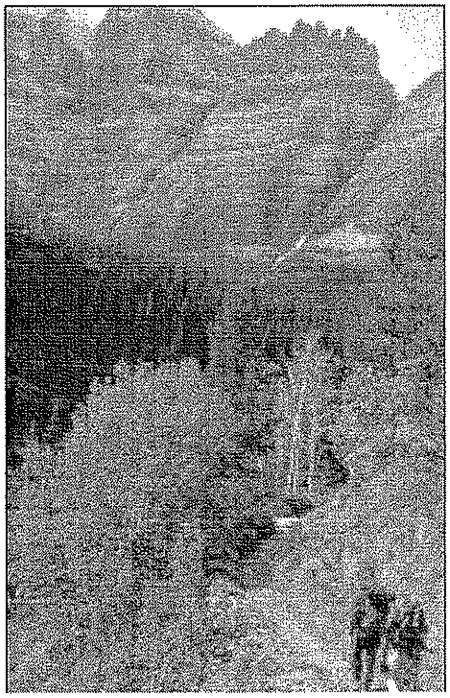
Glacier Park has become Flathead County's most pervasive icon, a widely recognized anchor for the region's many natural amenities, and a primary attraction for residents, visitors, and business leaders alike.

This is Glacier Country

Glacier National Park runs neck-and-neck with Yellowstone as Montana's number one attraction for vacationers. More than 80 percent of vacationers in Flathead County say Glacier was one of the attractions that drew them here.[12] Every year, Glacier is visited by people from every U.S. state and territory, from every Canadian province, and from nations around the globe.

Glacier's single most popular attraction is Going-to-the-Sun Road, with more than three-quarters of park visitors enjoying the spectacular scenery, wildlife viewing, and fresh alpine air at Logan Pass.[13] The park is just as well known as a premier hiking destination. Two-thirds of prospective park visitors surveyed planned to hike on some of the park's many trails.[14] In 2000, readers of *Backpacker* magazine selected Glacier as America's best backcountry park.

The park is beloved by Flathead residents, as well. Glacier National Park is the most popular place for Kalispell residents to take people who come to visit. Glacier is twice as popular as magnificent Flathead Lake, and outranks Big Mountain by a factor of three.[15]



Glacier hikers on the trail to Iceberg Lake

PHOTO: KAREN NICHOLS

Velinda Stevens, Kalispell

"Conservation affects the attractiveness of the area and the kinds of people we recruit to the Flathead Valley. We have been able to attract and retain an outstanding medical staff because this is such a nice place to live. And you know those things that make it a nice place to live—clean air, water quality, Glacier National Park, the wildlife—all the reasons that people live here, they want to keep.

Glacier is a big part of why I choose to live here. The hiking is spectacular. I like that there's nothing ostentatious about the park. I like the wildlife, how accessible it is. There isn't anything I don't like about the park. It's a huge part of our valley's quality of life, and the quality of life is why our economy is growing. Our challenge is to make sure we protect these qualities for the long term."

Velinda Stevens
Chief Executive Officer
Kalispell Regional
Medical Center

Overwhelmingly, Flathead business leaders treasure Glacier Park, expressing a deep personal fondness. Across various business sectors, managers and owners believe Glacier is good for local business and the overall economy. Nearly 200 Flathead businesses make that link directly, adopting Glacier as part of their name and identity. And several of the valley's largest developments, either under way or proposed, have adopted Glacier as their icon. These include a proposed mall, a performing arts center, and a redeveloped ski village.

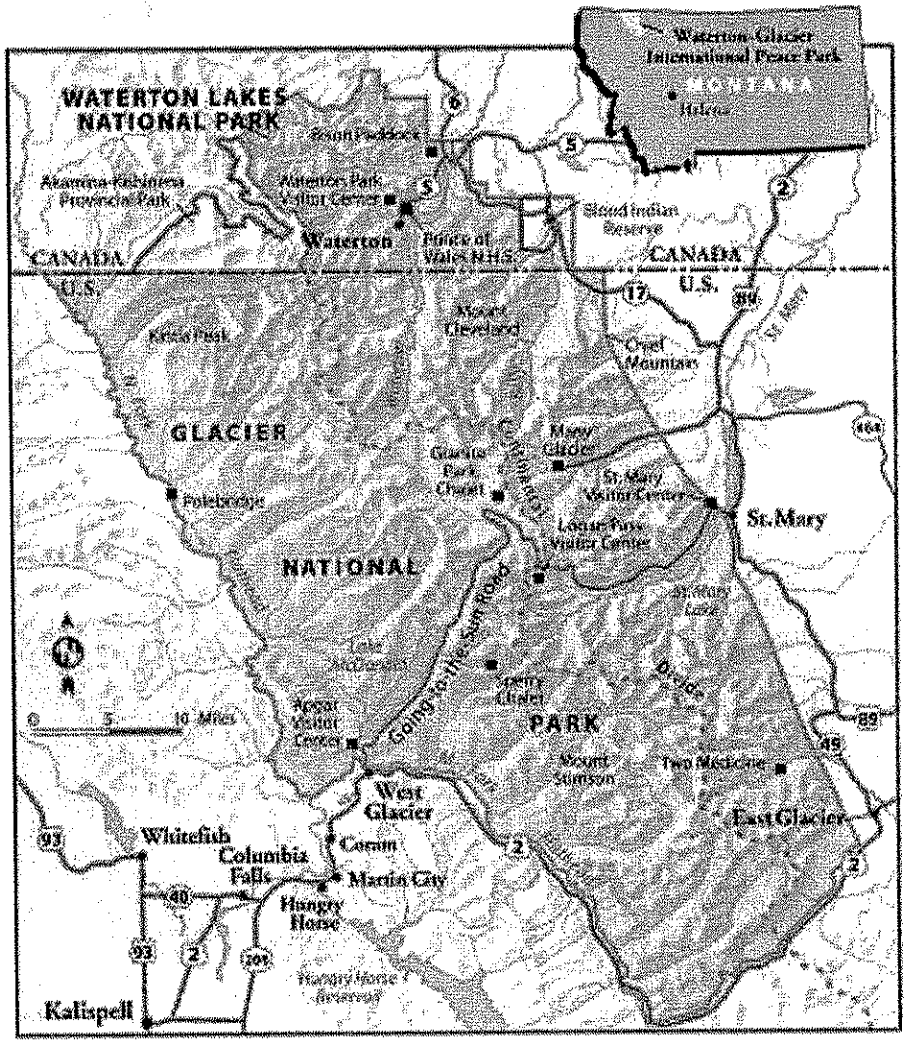
Glacier's Ecological Importance

The landscapes protected within Glacier National Park are essential to the natural amenities that Flathead residents and visitors enjoy, even many miles outside park boundaries. Substantial reaches of the North Fork and Middle Fork of the Flathead River are fed by clean waters that originate in the park. These rivers provide much of the volume in Flathead Lake.

Glacier Park is at the core of an extensive system of U.S. and Canadian public lands that provides important habitat for native species from elk to bull trout, from bear grass to mountain goats, and from lichens to peregrine falcons. The North Fork Flathead drainage provides unique habitat for carnivores such as lynx, grizzly bear, wolf, mountain lion, and marten. Spanning the U.S.-Canada border, this relatively intact and varied natural system hosts in abundance species that are now rare elsewhere in North America. A large part of this critical habitat is protected within Glacier National Park.[16]

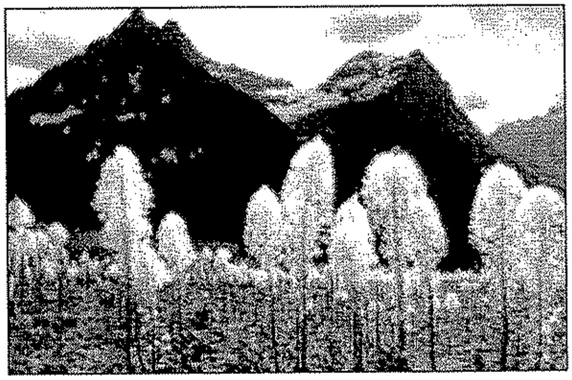
FIGURE 8.

Waterton-Glacier International Peace Park



Waterton-Glacier was designated the world's first international peace park in 1932 by Congress and the Canadian Parliament

MAP: MATT KANIA AND ROGER PARCHEN



Bear grass blossoms enchant Glacier's visitors

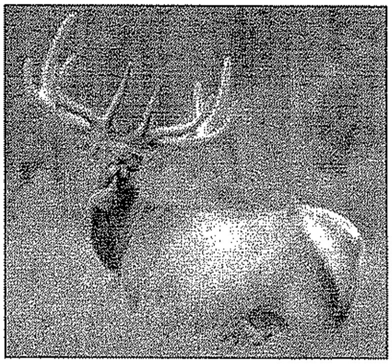
PHOTO: KAREN NICHOLS

FINDING 4

Proximity to national parks is an economic advantage for gateway communities such as Flathead County

Glacier is home to a full theater of large wild mammals

PHOTO: KAREN NICHOLS



The close relationship between Glacier National Park and Flathead County's economic growth and vitality reflects a larger pattern among national park gateway communities across the western United States. These gateway communities—which provide access to and visitor services for national parks— are experiencing similar changes in population, income, and employment. In the West, national parks often anchor a larger complex of public lands that provide desirable natural amenities. Like Glacier, these parks are key economic assets for the surrounding communities.

Magnets for Migrants

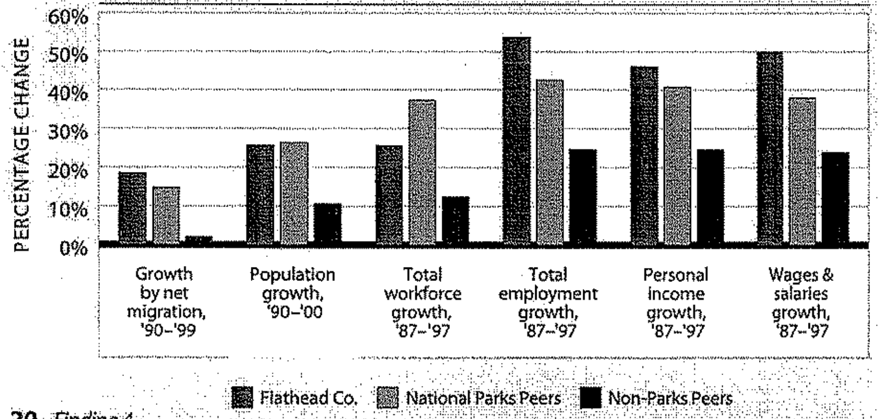
Throughout the western United States, national park gateway communities are among the most attractive to new residents. Fifty-one counties in the West, including Flathead, are next to large, attractive national parks and not part of a large metropolitan area. During the 1990s, 196,000 more people moved into all of these counties put together than moved away—triple the rate of net migration during the '80s.

National parks are magnets for new residents, and not because the parks are generating new jobs for government employees or contractors. In fact, park employment overall has declined. Similarly, population growth and business growth in these communities is not explained by booming numbers of park visitors. National parks play a different role in today's economy.

Attracted in large part by a clean and beautiful natural environment and access to outdoor recreation—as well as small, friendly towns—people are choosing to live in communities near national parks. Gateway counties that, like Flathead, serve as small regional trade centers, are attracting much of that growth. During the 1990s, such counties bordering national parks saw their populations increase by more than 26

The economic advantage of these park gateway communities can be gauged by comparing the performance of counties that differ primarily in their proximity to national parks. Throughout the West, Flathead County has 64 "peer counties" of similar size and character. Nine of these, including Flathead, are national parks gateway communities (or "national park peers"). The remaining 55 peer counties are not park gateways (or "non-park peers").

FIGURE 9. **Trends in Peer Counties of Flathead County**



Note: National park "peer counties" are nine counties near large national parks in the 22 contiguous states of the West that: 1) had 1990 populations between 30,000 and 100,000, 2) contained small regional trade centers under 50,000 population, and 3) had less than 10 percent American Indian population.
Of the ten national park counties listed in Figure 10 on page 22, Cococino County, AZ, was eliminated as a peer because of its high American Indian population.
The non-park peer counties are 64 other counties in the West with similar populations and small regional centers that are not near a major national park.
(Source: Swanson, 2002)

percent. Population growth in similar types of trade center counties that are not park gateways was less than half as strong, at 10 percent.

New residents from outside the county are responsible for most population growth in park gateway communities. By contrast, in their non-park peer counties, more people left than moved in during the 1980s. The 1990s were not much better, with very small net in-migration during the decade. While these non-park counties experienced population growth in the 1990s, it was largely because the number of births exceeded deaths.

Fueling Economic Growth

Across the western United States, national parks fuel strong economic growth in nearby communities. Like Flathead County, these areas enjoy a level of vitality not shared by most of their "non-park" peers. The attractiveness of these park areas drives economic growth.

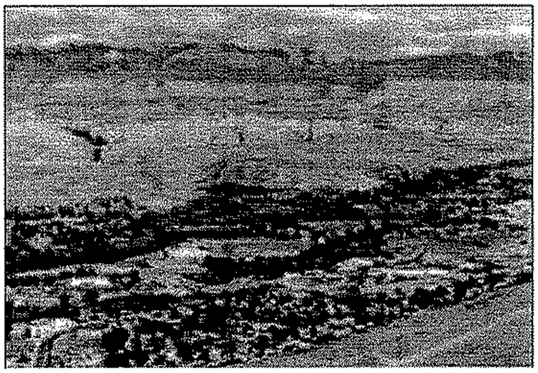
From 1987 to 1997, gateway counties like Flathead enjoyed a 40 percent growth in total personal income (all income received by individual and households). Income in non-park counties grew at less than two-thirds that rate. During the same time, total employment (all full- and part-time jobs) in park gateway counties grew almost twice as fast as in counties not adjacent to national parks.

National parks and the other public lands that often surround them are critical anchors for an array of natural amenities. Clean air and water, scenic beauty, recreation opportunities, and wildlife attract visitors and new residents and support economic growth.

Patterns of Economic Transition

National park gateway counties are going through similar economic changes, including a shift away from reliance on resource extraction. Lumber and wood products manufacturing declined sharply in regional center counties near parks. In these park gateway counties all together, income in the wood products industry fell by 23 percent between 1987 and 1997. Flathead County fared better than many of its peers in this respect—its lumber and wood products earnings declined by only 13 percent during that time.

Flathead County's gateway peers (see Figure 10) have also grown rapidly in income and employment, particularly in service and trade sectors linked to a growing population. Further, these areas also show evidence of an increasing influence of visitors and part-time residents. As in the Flathead, activity in construction and certain service and trade sectors appears to be expanding more quickly than the local population and income base.



Located between Arches and Canyonlands national parks, Moab, Utah, has seen 20 percent growth in the last 10 years. PHOTO: BRAD WEIS

Morrie Schechtman, Kalispell

"The Flathead valley is an extraordinary place in two respects: It is one of the most beautiful and inspiring natural environments in the world. And it is an ideal environment for creative people and virtual businesses. Both of these guarantee economic and population growth in the valley—and also in similarly beautiful places—to meet the increasing demand for quality of personal life, as well as the ability to conduct global businesses from a low-stress, people-friendly environment.

But these qualities also guarantee change, and even a certain anger and grief over the speed with which change has been occurring. The ability of all constituencies to identify and grieve their losses will determine how well these changes are integrated into future life in the Flathead.

By acknowledging our losses and embracing change, it should be possible for all parties to engage in an ongoing planning process that maintains many of the values we all share. Planning is absolutely essential to growth. On the surface, people think planning is antithetical to property rights. Actually, planning preserves the sanctity of property."

Morrie Schechtman
Business Management Consultant

Paul Wachholz, Kalispell

"People in the Flathead Valley are waking up to the fact that we can determine the fate of our area. We can either sit back and watch what happens or step forward and direct what happens. Maybe people didn't think they could make much difference before, but now they do. If we don't get a plan in position, basically the whole valley will look hodgepodge. It's to all of our advantage to have clusters where people live and clusters of farming and country landscape.

Same thing with the park. I think it's very important to keep it in its natural state because that's the essence and the beauty of it. We need to provide adequate funding for the parks, and we need to restore and maintain the Sun Road and the old buildings.

We can have a beautiful Glacier Park. We can have a beautiful Flathead Lake. We can have beautiful communities. But if we don't clean up our act where we live, we're not going to end up with what we want."

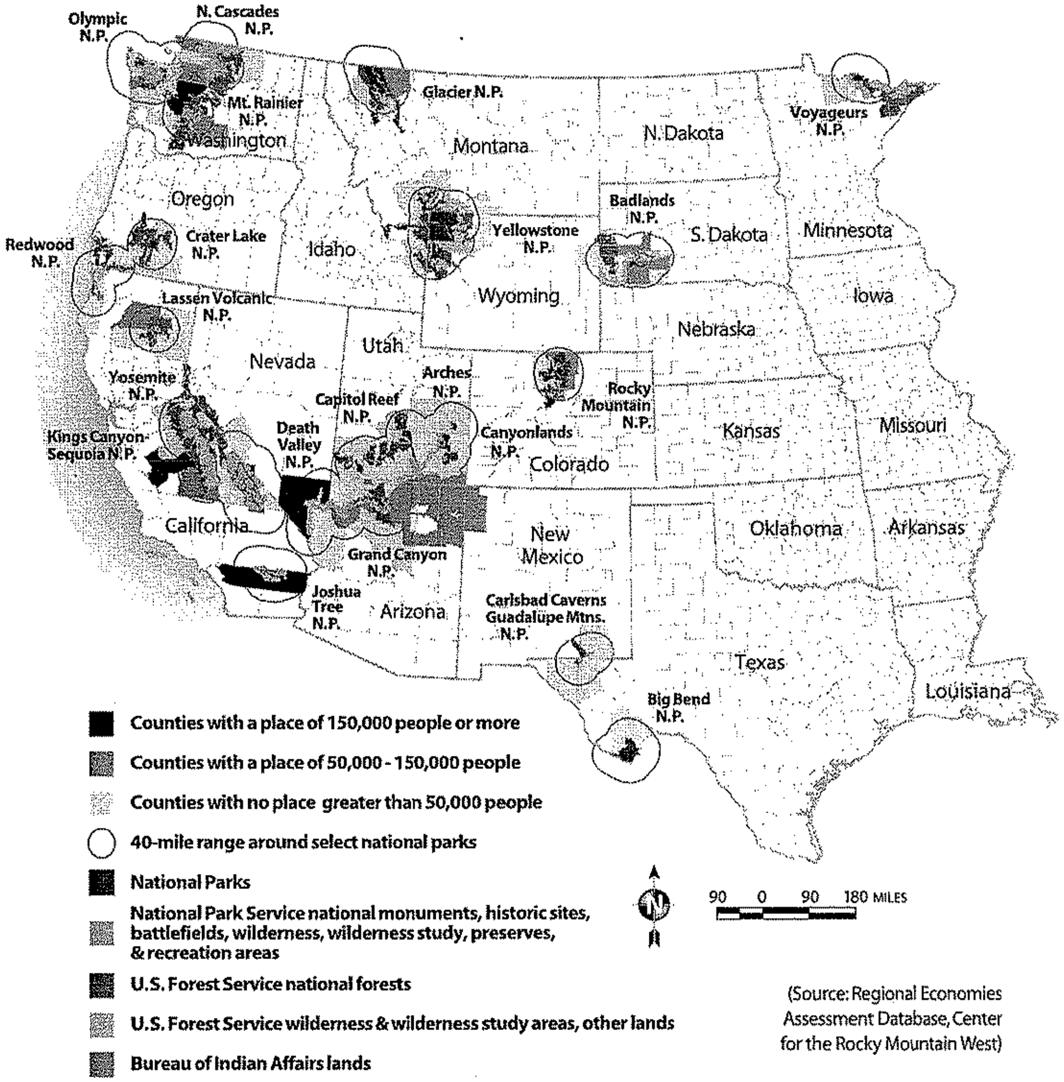
Paul Wachholz

Wachholz and Company Real Estate

By some measures, Flathead County seems to be doing better than its park gateway peers in linking rapid population and economic growth with qualitative improvements in the well-being of its residents. In 1997, for example, the Flathead poverty rate was 14.2 percent, almost a full percentage point lower than the average for its peer group. And between 1987 and 1997, per capita income in Flathead County grew by 17 percent, more than double the rate of growth in peer counties. Flathead's per capita income in 2000 exceeded the peer average by more than $1,200. Like the Flathead, gateway communities across the West are getting an economic lift from an influx of new residents, part-timers, and visitors. But they find this growing popularity threatens the very qualities that make their communities so attractive.

FIGURE 10. **National Park Areas in Western United States**

This map shows areas near major national parks in the 22 contiguous states west of the Mississippi River. Other federal lands adjacent to these parks are also shown. There are 80 western counties whose geographic center is within 40 miles of these parks, the majority of which (51 counties) are non-metropolitan in character. Recent shifts in migration patterns are channeling more and more new residents into many of these non-metropolitan areas that serve as national park gateways.



(Source: Regional Economies Assessment Database, Center for the Rocky Mountain West)

FINDING 5

The Flathead Valley's most valued qualities and primary economic assets are at risk

Among this region's most important economic assets are those that give the Flathead Valley its unique appeal: The small-town community atmosphere, uncrowded spaces, easy access to outdoor recreation, scenic landscapes, clean water, and wildlife. These are the qualities that area residents are most attached to—and that attract new people to the area.

In the face of rapid population growth and commercial, recreational, and residential development, there are signs that stewardship of these valuable assets has been lacking.

Perceptions of Change

Overall, valley business leaders agree that the Flathead's unique characteristics have already been degraded, and that these losses continue. They most lament the loss of open space, farmland, and the valley's rural character. Many of them believe that small-town friendliness is being challenged by impatient drivers and demanding customers. Some point to commercial sprawl, the decline in traditional jobs, and the influx of national chain stores as further evidence of the valley's changing character.

Kalispell residents surveyed expressed concerns about open space in their community. Most believe that there is already too little undeveloped open area, and are concerned that what is there will disappear. Survey results suggest that Kalispell residents are more concerned about the loss of open space than are Montanans in general.[17]

A survey of Whitefish residents found that their biggest concerns for the future of their community are maintaining their town's character and protecting environmental qualities. They identified traffic congestion and growth issues, such as strip development, as significant concerns.[18]

Flathead visitors are beginning to echo residents' concerns. In a 2001 survey, returning Montana visitors were asked to indicate how they saw the state changing over time. For each of the 12 characteristics included in the survey, people indicated whether they thought the condition was better, the same, or worse than on previous visits. Survey responses from Glacier Park visitors raise a red flag, suggesting that the very qualities that attract visitors to the area in the first place are being eroded.

Development in the Flathead Valley, 1980

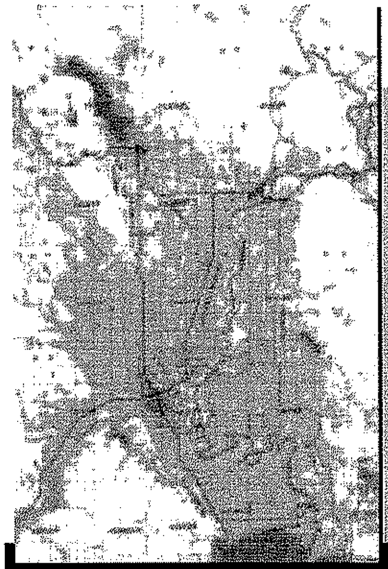
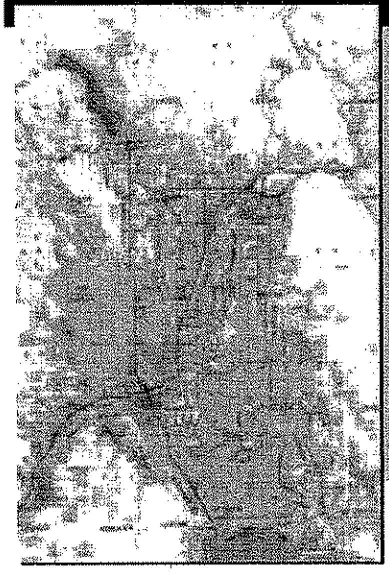


FIGURE 11. **The Face of Growth in the Flathead**



Development in the Flathead Valley, 1998

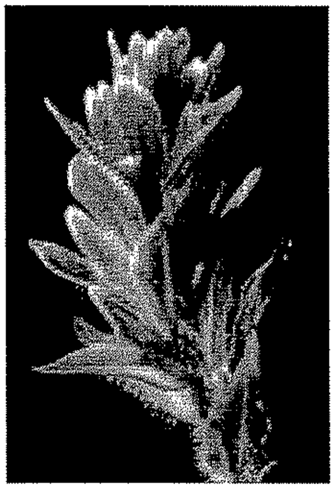
MAPS COURTESY OF CITIZENS FOR A BETTER FLATHEAD

Most of Flathead County's growth is occurring in rural areas, converting wildlife habitat, farms, and forestlands into development. Land-use planning lags behind development pressure in the Valley.

FIGURE 12. **Open Space Concerns in Kalispell**

	KALISPELL		MONTANA	
	Agree	**Disagree**	**Agree**	**Disagree**
There is adequate undeveloped space in my community	42%	58%	59%	41%
I am concerned with the potential disappearance of open space in my community	76%	24%	60%	40%

(Source: Institute for Tourism and Recreation Research, The University of Montana)



Among Glacier Park visitors, three features received "worse" ratings from more than 10 percent of respondents: the condition of the natural environment, amount of open space, and wildlife viewing opportunities. One of every five respondents perceived a decline in the amount of open space.[19]

The park visitors surveyed did not go to Yellowstone and were likely to have spent almost three-quarters of their Montana stay in and around Glacier Park. Their perceptions reinforce Flathead residents' concerns about changes in the local landscape. A clear picture is emerging in which the pace and nature of growth and development are bringing about changes that residents and visitors alike find unappealing.

Indian Paintbrush in Glacier PHOTO: NATIONAL PARK SERVICE

FIGURE 13. **Threats to Park Resources**

Ⓐ Proposed expansion of Highways 2 (U.S.) and 3 (Canada), paving of the North Fork Road, and associated development may impede the travel routes of grizzlies, elk, mountain goats, and other wildlife species. Several grizzlies, attracted to grain spills along the Burlington Northern-Santa Fe railroad, have been killed.

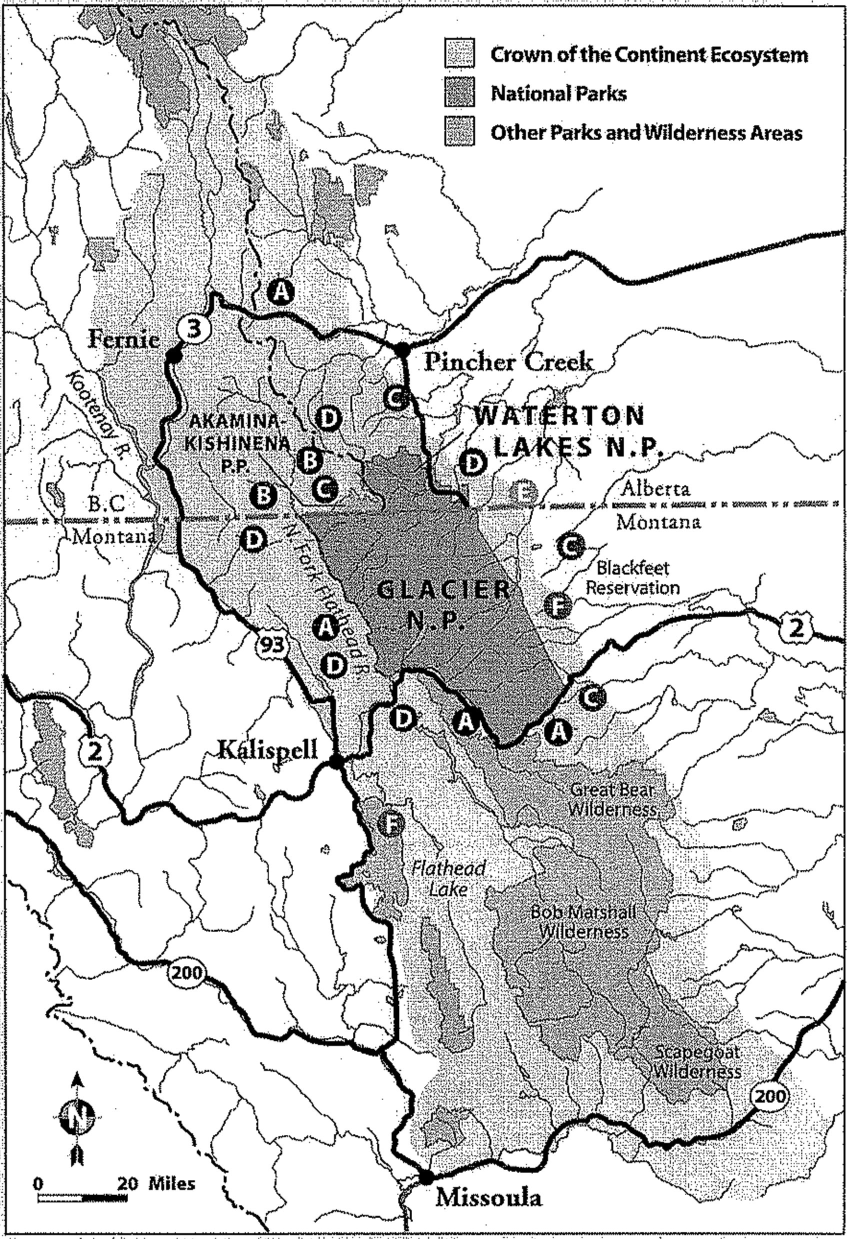
Ⓑ In the currently unsettled Canadian Flathead region, potential hard rock mining, long-term plans to construct an open-pit coal mine, and associated development would adversely affect water quality and transboundary populations of bull trout and other wildlife populations.

Ⓒ High-density road systems and other infrastructure associated with proposed logging, recreational and rural development, and extraction of oil and gas along the Rocky Mountain Front on both sides of the border would displace grizzlies and big game wildlife species that are known to avoid roads and drilling sites. Extensive gas-field development already has degraded habitat and displaced wildlife north of Waterton.

Ⓓ Residential, commercial, and resort developments on ranch, farm, and forest lands have encroached on important seasonal range for elk, mule deer, bears, mountain lions, and other wildlife species. Rapid population growth and poorly planned development may result in even more adverse impacts on wildlife.

Ⓔ In Alberta, the gray wolf can be legally hunted about nine months of every year. Ranchers are allowed to kill wolves within five miles of their land, and there is no limit on the number of gray wolves that can be trapped in a year.

Ⓕ Invasive non-native fish species have migrated from Flathead Lake into the park, and numerous non-native weed species have been introduced into the park through unauthorized grazing by cattle and horses along the borders of the park.



Examples of landscape alterations abound on land surrounding Waterton-Glacier International Peace Park. Most such changes have negative impacts on the native species that find refuge in the park.

MAP: MATT KANIA AND ROGER PARCHEN

Losing Farm and Forest Land

When business leaders talk about losing open space, farmlands, and the rural feel of the valley, it is easy to substantiate their concerns with facts. Periodic Agricultural Censuses report that, between 1978 and 1997, the amount of land in agricultural use decreased by a third, from 327,000 acres to 216,000 acres. Although similar statistics are not available for forested acreage, development patterns in the foothills and at the valley edges suggest a dramatic conversion of historic timberland.

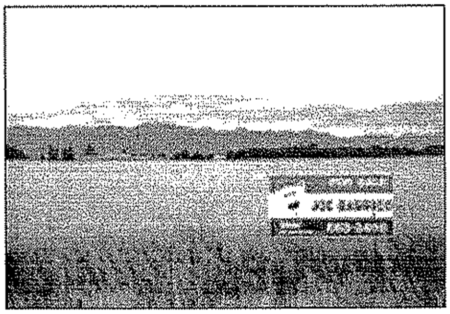
Development is not the only force influencing the amount of farmland in the valley, but it is an important one. During the rapid-growth years from 1992 to 1997, Flathead County lost 1.4 acres of farmland per hour, according to the U.S. Agricultural Census. More than a quarter of all homes in Flathead County were built after 1990. County data show 6,194 new lots and tracts created by subdivision between 1990 and 2000, and 8,225 housing starts in the same period. More than 70 percent of these housing starts went up in rural Flathead County, outside municipal sewer districts.[20]

A long-term decline in agricultural income contributes to the conversion of farmland to yards and parking lots. From a high of $45 million in 1980, farm income in the county has steadily declined to $30-$35 million a year during the last half of the 1990s. Annual production expenses also total between $30 and $35 million a year, indicating that Flathead farmers are either losing money or not making very much. As real estate values climb because of development potential, the valley's farmlands and private forest lands are more likely than ever to be sold and developed. The conversion of these lands affects the area's open, rural feel; access for outdoor recreation such as hunting, fishing, and walking in the woods; and habitat for wildlife—especially seasonal range for bears, deer and elk, and mountain lions.

Threats to Waterton-Glacier International Peace Park

In 2002, the National Parks Conservation Association released its State of the Parks® report for Waterton-Glacier International Peace Park.[21] This assessment finds that haphazard development of nearby landscapes and inadequate funding for basic park operations threaten the natural and cultural resources that make the park so extraordinary. Key points include:

- The Peace Park is one of the few protected places in the lower 48 states and southern Canada where a complete set of large predators, including grizzlies and gray wolves, still plays a prominent role in a largely natural ecosystem. The health of these wildlife populations is tied to their current ability to range freely across governmental boundaries.



According to the U.S. Agricultural Census, Flathead County lost 1.4 acres of farmland per hour in the mid-1990s

PHOTO: KAREN NICHOLS

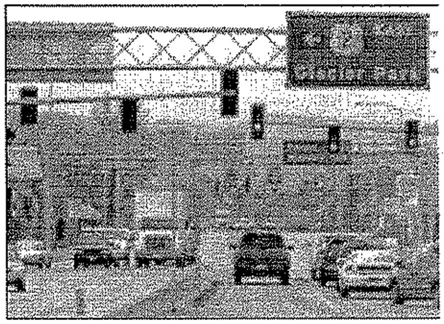


PHOTO: KAREN NICHOLS

> "I wouldn't drive up the Flathead Valley again…. There's a lot more sprawl than I expected. Really, I mean Missoula basically to Whitefish looks a lot like Oregon. It looks a lot like California. Where little towns stop being little towns and there's kind of sprawl. I haven't been here since '61, so it's been a long time. I think my expectation was that it was going to be a little wilder than it was. And that was a … disappointment."

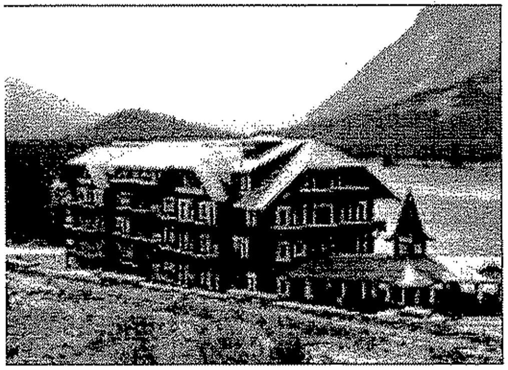
Couple from California, describing their trip through the Flathead Valley

(The Montana Vacation Experience, Institute for Tourism and Recreation Research, 2002)

Proposed highway expansion and North Fork road paving could impede the travel routes of grizzlies, elk, mountain goats, and other wildlife. Intensified development on ranch, farm, and forest lands has encroached on important seasonal range. Rapid population growth and poorly planned development may result in even more adverse impacts on wildlife.

The historic Many Glacier Hotel is in need of extensive repairs

PHOTO:NPCA



- Waterton-Glacier protects six National Historic Landmarks and more than 350 structures listed on the National Register of Historic Places. Many Glacier Hotel and Going-to-the-Sun Road are two of the best known of these attractions.

  Park staff estimate that Glacier's backlog of deferred maintenance and construction needs exceeds $400 million. The total includes funds needed to construct a new west-side visitor center, stabilize historic hotels, and rehabilitate Going-to-the-Sun Road.

- Glacier Park was designated to protect the area's natural and cultural resources.

  The park has neither the staff nor the money to monitor wildlife populations adequately, complete needed archaeological research, maintain historic structures and museum collections, and provide high-quality visitor services that people have come to expect at national parks.

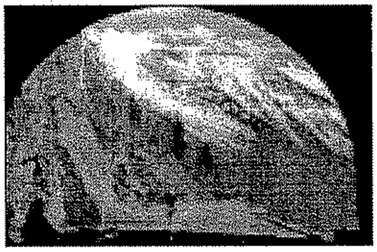
Overall, the State of the Parks® assessment suggests that a long history of protection has not spared the park from serious threats. These threats are worthy of Flathead residents' attention and action, as an investment in the valley's continued economic success.

Bighorn sheep graze in Glacier's alpine meadows

PHOTO:LARRY STOLTE

In a tunnel on the Going-to-the-Sun Road

PHOTO:KAREN NICHOLS

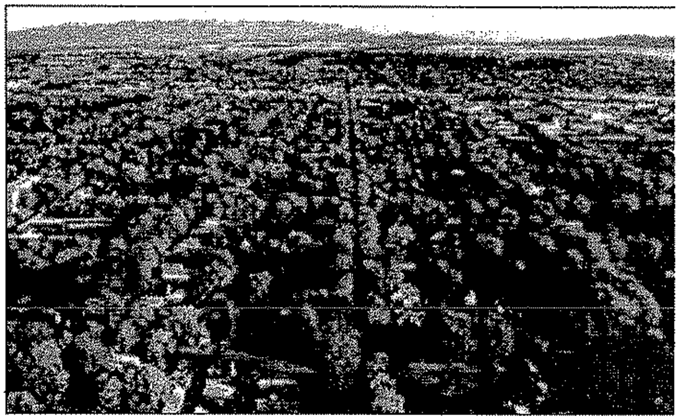


Flathead communities must encourage high-quality economic growth and development

The Flathead economy might best be thought of as a "transitional" economy. Across the country, resource industries such as wood products and metals processing are playing a smaller economic role. In the Flathead, troubles caused in part by declines in these long-standing pillars of the local economy have been offset in the 1990s by economic expansion closely linked to an influx of new valley residents.

The valley's growing popularity has been such a strong force that the local economy has become largely driven by, and dependent on, that growth. To ensure long-term prosperity, the Flathead must use its current strength to retool the valley's economy so it remains strong and resilient, even when population growth subsides.

For now, the Flathead's popularity remains high. Over the longer term, however, growth may degrade the very assets that make the area an attractive place to live.



Downtown Kalispell maintains its small-town feel

PHOTO: KAREN NICHOLS

Quantitative growth—more people, more jobs, and more income—is a given for now. The valley's communities must focus their attention on promoting "qualitative" growth—change that improves the well-being of Flathead residents and protects the area's most vital economic assets. The influx of new full-time and part-time residents has brought more jobs and income, volunteer energy, tax revenues, ideas, and other resources to valley communities. This puts the Flathead in a position to better guide growth and development to support local values.

Quality Economic Development

The economic setbacks of the 1980s have been more than offset by a resurgence in per capita income and median family income, and a drop in the area poverty and unemployment rates. Flathead County is on par with its peers in these indicators of economic well-being. Still, the community could do much to improve its residents' quality of life, and to ensure that economic growth leads to higher levels of qualitative growth and genuine economic improvement.

FIGURE 14. **Business Leaders' Views on Land Use Planning**

	More	Less	OK Now	Don't Know
Do you feel there should be more land use planning or less land use planning?	55%	24%	9%	12%

(Source: A & A Research, Kalispell Chamber of Commerce Survey, October 2001)

Joel Bonda, Kalispell

"In my work I deal with entrepreneurial high-tech firms located throughout the country, and I've asked them what factors might attract them to expand or relocate in Flathead Valley. First, they say that they would move to Montana for its environment: open spaces, big sky, pure water, fresh air. Glacier National Park is a huge part of the attractiveness of this place.

But these entrepreneurs also say, without exception, that they would only move to a state that showed total commitment to public education. They want this for their children, yes, but they say they cannot operate in today's new economy without a highly educated workforce. Not just a workforce that is literate, but one that is technologically sophisticated and that has been taught to think analytically.

Our environment and quality of life are our strongest economic assets. As a community, we can best use this asset for economic development only if we also invest in a top-notch education system. That's how the Flathead can thrive in this new economy.

Joel Bonda
Software Developer

The Flathead's greatest economic development need is to cultivate growth in better paying jobs with benefits that can fully sustain workers and their families. Because job growth is already happening, creating higher quality jobs should be the focus rather than simply creating more jobs.

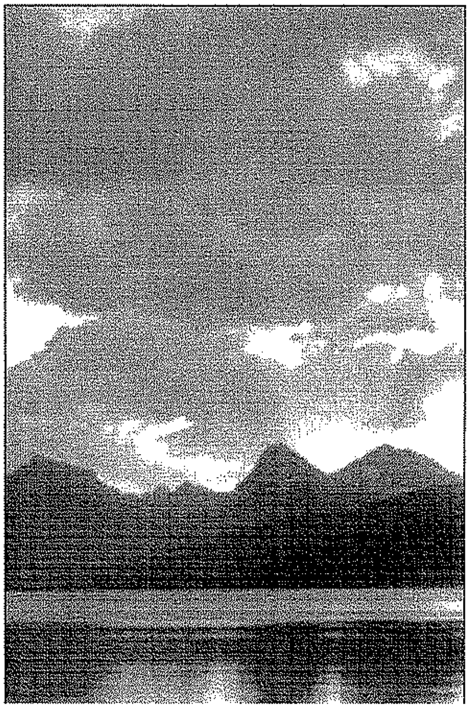
Flathead County should do all it can to foster a pool of high-quality, well-educated workers and entrepreneurs. Doing so requires a sustained public commitment to education and training. This serves to prepare future employees, and it attracts high-caliber workers and business owners with school-aged children to the area. Education and training also help workers adjust to economic transitions.

Planning for Growth

If population growth meets current forecasts, Flathead County will be home to between 87,000 and 100,000 people by 2010. As development continues, the character and appeal of the valley may be increasingly difficult to maintain. "...[N]o place will retain its special appeal by accident," writes Ed McMahon, co-author of *Balancing Nature and Commerce in Gateway Communities* (1997). He notes that gateway communities such as Flathead County are "ground zero" in the struggle between haphazard development and planned growth.[22] Haphazard development undermines the qualities that long-time community members, new residents, and visitors all find most attractive—the valley's most important economic assets.

Local business leaders interviewed for this report share a belief that unplanned growth could one day act as a drag on the region's economy and that city and county governments have not responded adequately to growth. In a survey of Kalispell residents, a solid majority of 80 percent agreed that they would support land use measures to help manage future growth in their community.[23]

In the Flathead Valley, no clear picture has yet emerged of what action would best help the valley get a handle on growth and encourage the kinds of recreational, residential, and commercial development that enhance the lives of area residents. Indeed, views diverge significantly on this question, and the local political climate may stand in the way of achieving consensus. More than half of the business leaders interviewed for this report believe that the tone of public debate in the Flathead Valley is harsh, dominated by parties with extreme viewpoints. Between the extremes is a vast middle ground and ample room for compromise and action.



Sunset on McDonald Lake

PHOTO: KAREN NICHOLS

INVESTING IN THE FUTURE

In the face of these challenges, people in the Flathead share similar concerns about the future. In separate surveys, Kalispell and Whitefish residents identified the most important issues facing their communities. Maintaining existing community character, protecting the natural environment, diversifying the economy, and supporting local business growth topped the lists.[24] Flathead residents recognize the importance of their natural and community amenities to their own quality of life and to the economic health of the valley.

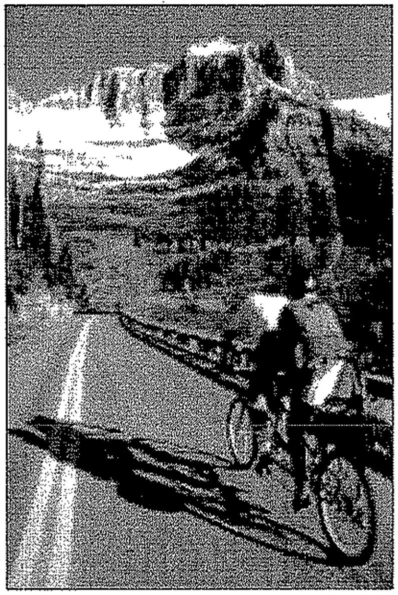
Collaborative Action

These common views can form a solid foundation for community dialogue and collaborative action. Flathead communities and their leaders need to begin sorting out "good growth" from "bad growth," and figuring out strategies to guide development.

Partnerships are critical to taking charge in the face of rapid change. In the Flathead, those partnerships must involve public land managers. The Flathead Valley's economic strength is closely linked to the health of the surrounding public lands. Similarly, the health of Glacier National Park, other public lands, and natural resources such as clean water depend on what happens within a broader context that includes the private lands and developed areas of the Flathead Valley. As the NPCA State of the Parks® assessment determined, most threats to Glacier originate outside park boundaries.

Given shortfalls in funding and staffing, Glacier National Park and other land management agencies cannot protect the valley's resources and assets without cooperation from Flathead community leaders. Broad support from its gateway communities will be essential as Glacier seeks massive congressional appropriations to fix its deteriorating infrastructure, particularly Going-to-the-Sun Road.

Dialogue and collaboration across all kinds of boundaries (including city/county, public/private, and U.S./Canada) must occur for the Flathead to create a unified effort to guide change, enhance residents' well-being, and protect the area's most important assets. If no place retains its special appeal by accident, as Ed McMahon suggests, then it is time for Flathead residents to craft clear plans and specific initiatives.



Working together in Glacier

PHOTO: KAREN NICHOLS

Forest glen in Glacier National Park

PHOTO: NATIONAL PARK SERVICE

> "Across America, dozens of communities are demonstrating that economic prosperity doesn't have to degrade natural surroundings, rob them of their character, or turn them into crowded tourist traps. Many of these initiatives resulted from partnerships involving both gateway communities and public land managers."
>
> —**Ed McMahon**, co-author of *Balancing Nature and Commerce in Gateway Communities*

Andy Feury, Whitefish

"We as decision makers must look to the future and recognize the changing face of our economies in the West. The quality of our environment and the character of our communities are fast becoming major contributors to that economy. They are our most important economic assets.

We have experienced a great deal of growth due to the beauty of the environment surrounding us and the easy recreational access to public lands. As a result of this growth, developers of all stripes want to move into our valley. We have the enviable opportunity to decide what kind of development we want, where we want it to go, and how we want it to look.

As a community, we can afford to steer development to meet our needs. We don't have to settle for whatever proposals walk in the door. In fact, we must direct development in a way that protects our core assets as an attractive, friendly place to live. To do otherwise would be unwise and unfair to future generations."

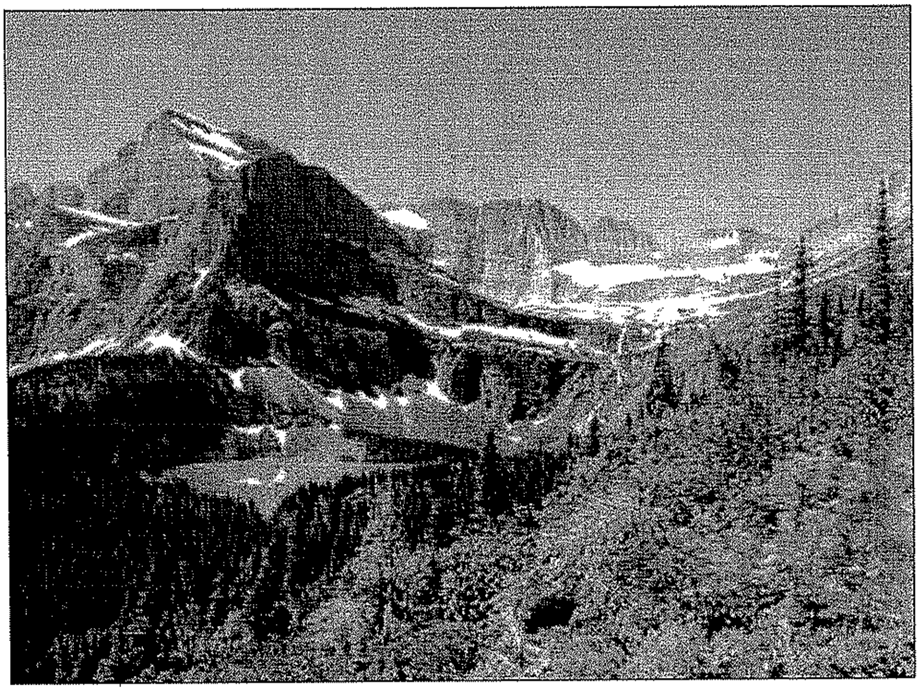
Andy Feury
Mayor of Whitefish, and
independent lumber broker

Investing in Valley Assets

Recent trends suggest that the next decade will bring many more people to Flathead County. To sustain the appeal that is at the heart of the Flathead's economic vitality, the fundamental assets of community character and environmental quality need to be protected and enhanced.

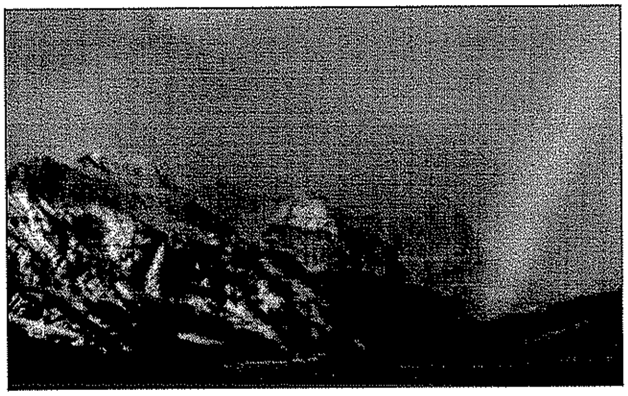
Recent trends suggest that Flathead County will see a continued influx of new residents, attracted by the area's outdoor amenities and quality of life. The economy will continue to grow, diversify, and add high-paying jobs. Yet many fear that a growing population may accelerate changes that erode the area's attractiveness.

The character of the Flathead's communities and its environmental qualities are at the heart of its appeal and economic vitality. Investing money, time, energy, and thought into protecting and enhancing these assets is an investment in the future.



Blackfeet Indians called Glacier's rugged spine the Backbone of the World. George Bird Grinnell, an early proponent of Glacier's park designation, called this region the Crown of the Continent.

PHOTO: KAREN NICHOLS



AN EXPLANATION OF TERMS

Amenity — A quality or feature that adds perceived economic value.

Gateway community — A town or group of towns that provides access to public lands such as national parks, as well as services for visitors to these natural areas.

Inflation-adjusted (real) dollars — Since the value of money changes over time due to inflation, economists account for these changes in their analyses. In this report, real dollar amounts are reported in "1996 dollars," which means that figures from years other than 1996 are adjusted to remove the effects of inflation, providing a true base of comparison.

Median income — This can be calculated for individuals, families, or households. To arrive at median family income for an area, imagine listing all of the families in that area according to the total amount of money they receive each year from all sources. The income figure in exactly the middle of that list is the median family income.

Net migration — The difference between the number of persons moving to an area and the number moving away, and considers only persons changing their permanent residence.

Natural change — The difference between the number of births and the number of deaths in a locality.

Per capita income — This is the average income per person in an area, calculated by adding all income received by all residents of an area, regardless of age, and dividing this total by the number of area residents.

Poverty rate — A U.S. Census Bureau calculation of the percentage of a population living at income levels below those deemed necessary for basic sustenance. No consideration is given to variations in the local cost of living in making poverty estimates.

Qualitative growth — Economic expansion and change that improves the well-being of area residents and protects valuable assets.

Quantitative growth — Expansion in the size of an area's economy, seen in indicators such as population growth and increasing numbers of jobs and total income.

Sector, Sub-sector — A "sector" is one of 14 major categories into which economic activity is divided. Sectors include manufacturing, construction, services, retail trade, local government, farm and ranch producers, and eight other categories. A "sub-sector" is a smaller economic division within a sector. For example, the "services" sector is comprised of activity in a number of areas including health care, business services, legal services, engineering and management services, auto repair, and so forth.

Total personal income — All money received from all sources by all individuals and households in an area.

Unemployment rate — The number of people who are not employed but who are actively seeking work, expressed as a percentage of the total adult population that is capable of working.

ENDNOTES

INTRODUCTION

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FINDING 1

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FINDING 2

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ACKNOWLEDGMENTS

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Diane Conradi
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Carol Edgar
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Andy Feury
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Independent Lumber Broker,
Whitefish, MT

Chuck Haney
Photographer,
chuckhaney.com,
Whitefish, MT

Liz Harris
President, Jobs Now, Inc.,
Kalispell, MT

Tony Jewett
Senior Regional Director,
NPCA Northern Rockies,
Helena, MT

Marti Kurth
Citizens for a Better Flathead,
Kalispell, MT

Marie Jorgensen
Director, Online
Communications, NPCA,
Washington, D.C.

Doug Lawrence
Center for the Rocky
Mountain West, Missoula, MT

Ben Long
Environmental Media Services
West, Kalispell, MT

Doug Mitchell
The Mitchell Group,
Helena, MT

Karen Nichols
Photographer,
Kalispell, MT

Tom Krustangel
Owner, Montana Tom's
Chocolate, Whitefish, MT

Dr. Mark Peterson
NPCA State of the Parks ®
Program, Fort Collins, CO

Linda Rancourt
Editor-in-Chief, NPCA,
Washington, D.C.

Ray Rasker
Sonoran Institute,
Bozeman, MT

Morrie Schechtman
Business Management
Consultant, Kalispell, MT

Brian Schott
Big Mountain Resorts,
Whitefish, MT

Velinda Stevens
Chief Executive Officer,
Kalispell Regional Medical
Center, Kalispell, MT

Larry Stolte
Photographer,
Whitefish, MT

Greg Sullivan
Independent Researcher,
Missoula, MT

Shannon Taylor
Assistant Professor of
Management, MSU-Bozeman,
College of Business

Steve Thompson
Glacier Program Manager,
NPCA Northern Rockies,
Whitefish, MT

Joe Unterreiner
President, Kalispell Chamber of
Commerce, Kalispell, MT

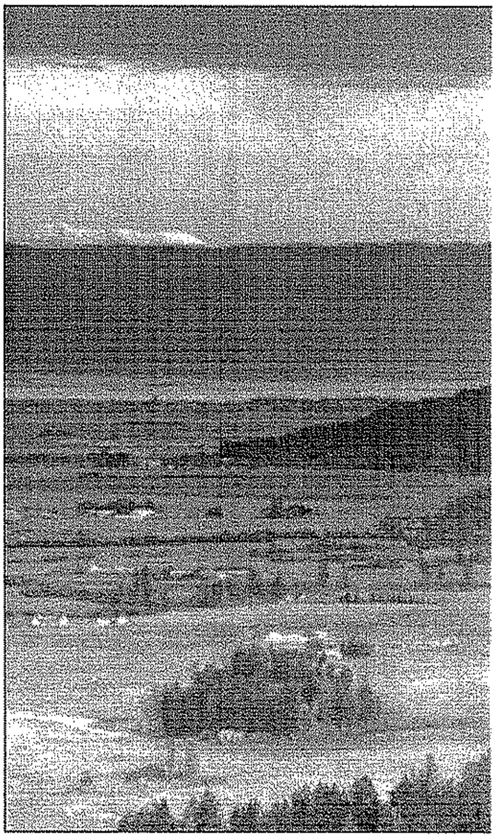
Russ Veenema
Port Angeles Chamber of
Commerce, Port Angeles, WA

Paul Wachholz
Wachholz and Company Real
Estate, Kalispell, MT

Brad Weis
Photographer,
scanneryrow.com, Moab, UT

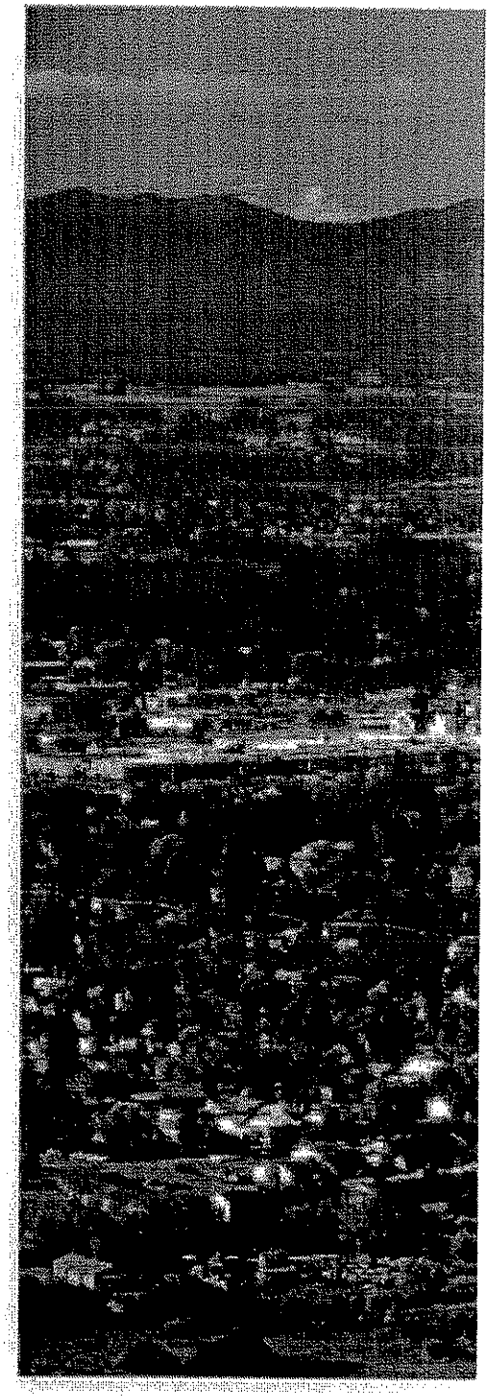
Flathead Lake near Somers

PHOTO: KAREN NICHOLS



Gateway to Glacier

The Emerging Economy of Flathead County



National parks exert a powerful pull on the American people. They rejuvenate us and they preserve our cultural and natural wonders. Every year, tens of millions of Americans visit our national parks.

But from an economic perspective, national parks do much more than draw visitors. Today, Americans in growing numbers choose to locate their families and businesses in gateway communities next to our national parks.

Growth brings change and change brings challenges. Fortunately, many gateway communities are forming creative partnerships to ensure that growth does not degrade the natural environment and community character that make these places so special.

—Tom Kiernan,
President, National Parks Conservation Association

National Parks
Conservation Association

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Healthy Communities

1300 19th St. NW, Suite 300
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1-800-NAT-PARK (628-7275)
www.npca.org

Northern Rockies
Regional Office
PO Box 824
Helena, MT 59624
406-495-1560

Glacier Field Office
PO Box 4485
Whitefish, MT 59937
406-862-6722

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CPC Ex 70

Aaron Bennett

915 Oliverea Road
Big Indian, NY 12410

(845) 254-9977
abennett@catskillcenter.org

EDUCATION

State University of New York College of Environmental Science and Forestry (SUNY ESF):
Bachelor of Science Degree in Water Resource Management in May of 1997.

EXPERIENCE

- **7/00-Present:** Watershed Coordinator for The Catskill Center for Conservation and Development and Hudson Basin River Watch. Coordinate existing and recruit new volunteer and student water quality monitoring groups and conduct trainings within the Catskills and NYC Watershed in addition to handling water resource issues in the Natural Resource Program at the Center. I have since hired three AmeriCorps members to assist with stream monitoring and watershed education efforts with students in grades 3-12.

- **7/01 – Present:** Webmaster for the Catskill Center, the Catskill Watershed Corporation, and the Olive Natural Heritage Society; updating and adding information and components to those sites.
Designed other web sites (www.catskilltowers.com, www.WatershEducators.org, www.catskillpark100.org).

- **7/00 –6/01:** Part-time Education Associate for the Catskill Watershed Corporation. Established an Educators' Network web site linking educators, teachers, resource people, and organizations in NYC Watershed with those in the City. Compiling and evaluating CWC Education Grants Program's funded projects.

- **9/98-6/00:** AmeriCorps Watershed Educator on the Building Watershed Bridges Team of the Youth Resource Development Corporation in Poughkeepsie, NY. Based at The Catskill Center for Conservation and Development, work included:
  - Providing fifteen Catskill region schools in five counties with the popular *Streamwatch* program in the spring and fall months. The majority of the audience was in grades 4-9.
  - Writing curricula (3rd-12th grade) for the first two components (*Water Resources* and *Geography and Geology of the Catskills*) of The Center's education initiative *The Catskills: A Sense of Place*. This five-part curriculum guide focuses on the six-county Catskill region.

- **4/98-5/98:** Staff member at the Wolverine Outdoor Education Camp for 4th-8th grade students in Wolverine, MI.

- **5/98:** Water quality monitoring volunteer for the Tip of the Mitt Watershed Council's report on the lakes of Northern Michigan.

INTERESTS / INVOLVEMENTS

Board President - *Pine Hill Community Center*
Tremper Mountain Fire Tower Committee
Catskill Institute for the Environment

Treasurer - *Olive Natural Heritage Society*
PEAG Member (Public Education and Advisory Group) of the Catskill Watershed Corporation

A NYS-certified licensed hiking guide
Co-author of an outdoor column for the *Phoenicia Times*

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CPC Ex 71

The DEC Policy System

	Department ID:	Program ID: NR -

Title: Adopt-a-Natural Resource

Issuing Authority: Name: Peter S. Duncan Title: Deputy Commissioner Signature: Date: Issuance Date: **DRAFT January 7, 1998**	**Originating Unit:** Office/Division: Natural Resources/ Lands & Forests Unit: Public Lands Phone: (518) 457-7433 Latest Review Date (Office Use):

Abstract: This policy provides the system for the Department to enter into stewardship agreements with individuals and organizations for activities which help preserve or enhance natural resources on lands under its jurisdiction.

Related References: Environmental Conservation Law Section 9-0113.

I. Purpose

The purpose of this policy is to foster public participation in the Adopt-A-Natural-Resource Stewardship Program authorized by Section 9-0113 of the Environmental Conservation Law.

II. Background

The Department of Environmental Conservation is responsible for the management of natural resources on lands under its jurisdiction. With the intent of improving the environmental quality of those natural resources at minimum cost to the state, 1995 legislation established an Adopt-A- Natural Resource Stewardship Program (Section 9-0113, ECL) effective July 28, 1995.

Volunteerism is the cornerstone of this program. It is a means for completing work that helps preserve, maintain and enhance natural resources at minimum cost to the state. Individuals and groups interested in providing volunteer services are afforded a formal opportunity to propose activities that meet management needs of state-owned natural resources. Such activities may involve remediating vandalism, picking up litter and trash, establishing or maintaining access or nature trails, providing interpretive services for school groups and other citizens, managing fish and wildlife habitats, and otherwise providing positive benefits to the natural resource.

The statute authorizes the Department to use a stewardship agreement for activities it approves for the preservation, maintenance, or enhancement of state-owned natural resources. Application procedures must be established for the Department's use in considering stewardship proposals. At its discretion, the Department may provide the assistance of personnel, facilities and supplies in support of activities in the stewardship agreement. Consistent with all other laws and regulations, stewardship activities shall be recognized through placement of appropriate signs on or near the adopted natural resource. Other forms of recognition, including but not limited to certificates, press releases, and newsletters may be provided, as the Department deems appropriate.

The stewardship agreement may be modified upon mutual agreement by the Department and the Steward. Stewards shall have the option to renew agreements subject to approval by the Department and its continuation of the program. Agreements may be terminated if the Department determines that conditions of the agreements are not being met.

III. Policy

It is the policy of the Department of Environmental Conservation to foster public participation in the Adopt-A-Natural Resource Stewardship Program to help preserve, maintain and enhance natural resources on lands under its jurisdiction at minimum cost to the state

IV. Responsibility

The responsibility for interpretation and update of this document, and overall management shall reside with the Office of Natural Resources, or its successor.

V. Definitions

1) Natural Resource - for the purpose of this program, natural resource shall mean all natural areas and related assets under the jurisdiction of the Department.

2) Respective Management Authority - Either the Division of Fish, Wildlife and Marine Resources or the Division of Lands and Forests or the Division of Mineral Resources, depending on which division has the administrative authority for the adopted natural resource.

3) Steward - The person who signs the Adopt-A-Natural Resource Stewardship Agreement as an individual; or organization or group, acting by or through its duly authorized

representative,
which assumes responsibility for the activities and related conditions stated therein.

4) Adopted Natural Resource - A natural area or asset, owned by the State of New York, under the jurisdiction of the Department of Environmental Conservation, and covered by an agreement under the Adopt-A-Natural Resource Stewardship Program.

5) Department - The New York State Department of Environmental Conservation.

VI. Procedure

The Department will invite and encourage individuals and groups to become active supporters of natural resource management through participation in the program. They will be informed about the purpose of the program, the procedures for entering into stewardship agreements and the responsibilities of undertaking a stewardship agreement.

These implementation efforts are to ensure public understanding that any stewardship activities undertaken through this program must help the Department meet its natural resource management objectives at minimum cost to the state. Adopt-A-Natural-Resource Stewardship Program applications should be submitted to the appropriate Respective Management Authority.

The following guidelines provide the basis for Respective Management Authority review of stewardship proposals to render judgment of their suitability, the prospect for satisfactory completion and the availability of Department staff for oversight and support.

A. Application

1. Individuals or groups who wish to adopt a state-owned natural resource shall be given an application and information describing the stewardship program.

2. Applications for natural resource adoption shall be submitted to the Respective Management Authority.

3. Applicants shall provide the names and social security numbers of all individuals who participate in the project. The Respective Management Authority shall complete a HR-3 form for each project. The starting and ending dates of proposed activities shall be shown on the application. This information is needed to afford liability and workers' compensation protection to the participants.

4. Activities must be in conformance with all applicable laws, regulations, policies and approved Unit Management Plans. In the absence of a plan, interim authorization of activities may be given by the Respective Management Authority. The Department may consider factors such as safety, environmental sensitivity, need, cost and other factors deemed relevant in determining which natural resource or activities may be eligible or appropriate for a

stewardship agreement.

B. Agreement

1. Upon approval of the application, the Respective Management Authority and the Steward shall review the proposed stewardship activities and other conditions of the agreement.

2. A Stewardship Agreement shall be completed and signed by both the Department and the Steward for each approved Adopted Natural Resource. Project specific conditions shall be a part of all agreements.

3. Stewardship activities may be amended in the agreement upon mutual agreement by the Department and the Steward.

4. The Department may suspend all activities immediately and may revoke the agreement on thirty days written notice to the Steward, at any time during the duration of the agreement, if the conditions of the agreement are not being met. The Steward shall provide the Department thirty (30) days written notice prior to terminating the agreement.

5. Stewardship activities shall be evaluated by the Respective Management Authority annually to determine whether they merit continuation or modification.

6. As volunteers, participants in the program are accorded the same liability and workers' compensation protection as salaried state employees, provided they are acting within the scope of the agreement.

7. The Department shall provide recognition of the stewardship activities by appropriate signage on or near the adopted natural resource and may provide recognition by such other measures as it may determine to be appropriate.

8. The Commissioner authorizes the Regional Directors to enter into stewardship agreements on his behalf.

9. Generally stewardship agreements will be issued regionally. However, an agreement involving more than one region may be issued, provided it is signed by the Director of each region involved.

10. Copies of all approved stewardship agreements shall be forwarded to the appropriate Division's Central Office.

Appendix I

NEW YORK STATE
DEPARTMENT OF ENVIRONMENTAL CONSERVATION
ADOPT-A-NATURAL RESOURCE STEWARDSHIP PROGRAM

APPLICATION

Participation in the Adopt-A-Natural Resource Stewardship Program is subject to:
1) completion of this application, 2) submission to the Department Office of the Respective Management
Authority indicated below, and 3) review and approval by that office. The accompanying information on the program should be read carefully before completing this application.

Your Name: ______________________________
Your Address: ______________________________
____
____

Telephone (home):__________ (work) __________

The activities of the Steward will be performed as (check one) :
__________ an individual; __________ an organization or group.

If activities are to be performed as an organization, or group, please indicate its :
Group Name: ______________________________
Group Address: ______________________________
____
Your office or authority: ______________________________

Please describe the activities you would like to perform as the Steward of a natural resource :

____

____

____

____

In addition to this application, it may be necessary to complete administrative forms and provide a copy of the by-laws or charter where formal organizations are involved.

Applicant Signature: ______________________________ Date: ______________

This application should be submitted to the following DEC Office:

____

____

____

____

Appendix II

New York State Department of Environmental Conservation

Stewardship No. ____________________

Project ____________________

Acres ____________________

ADOPT-A-NATURAL RESOURCE STEWARDSHIP PROGRAM

This agreement, made between ______________________________, residing at

____

, hereinafter called the "Steward"; and the Department of Environmental Conservation of the State of New York, hereinafter called the "Department".

WHEREAS, Section 9-0113 of the Environmental Conservation Law authorizes a stewardship program between the Commissioner and an individual, group or organization for the purpose of preserving, maintaining or enhancing a state-owned natural resource or portion thereof in accordance with the policies of the Department; and,

WHEREAS, there is need for the services and support of volunteers provided through this new stewardship opportunity to aid the preservation, maintenance and enhancement of state-owned natural resources at minimum cost to the state:

NOW, THEREFORE, it is agreed that this Stewardship Agreement for a period of ______ years from the date hereof, shall provide that the natural resource named in this agreement be preserved and maintained in its natural state or managed to enhance or restore the natural resource values it provides, involving the activities specified in this agreement and consistent with the policies of the Department.

This natural resource is located on that certain tract of land known as ________________________ __________, and situated in the Township of ________________ County of ______________, and the State of New York containing acres more or less.

IT IS MUTUALLY AGREED THAT :

1) **Activities**

Activities of the Steward permitted on this natural resource are :

____

(Use additional sheets and attach as a part of this agreement, if necessary)

2) **Technical Services**

Assistance provided by the Department shall consist of :

3) **Responsibilities**

The Steward is responsible for :

a) completing the activities in the matter agreed upon with the Department.

b) providing the identification of each volunteer, including Social Security number, in advance of the performance of activities. This information is needed to afford the participants liability and workers' compensation protection. (The participant list shall be kept current and attached as part of the agreement).

c) complying with the Child Labor Law, as it pertains to under-aged volunteers; parent signature is required for volunteers under the age of 18 and volunteers under 16 may only participate in yard/household type work activities (no machinery) as part of an organization.

d) reporting to the Department annually, on work accomplished and number of volunteer hours spent on activities.

e) discussing with the Department's contact person any problems, disagreements, questions of interpretation regarding the agreement or other concerns as soon as possible.

The Department is responsible for :

a) completing a HR-3 form (Volunteer/IPA Application).

b) evaluating stewardship activities annually to determine their merit for continuation.

c) discussing with the Steward's contact person any problems, disagreements, questions of interpretation regarding the agreement or other concerns as soon as possible.

4) **Contacts**

The contact person for the Steward is ______________________, who may be reached at the following address and telephone number ______________________ ______________________. The contact person for the Department is

________________________________who may be reached at the following address and telephone number____

____

.

5) **Recognition**

The Department shall provide recognition of the stewardship activities by appropriate signage on or near the adopted natural resource and may provide recognition by such other measures as it may determine appropriate.

6) **Land Use**

Nothing contained herein shall prevent or hinder the Department from carrying out its regular activities on, nor alter or change the traditional access to and public use of the lands covered by this agreement.

7) **Agreement and Renewal**

This agreement may be modified in scope or altered in any other manner, upon mutual agreement by the Department and the Steward. The Steward shall have the option of renewing the agreement with the approval of the Department and subject to the continuation by the Department of the Adopt-A-Natural-Resource Stewardship program.

8) **Termination**

The Department may terminate this agreement and remove signs upon thirty (30) days written notice, if in its sole judgment it finds and determines that the Steward or anyone working thereunder are not meeting the terms and conditions of this agreement. The Steward shall provide the Department thirty (30) days written notice prior to terminating this agreement.

9) **Liability Protection**

As volunteers, participants in the program are accorded the same liability and workers' compensation protection as salaried state employees, provided they are acting within the scope of the agreement.

10) **Special Conditions**

Special conditions of this agreement are :____

____

____

____

____

Date of Agreement ______________________

Steward ______________________
(Print)

Address ______________________
____

Signature ______________________
(Individual or Authorized Representative)

Date ______________________

Commissioner of Environmental Conservation

By: ______________________

Title: ______________________
(Authorized Representative)

Signature ______________________

Date: ______________________

Appendix III

page ____ of ____

New York State Department of Environmental Conservation
ADOPT-A-NATURAL-RESOURCE PARTICIPANT LIST

Stewardship No. ______________
Project ______________

Name: ______________	Name: ______________
Signature: ______________	Signature: ______________
Social Security No. ______________	Social Security No. ______________
Name: ______________	Name: ______________
Signature: ______________	Signature: ______________
Social Security No. ______________	Social Security No. ______________
Name: ______________	Name: ______________
Signature: ______________	Signature: ______________

Social Security No. ______________________

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Name: ______________________
Signature: ______________________
Social Security No. ______________________

NEW YORK STATE DEPARTMENT OF ENVIRONMENTAL CONSERVATION
DIVISION OF MANAGEMENT AND BUDGET SERVICES
BUREAU OF PERSONNEL SERVICES

VOLUNTEER/IPA APPLICATION

NAME (First, MI, Last)

TELEPHONE (Home)

ADDRESS (Street and No.)

TELEPHONE (Business)

CITY, STATE, ZIP CODE

SOCIAL SECURITY NO.

LEGAL RESIDENCE (If different from above)

DIVISION

BUREAU

WORK LOCATION CITY/STATE

COUNTY

REGION

SUPERVISED BY

DATES OF VOLUNTEER/IPA WORK

/ / Beginning

/ / Ending

NATURE OF WORK (Use reverse side, if necessary)

EMPLOYMENT (If presently employed, list employer)

Name, Address, Phone Number and Business of Employer

Title and Duties:

Name and Title of Supervisor:

Additional Questions:

☐ Yes ☐ No Were you ever discharged from any employment except for lack of work, funds, disability or medical condition?

☐ Yes ☐ No Did you ever resign from any employment rather than face discharge?

☐ Yes ☐ No Did you ever receive a discharge from the Armed Forces of the United States which was other than "Honorable" or which was issued under other than honorable conditions?

☐ Yes ☐ No Have you ever been convicted of any crime (felony or misdemeanor)?

☐ Yes ☐ No Are you now under charges for any crime?

If you answered "yes" to any of the above questions, please explain on a separate sheet or on the reverse side. None of the above circumstances represents an automatic bar to volunteer work. Each case is considered and evaluated on individual merits in relation to he duties and responsibilities of the position(s) for which you are applying.

OVER

REMARKS OR ADDITIONAL INFORMATION

IN CASE OF EMERGENCY, PLEASE NOTIFY:

NAME: ____________________

TELEPHONE:

Home: ____________________ Work: ____________________

I certify that the answers on this Volunteer/IPA Application are correct to the best of my knowledge and belief and that a false statement knowingly made may be considered cause for termination of volunteer/IPA service.

Signature ____________________ Date ____________________

Requests for reasonable accommodations necessary to insure full participation in our interview and selection process should be addressed to the Affirmative Action Officer, 50 Wolf Road, Albany, New York 12233 (518) 457-7411.

THE NEW YORK STATE DEPARTMENT OF ENVIRONMENTAL CONSERVATION DOES NOT DISCRIMINATE ON THE BASIS OF RACE, COLOR, NATIONAL ORIGIN, GENDER, RELIGION, SEXUAL ORIENTATION, AGE, MARITAL STATUS OR DISABILITY IN EMPLOYMENT OR PROVISION OF SERVICES.

PERSONAL PRIVACY PROTECTION NOTIFICATION

The information you are providing on this application is being requested to meet the Department's legal obligations. It will be used in accordance with Section 96 of the Personal Privacy Protection Law. Failure to provide the requested information may result in your disqualification as a volunteer/IPA. The information will be maintained by the Director of Personnel Services, Department of Environmental Conservation, 50 Wolf Road, Albany, New York 12233 (518) 457-3263.

NITIATED BY: Bureau Head/Section Chief	APPROVED BY: Division/Region	CERTIFIED BY: Personnel Administrator

OVER

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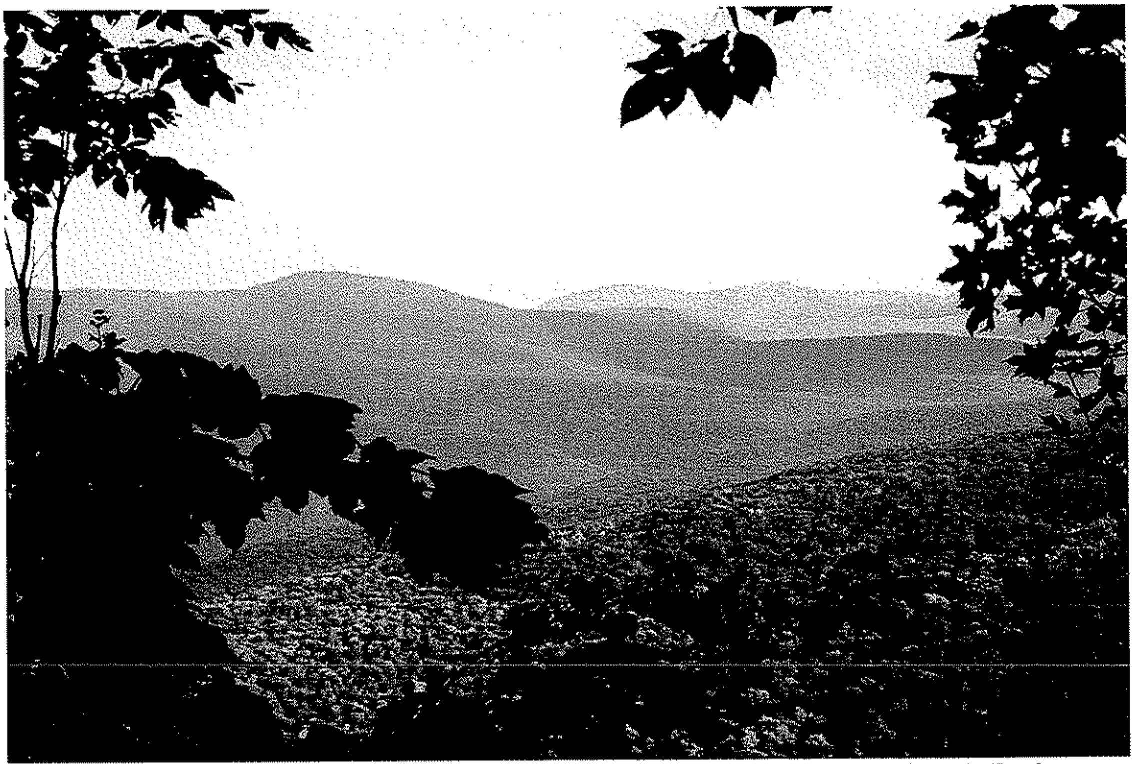
CAC 72


(L to R): View of Panther, Giant Ledge, Wittenberg, and Cornell Mtn's from Simon's Rock


(L to R): View of Slide and Balsam Mountains from Simon's Rock

73

Burger

United States
Department
of Agriculture

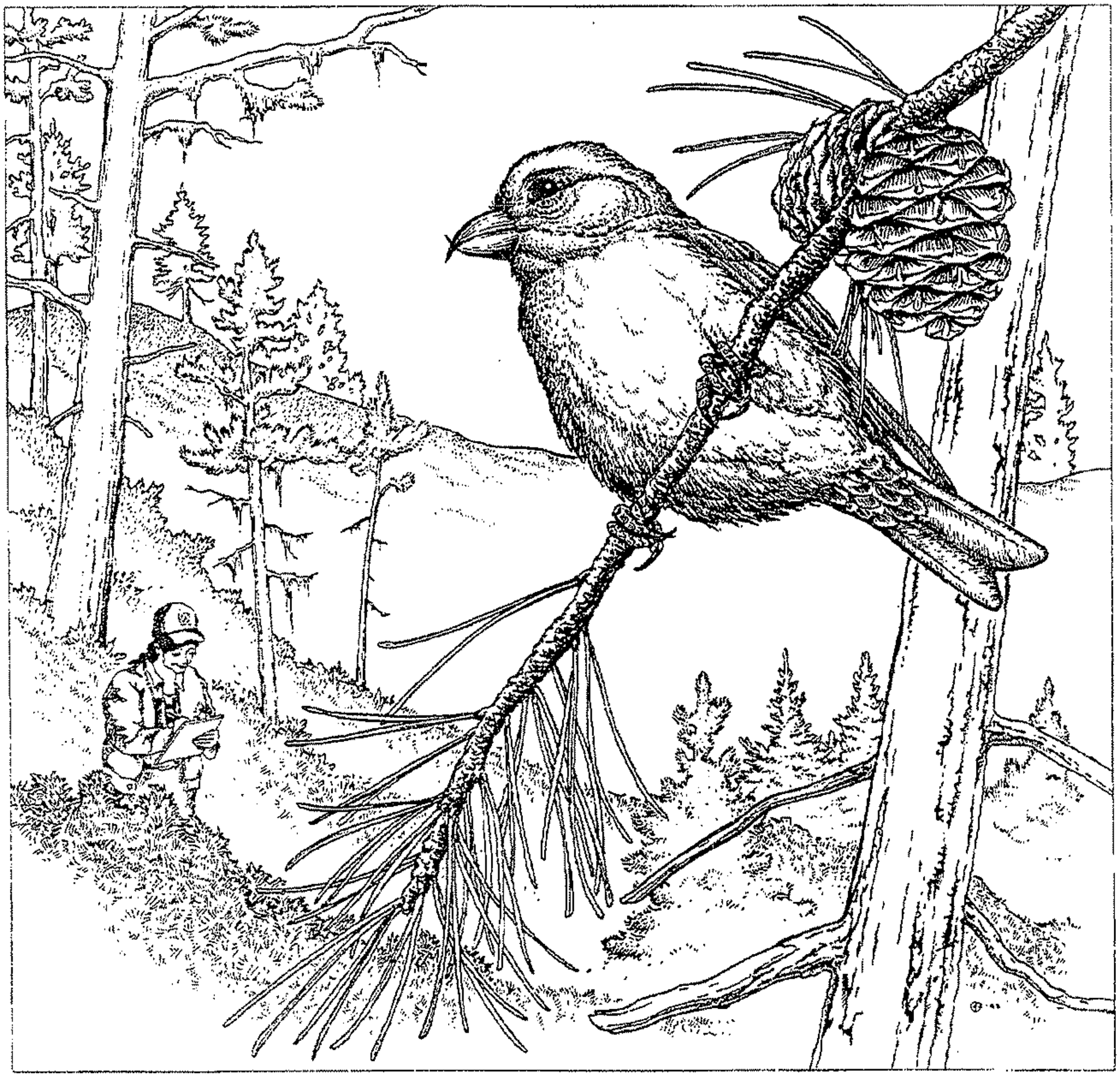
Forest Service

Pacific Southwest
Research Station

General Technical
Report PSW-GTR-149

Monitoring Bird Populations by Point Counts

CPC
Ex 73



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April 1997

Pacific Southwest Research Station

Forest Service
US Department of Agriculture

Abstract

Ralph, C. John; Sauer, John R.; Droege, Sam, technical editors. 1995. **Monitoring Bird Populations by Point Counts.** Gen. Tech. Rep. PSW-GTR-149. Albany, CA: Pacific Southwest Research Station, Forest Service, U.S. Department of Agriculture; 187 p.

This volume contains in part papers presented at the Symposium on Monitoring Bird Population Trends by Point Counts, which was held November 6-7, 1991, in Beltsville, Md., in response to the need for standardization of methods to monitor bird populations by point counts. Data from various investigators working under a wide variety of conditions are presented, and various aspects of point count methodology are examined. Point counts of birds are the most widely used quantitative method and involve an observer recording birds from a single point for a standardized time period. Statistical aspects of sampling and analysis were discussed and applied to the objectives of point counts. Symposium participants agreed upon standards of point counts that should have wide applicability to a variety of habitats and terrain.

Retrieval Terms: Bird counts, bird populations, census methodology, evaluation, monitoring, point counts, sampling of populations, standards of censusing

Technical Editors:

C. John Ralph is a Research Wildlife Biologist at the Station's Timber/Wildlife Research Unit, Redwood Sciences Laboratory, 1700 Bayview Drive, Arcata, CA 95521. **John R. Sauer** and **Sam Droege** are Research Wildlife Biologist and Wildlife Management Biologist, respectively, at the Patuxent Wildlife Research Center, USDI National Biological Service, Laurel, MD 20708.

Final drafts of manuscripts in these Proceedings were edited by Sandy Young and Shimon Schwarzschild, and the layout was prepared by Kathryn Stewart, Pacific Southwest Research Station, USDA Forest Service. Cover art by Gary Bloomfield.

Sample Size and Allocation of Effort in Point Count Sampling of Birds in Bottomland Hardwood Forests[1]

Winston P. Smith, Daniel J. Twedt, Robert J. Cooper, David A. Wiedenfeld, Paul B. Hamel, and Robert P. Ford[2]

Abstract: To examine sample size requirements and optimum allocation of effort in point count sampling of bottomland hardwood forests, we computed minimum sample sizes from variation recorded during 82 point counts (May 7-May 16, 1992) from three localities containing three habitat types across three regions of the Mississippi Alluvial Valley (MAV). Also, we estimated the effect of increasing the number of points or visits by comparing results of 150 four-minute point counts obtained from each of four stands on Delta Experimental Forest (DEF) during May 8-May 21, 1991 and May 30-June 12, 1992. For each stand, we obtained bootstrap estimates of mean cumulative number of species each year from all possible combinations of six points and six visits. ANOVA was used to model cumulative species as a function of number of points visited, number of visits to each point, and interaction of points and visits. There was significant variation in numbers of birds and species between regions and localities (nested within region); neither habitat, nor the interaction between region and habitat, was significant. For $\alpha = 0.05$ and $\beta = 0.10$, minimum sample size estimates (per factor level) varied by orders of magnitude depending upon the observed or specified range of desired detectable difference. For observed regional variation, 20 and 40 point counts were required to accommodate variability in total individuals (MSE = 9.28) and species (MSE = 3.79), respectively, whereas ±25 percent of the mean could be achieved with five counts per factor level. Sample size sufficient to detect actual differences of Wood Thrush (*Hylocichla mustelina*) was >200, whereas the Prothonotary Warbler (*Protonotaria citrea*) required <10 counts. Differences in mean cumulative species were detected among number of points visited and among number of visits to a point. In the lower MAV, mean cumulative species increased with each added point through five points and with each additional visit through four visits. Although no interaction was detected between number of points and number of visits, when paired reciprocals were compared, more points invariably yielded a significantly greater cumulative number of species than more visits to a point. Still, 36 point counts per stand during each of two breeding seasons detected only 52 percent of the known available species pool in DEF.

Despite the extensive literature on estimating numbers of terrestrial birds (e.g., Scott and Ralph 1981), general agreement over a standardized protocol for monitoring Neotropical migrant birds using point counts is only now being achieved (Ralph and others 1993). Required sample sizes using point counts and allocation of effort among points and visits to points are poorly understood. Monitoring efforts applied over a large region (e.g., lower Mississippi Alluvial Valley) need to accommodate local, habitat, and regional variation in Neotropical migratory bird species distribution and abundance. Only then can we hope to achieve optimum sampling protocols, i.e., provide sufficient ecological information with the least amount of sampling effort.

This paper examines sample size requirements for point count surveys in bottomland hardwood forests of the Mississippi Alluvial Valley (MAV). Specific objectives were to determine (1) minimum sample size to accommodate the variation in bird species distribution and relative abundance throughout the MAV; (2) the optimum number of points to sample at each locality; and (3) the optimum number of counts at each point during a season.

Methods

Study Areas

For this paper, we compiled data from two studies. To estimate variability throughout the MAV, we developed a balanced study design that included three point counts at each of three localities within each of three habitats (Wet, Mesic, Dry). This sampling design was repeated in each of three regions (Southern, Central, Northern) of the lower MAV (i.e., 3 x 3 x 3 x 3) for a total of 81 point counts. Wet habitat localities were characterized by cypress (*Taxodium* sp.) or tupelo (*Nyssa* sp.). Mesic habitat localities were seasonally flooded, lowland flatwoods, whereas Dry habitat localities were ridges or rarely inundated bottomland forests. Each locality was >40 ha to accommodate three randomly selected points that were at least 250 m apart (Ralph and others 1993) and >200 m from the forest edge.

In addition, Delta Experimental Forest (DEF), Stoneville, Mississippi was the site of a 2-year study (1991-1992) examining the influence of forest management on breeding bird abundance and diversity (Smith 1991). DEF encompasses about 1,050 ha and represents one of the few remaining large (≥100 ha), contiguous bottomland forests in a 100-km radius.

Point Count Protocol

With few exceptions, we followed the general guidelines and procedures for point count censusing of birds by Ralph and others (1993). Point counts within the lower MAV were of 10-minute duration (with cutoffs at 3 and 5 min as well) and occurred during the first four hours after dawn (i.e., before 1000 CDT). Each point was visited once during May 7-16, 1992. An assistant estimated distance to each bird according to predefined landmarks and recorded data. Before each count began, distance to selected landmarks was estimated with a rangefinder (Ranging Optimeter 620, Ranging Inc., East Bloomfield, NY). Landmarks were used to assign birds seen or heard to one of three concentric distance bands: <25 m; 25 m to 50 m; or >50 m. When necessary, the

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[1] This paper was not presented at the Workshop on Monitoring Bird Populations by Point Counts but is included in this volume because of its relevance.

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rangefinder was used to verify the distance band within which individual birds should be recorded.

Briefly, we found (Smith and others 1993) that the 50-m distance band and a sampling period of 5 minutes provided the most favorable results with respect to recording number of species per unit effort. Therefore, for the purposes of this study, we will use only data recorded using those constraints.

On DEF, we established 25 randomly selected points within each of four stands: two silvicultural treatments and a paired control for each treatment. One treatment was a 1937 clearcut that regenerated naturally; the second underwent timber stand improvement cuts in 1937. Each control had not been managed since the last high-grade harvest (mid-1930's). To minimize the potentially confounding influence of treatment effects on habitat structure and probability of detection, we recorded birds seen or heard within a 20-m radius of each point.

Within each stand, each point was systematically sampled five to seven times during the 3-hour period following sunrise from May 8 to May 21 in 1991, and from May 30 to June 12 in 1992. A sampling schedule was implemented whereby each point within a stand was visited on separate days at a different time on each of the subsequent visits. Each census consisted of recording all birds seen or heard within 20 meters of the observer per minute, for a total of four minutes.

Data Analyses

Calculation of minimum sample size followed Neter and Wasserman (1974:492) for a specified α (probability of rejecting the null hypothesis when it should be accepted), β (probability of not rejecting the null hypothesis when it should be rejected), and ϕ, the non-centrality parameter (*appendix A*). Specifying ϕ requires determining how much factor (i.e., treatment) level means (e.g., region) must differ to represent a statistical difference (Neter and Wasserman 1974). For this paper we chose three different specifications for ϕ. The first reflected the observed variation of variables among each of the main effects, i.e., region, habitat, and locality. Here, the range of mean values observed for a dependent variable relative to each effect (e.g., mean number of species in each of the regions, or mean number of a species among habitats) was used to calculate ϕ. The other two specifications were arbitrary but represent extremes with respect to resolution: (1) sample sizes for a difference of ±0.25 to detect statistical significance if the greatest difference among factor levels was 0.25 birds, or 0.25 species, and (2) a precision of ±25 percent of the mean, which represents a coarser filter for investigating gross differences in species distribution and abundance.

From point count data recorded within DEF, we generated a matrix of mean cumulative number of species for censuses with all possible combinations of six points and six visits using the bootstrap procedure (Efron 1982). Within each stand, observations for each combination (e.g., two visits to each of four points) were obtained by randomly sampling the "population" of point counts (e.g., 150 counts: 6 visits to 25 points) recorded each year. For each randomly selected point count, location was constrained while successive visits were randomly selected. Each mean value was computed from 250 resampling iterations and represented an independent observation of a point × visit combination within the selected stand.

We used analysis of variance (ANOVA, GLM Procedure: SAS Institute, Inc. 1988:549) to determine whether significant variation in cumulative number of species occurred as a function of number of points, number of visits, or an interaction of points and visits. Scheffé's multiple comparison procedure was performed to determine which main effect means differed. We made an *a priori* simultaneous comparison using a contrast statement within the ANOVA (SAS Institute, Inc. 1988:560) to compare the 15 possible reciprocal combinations of points and visits that were conducted on Delta Experimental Forest.

Results and Discussion

Distribution of Point Counts

Although the proposed experimental design for the lower MAV study provided for a balanced design of 81 point counts (3 regions × 3 habitats × 3 localities × 3 counts), we did not find all three types of habitat in all localities. Specifically, only one Dry habitat locality was identified in the southern region, and one Wet habitat locality was not found in the Central region. Nonetheless, we generally followed our basic study design completing 82 10-minute point counts throughout the lower MAV during the period May 7-May 16, 1992 (Smith and others 1993).

On Delta Experimental Forest, Stoneville, Miss., we conducted 600 4-minute point counts from May 8 through May 21, 1991—six visits to 25 points in each of four stands. An additional 600 4-minute point counts were completed during the period May 30-June 12, 1992.

Variation among Point Counts and Minimum Sample Size

Nature and Extent of Point Count Variation

A critical aspect of this study was to characterize the nature and extent of variation that investigators may encounter in conducting point count censuses in bottomland hardwood forests. Only then can an appropriate study design with adequate sample sizes be developed (objective 1). There was significant variation in numbers of both individuals and species per count for the lower MAV. Mean number of individuals ranged from 10.8 birds/count in Wet habitat within the Central region to 20.0 birds/count in Mesic habitat within the Southern region. Corresponding values for species counts were 8.3 and 13.7, both in Wet habitat, within the Southern and Northern regions, respectively. Point counts in the Central region averaged the fewest number of individuals per census (13.2, $s = 3.07$); the Southern and Northern regions averaged 16.8 ($s = 2.20$) and 15.0 ($s = 2.16$), respectively. The Central region also averaged the fewest species per census (9.6, $s = 1.93$). Mean number of species per census in the Southern region was 10.2 ($s = 1.74$), whereas the Northern region averaged 11.2 ($s = 1.70$).

Variation among Localities and across Regions

Overall ANOVA models for both number of species and number of individuals were significant; differences between regions and localities nested within regions were significant, but neither habitat nor the interaction between habitat and region were significant (*table 1*). This result suggests that at the finer scale most of the variation in point counts occurs among locations, but less so among habitats. This may be because continuously forested habitats in the lower MAV are very similar; most habitats have comparable elevation and microrelief, experience perennial inundation, and generally support forest cover types that are similar in composition and structure. In contrast, species composition and other habitat features presumably show appreciable variation among regions.

Minimum Sample Size

There are two major approaches to estimating minimum sample size. The "non-power method" (Ott 1977) calculates the minimum sample size for a specified difference between two means, given the variance in the data, but considers only the probability of making a Type I error. The "power method" (Neter and Wasserman 1974) calculates minimum sample size relative to the probability of making Type I and Type II errors. The power method dictates minimum sample sizes greater than or equal to the non-power method and thus is more conservative.

Minimum sample size estimates for the lower MAV varied greatly according to the variable measured and scale of resolution (*table 2*); only extremely large sample sizes would accommodate all possible measurements. The sample size (given a particular variance) determines the magnitude of the difference between factor means that can be detected with statistical significance. If the difference between two means is small relative to their variance, the power of the test will probably be low. To achieve greater power in this situation usually requires very large sample sizes, even approaching infinity. Unfortunately, selecting an acceptable power for each test may often be largely subjective.

Nevertheless, one does not want all comparisons for all species to be significant. If all tests were significant, there would be little information about the relative importance of each factor in determining bird distributions. Thus, it is necessary to choose a minimum sample size that is reasonable for identifying biologically important factors, yet is achievable with reasonable effort. We calculated minimum sample sizes for a variety of differences among means, and for several different variables: number of species, number of individuals, and for species exhibiting different distributions and abundances throughout the lower MAV (*table 2*). Also, *appendix B* summarizes minimum sample sizes for 20 selected species with differences among localities across all three regions. (Scientific names of species included in *appendix B* are included in an appendix of this volume.)

For each variable in the table, we presented four minimum sample sizes (*table 2*). Note that these are minimum sample sizes for each level of a factor. Thus, the total sample size for a study comparing three regions would be three times the number given in the table. The numbers in the column called "actual difference" represent minimum sample sizes that would have been required to detect the difference in factor means according to the variation incorporated in the point counts conducted in the lower MAV. (Note that the MSE [mean square error], mean, and range were also calculated from these censuses.) The actual difference could not be statistically significant for variables with sample sizes greater than about 82, which was the number of counts conducted in the lower MAV. For example, differences among habitats (*table 2*) could have been significant only for the Prothonotary Warbler (*Protonotaria citrea*) or Red-eyed Vireo (*Vireo olivaceus*).

Sample sizes for a difference of ±0.25 birds are those that would be required for statistical significance if the greatest difference among factor levels was 0.25 birds (or 0.25 species). Since this value designates an absolute change in abundance, the relative difference identified as statistically significant will vary with the mean. When the mean is large, such as mean total number of species or number of individuals, the relative difference represented by ±0.25 is small (about 2.4 percent and 1.7 percent of the means for regional total species and total individuals, respectively). In contrast, our regional estimate of mean number of Wood Thrush (*Hylocichla mustelina*) was 0.23 per census (*table 2*); a difference of ±0.25 individuals becomes an increase or decrease of >100 percent of the mean. This was the situation for the majority of species in the lower MAV, including nine of the 20 more common species reported in *appendix B*.

Perhaps a better approach for estimating minimum sample sizes of individual species is to specify some relative change in population abundance. For this reason, we included a column in *table 2* that summarizes sample sizes for detecting differences of ±25 percent of the mean. This translates into a maximum difference among treatment means of 50 percent of the overall mean. One can readily compute sample sizes for a wide range of relative changes in abundance by simply increasing or decreasing the disparity between treatment means and overall mean (i.e., $\mu_j - \mu$; Neter and Wasserman 1974:493). Selecting an appropriate magnitude of relative change will depend on the objectives of the research or monitoring program. We calculated sample sizes required to detect variation of ±25 percent of the mean because such a difference should frequently reflect biologically meaningful changes, and it represents an achievable goal for most public and private land managers. For more detailed research endeavors such as modeling population dynamics or population viability analyses of endangered species, consistent detection of smaller relative changes may be necessary.

Finally, to provide a different perspective on the question of sample size, we presented minimum difference detected among factor level means (given the MSE) with a sample size of 70 (*table 2*). We initially selected a sample size of 70 for this exercise because it was the largest sample size value presented in the table of curves (TABLE A-10, Neter and Wasserman 1974:827). Since then, however, we recognized that 70 point counts was an achievable goal and would probably accommodate the needs of most public and private land managers. Although the values for minimum sample size vary widely, most of the values are ≤70, and many fall into the range of 40-60, especially for differences that probably are biologically meaningful. For species that have large differences relative to their overall mean (e.g., Prothonotary Warbler), sample size could be much smaller, especially if the study were designed carefully with respect to selected

Table 1—*ANOVA tables (overall models) for the number of species and individuals per count. (Region and habitat were treated as main effects with patch nested within region).*

Effect	Degrees of freedom	F	P > F
	Species		
Region	2	5.70	0.005
Habitat	2	0.32	0.730
Region*Habitat	4	1.11	0.357
Locality (Region)	6	2.82	0.017
Within	67		
	Individuals		
Region	2	7.46	0.001
Habitat	2	0.61	0.546
Region*Habitat	4	0.31	0.871
Locality (Region)	6	2.33	0.042
Within	67		

Table 2—*Minimum sample sizes calculated for several variables according to the power method with several detectable difference values among factor level means. MSE, mean, range, and actual difference were calculated from observed variation among factor levels in this study. (Unless otherwise noted, α = 0.05 and β = 0.10).*

Variable	MSE[1]	Mean[2]	Range[3]	Sample size required for: Actual difference[4]	±0.25 birds[5]	±25 percent of mean[6]	Difference[7] detected if n = 70
Total species							
Region	3.791	10.30	0.63	41	>500	5	1.192
Locality	3.759	9.60	1.87	29	>500	5	1.187
Habitat	4.143	10.30	0.69	>500	>500	5	1.245
Total birds							
Region	9.283	14.95	3.56	20	>500	5	1.866
Locality	9.174	13.21	2.63	35	>500	6	1.855
Habitat	11.272	14.95	0.87	>500	>500	5	2.056
Northern Cardinal							
Region	1.292	1.58	0.48	>200	>200	53	0.696
Locality	1.144	1.71	1.04	28	>200	44	0.655
Habitat	1.326	1.58	0.27	>200	>200	53	0.705
Prothonotary Warbler							
Region	0.563	0.95	1.38	9	58	70	0.453
Locality	0.571	0.57	0.35	>200	58	>200	0.463
Habitat	0.822	0.95	0.94	23	90	95	0.545
Red-eyed Vireo							
Region	0.358	0.52	0.79	15	37	>200	0.366
Locality	0.208	0.32	0.78	9	23	>200	0.279
Habitat	0.445	0.52	0.36	44	44	>200	0.408
Wood Thrush							
Region	0.232	0.23	0.13	>200	27	>200	0.295
Locality	0.151	0.18	0.24	58	15	>200	0.238
Habitat	0.235	0.23	0.03	>200	27	>200	0.297

[1] Mean Square Error of one-way Analysis of Variance, with three levels of treatment (for example, northern, central and southern region).

[2] Mean birds or species per count. This value is the same for Region and Habitat.

[3] Range between the means for the highest and lowest levels of treatment.

[4] Sample size that is required to get statistical significance for the actual observed difference among factor level means (range). Note that the minimum sample sizes in *table 2* were all calculated using a design with one factor and three factor levels. If more or fewer levels were used, this number would be slightly greater or smaller; however, the numbers in *table 2* are a useful approximation.

[5] Sample size that would be required to detect a significant difference of 0.25 birds (or species) above or below the overall mean.

[6] Sample size that would be required to detect a significant difference between two treatments that is between 25 percent above and 25 percent below the overall mean (that is, the difference between two treatment means of 50 percent of the overall mean).

[7] The difference (in number of birds) that could be significantly detected by a sample size of 70.

[8] Because locality was nested within region, no overall minimum sample size can be calculated for locality. The minimum sample sizes in this table were calculated from one-way ANOVA of the three patches within the central region because of the balanced sample size design.

variables and factor levels. An analysis of regional choices by Prothonotary Warblers at three factor levels would require 27 counts (nine point counts per factor level). Conversely, species that have more variation and exhibit smaller differences, such as the Northern Cardinal (*Cardinalis cardinalis*), would require larger sample sizes.

Multiple Points Versus More Visits to Points

We initially compared all possible combinations of six visits to each of six points by using ANOVA to model cumulative number of species as a function of number of points visited, number of visits to each point, and their interaction across all four stands. We considered each year independently because total species recorded in DEF during 1991 ($S = 39$) and during 1992 ($S = 55$) were substantially different, presumably because of late flooding in 1991. There was significant variation in mean cumulative species among number of points and among number of visits to each point, both in 1991 ($F \geq 91.30$, df = 35, $P < 0.0001$) and 1992 ($F \geq 89.78$, df = 35, $P < 0.0001$). There was no significant interaction between number of points and number of visits. However, the ANOVA model explained about 97 percent of the variation in mean cumulative number of species both in 1991 ($R^2 = 0.9673$) and 1992 ($R^2 = 0.9668$).

In 1991, cumulative number of species increased significantly with each added point through five points (*fig. 1*), but six points did not differ from five points ($F = 3.19$, Minimum Significant Difference = 0.7853, df = 108, $P < 0.05$). Similarly, cumulative number of species increased with each revisit up to four visits to a point station, but four visits did not differ from five visits to a point station ($F = 3.19$, Minimum Significant Difference = 0.7853, df = 108, $P < 0.01$). Also, as we increased the number of points from one to six, total increase in cumulative number of species (across all six visits) averaged 7.4 species across all stands and represented an addition of 20 percent of the species pool to our estimate. Total increase in cumulative number of species with six visits to a point station (across all six points) averaged 5.49 species, adding only 14 percent of the species pool to our estimate. In 1992, significant increases in cumulative number of species occurred with each added point through all six points, whereas significant increases with revisits occurred through four visits as in 1991 ($F = 2.29$, Minimum Significant Difference = 1.0451, df = 108, $P < 0.05$) (*fig. 2*). Average total increase in cumulative number of species with six points in 1992 was 11.82, a 21 percent increase in total number of species; six visits increased the total cumulative number of species by 8.9, a 16 percent increase in total number of species.

Although no interaction was detected between points and visits, when all possible paired reciprocals (e.g., one point-two visits vs. two points-one visit) were compared.

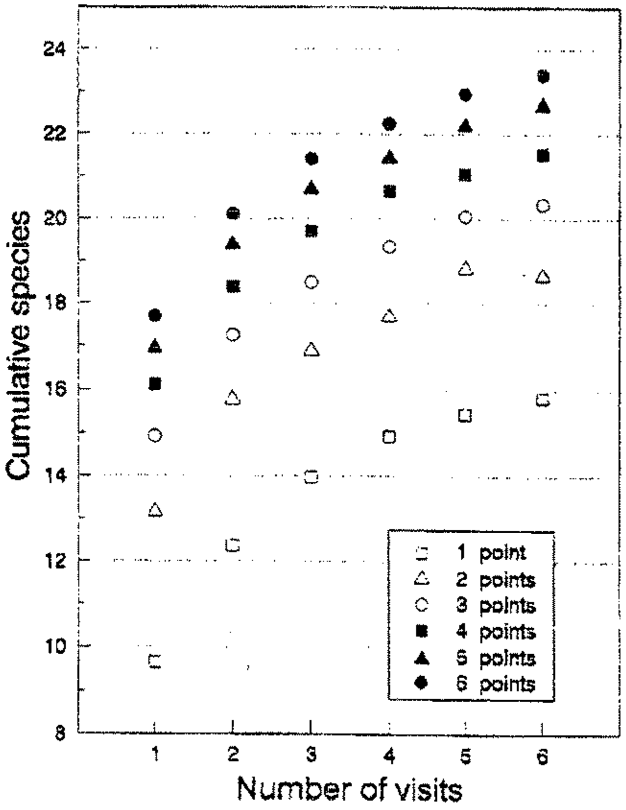

Figure 1—Cumulative number of bird species recorded during 1991 censuses for all possible combinations of six visits to each of six points on Delta Experimental Forest, Stoneville, Miss.

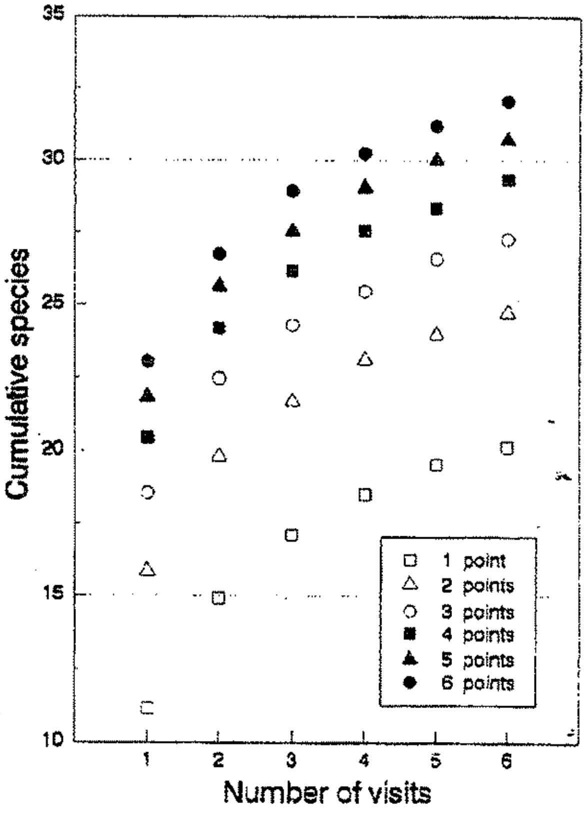

Figure 2—Cumulative number of bird species recorded during 1992 censuses for all possible combinations of six visits to each of six points on Delta Experimental Forest, Stoneville, Miss.

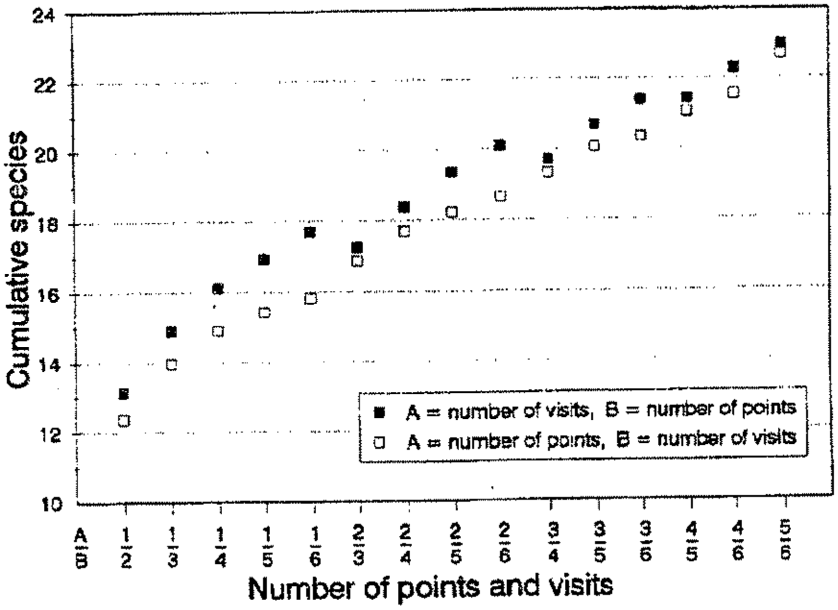

Figure 3—Comparison of cumulative number of bird species recorded between 15 possible paired reciprocals (e.g., 1 point-2 visits vs. 2 points-1 visit) of number of points visited and number of visits to each point, Delta Experimental Forest, Stoneville, Miss., 1991.

more points visited yielded significantly greater cumulative number of species than more visits to each point both in 1991 ($F = 4.34$, df = 15, $P < 0.0001$) and in 1992 ($F = 4.07$, df = 15, $P < 0.0001$). Moreover, in all individual-paired comparisons, more points visited invariably yielded more species than more visits to each point in both 1991 (*fig. 3*) and 1992 (*fig. 4*). Also, as number of points and visits approached their maximum values, increases in either had increasingly less effect on cumulative number of species recorded in 1991 (*fig. 3*) and 1992 (*fig. 4*).

Despite the suggestion that five points or four visits to each point represented sufficient sampling effort (i.e., increases beyond either level did not significantly increase total number of species), our performance relative to capturing the variation in DEF was not impressive. In both years, the maximum proportion of the total species pool (estimated by total species recorded for the entire DEF) included in our censuses (i.e., sampling efficiency) continued to increase gradually with additional points, but approached only 55 percent in 1991 and 52 percent in 1992 (*fig. 5*). Increasing revisits beyond five visits in 1991 did not improve our ability to capture more of the species pool (*fig. 6*); in 1992, a sixth visit increased the efficiency by 1.5 percent ($\Delta p_i = 0.015$). In both years, increased efficiency (Δp_i) began to decrease rapidly beyond three visits and three points.

Applications

In planning a monitoring scheme, the amount of effort (money, personnel, time) one can expend is often fixed. Often there is a tradeoff between allocation of sampling effort toward increasing the number of experimental units, which increases statistical power, or allocation of effort toward increasing the precision and accuracy of bird abundance estimates within experimental units, which decreases statistical power if overall effort remains constant. Increasing precision and accuracy can be done by visiting more points in an experimental unit or by making more visits to single points in an experimental unit.

Our results from bottomland hardwood forests suggest that, if bird abundance is to be compared among different factor levels (patch size, habitat type, silvicultural treatment), about 50 counts per factor level should be sufficient to detect most of the biologically meaningful differences. Thus, a study comparing species distribution and abundance among three forest patch-size categories would require a minimum of 150 counts (50 counts per treatment or factor level). To avoid pseudoreplication (Hurlbert 1984), an independent observation (i.e., single point count or the mean of ≥2 censuses) should be obtained from each of the 150 forest patches. Our results also suggest that up to five points should be visited per experimental unit. Increasing the number of points, rather than the number of visits to a point, is likely to be more efficient in terms of detecting new birds. After three points or visits, efficiency decreases.

Finally, another means of reducing sample size is to accept a higher probability of rejecting the null hypothesis when it is true (i.e., accept an $\alpha > 0.05$); or accept a lower probability of rejecting the null when it is false, i.e., increase ß or reduce the power of the test (Neter and Wasserman 1974). Most biologists recognize the need to report the alpha level associated with each statistical test. It is equally important to report the power of each test when the null hypothesis is not rejected (Forbes 1990). This provides the reader with explicit information regarding the likelihood that the null hypothesis was not rejected because of small sample size.

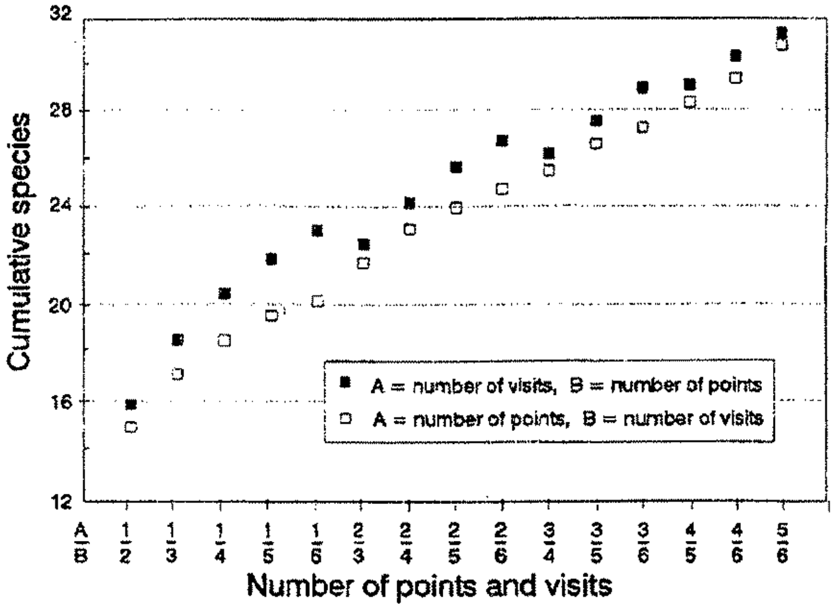

Figure 4—Comparison of cumulative number of bird species recorded between 15 possible paired reciprocals (e.g., 1 point-2 visits vs. 2 points-1 visit) of number of points visited and number of visits to each point, Delta Experimental Forest, Stoneville, Miss., 1992.

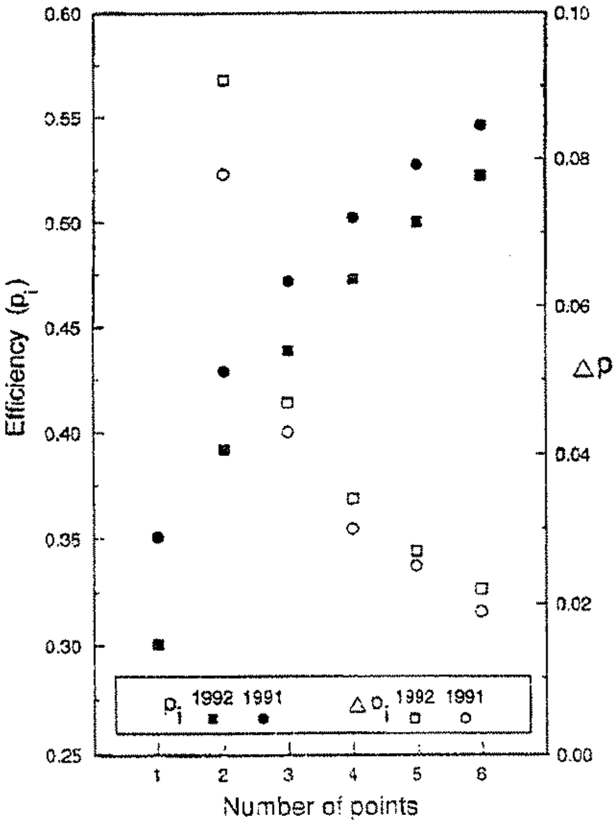

Figure 5—Proportion of 1991 and 1992 species pool included in point count censuses (EFFICIENCY, p_i) and change in efficiency (Δp_i) relative to number of points visited within a stand (averaged across all six visits), Delta Experimental Forest, Stoneville, Miss.

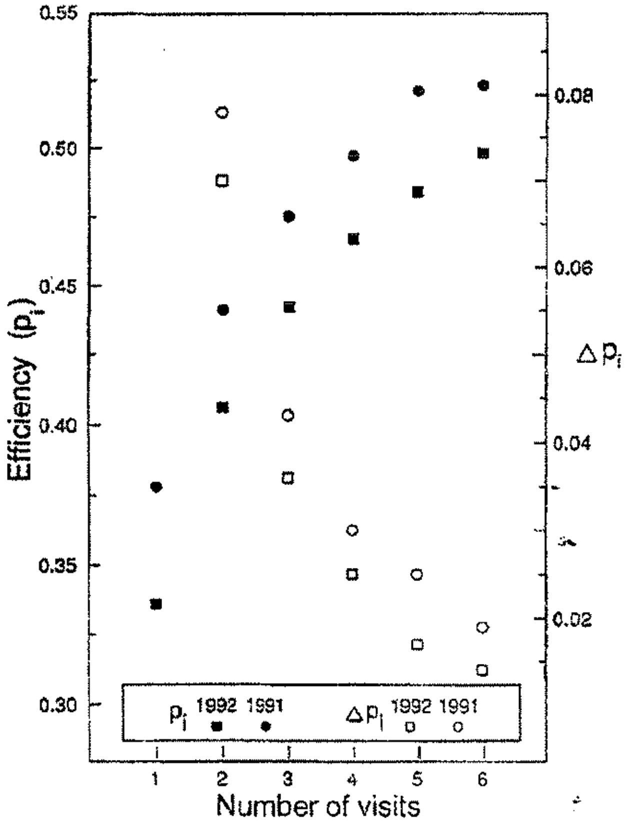

Figure 6—Proportion of 1991 and 1992 species pool included in point count censuses (EFFICIENCY, p_i) and change in efficiency (Δp_i) relative to number of visits to each point within a stand (averaged across all six points), Delta Experimental Forest, Stoneville, Miss.

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Joseph H. McGuiness and Tracy D. McCarthey provided valuable assistance with point counts of songbirds on Delta Experimental Forest. Richard Cody contributed valuable field assistance during point count censuses throughout the lower Mississippi Alluvial Valley. Funding for this work was provided by the Southern Hardwoods Laboratory of the USDA Forest Service's Southern Forest Experiment Station and by the Vicksburg Station of the Southern Research Center, USDI National Biological Survey.

Appendix A—We calculated minimum sample size using the power method according to Neter and Wasserman (1974:492). For this paper, we selected α = 0.05 and ß = 0.10. The power of the test is given by 1-ß; for this calculation, it is necessary to compute ø, the non-centrality parameter, which reflects how evenly dispersed the factor level means are relative to the overall mean. The actual factor level means were used for the calculation of "actual difference" in *table 2*; the remaining minimum sample size estimates in the table were derived using uniformly dispersed and symmetrical factor means, which minimizes the value of ø and provides the most conservative (i.e., maximizes) estimates of minimum sample size (Neter and Wasserman 1974). The formula for ø' is:

$$\phi' = \frac{1}{MSE}\sqrt{\frac{\Sigma(u_i - u)^2}{r}},$$

where:

ø' = estimate of the non-centrality parameter ø.
MSE = mean square error from ANOVA.
μ_i = mean for factor level *i*.
μ = overall mean.
r = number of factor levels (3, for this paper).

Once ø' has been calculated, the minimum sample size can be obtained for a specifed α and ß from TABLE A-10 in the appendix tables of Neter and Wasserman (1974:827).

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Important Bird Area Technical Committee Members
Second Round of Site Identifications (2003-2004)

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Hiking At Belleayre

The Indians called the Catskill Mountains "Onteora" which has been translated as "Land in the Sky." The terrain throughout the Catskills is generally rugged and steep. Elevations range from approximately 600 feet to 4200 feet. Forest cover is primarily Northern Hardwoods with Sugar Maple, American Beech, and Yellow Birch dominating. Stands of Red Spruce and Balsam Fir are found at higher elevations. Oak stands cover the Eastern slope of the Catskills. Many other species such as White Birch, Hemlock, Black Cherry, Red Maple, Mountain Ash, and White Pine are also present in varying amounts. Here at Belleayre Mountain you can hike any ski trail, or you can hike our new trail taking you from the Summit down to the The Belleayre Beach at the Pine Hill Lake. You can also try the new Belleayre Mountain Interpretive Adventure Trail located on the Wild West side of the Mountain. Have fun hiking while learning about the Catskill region, its wildlife, water, geology, and avian life. Stop at each marked kiosk and read about the area. This is a great opportunity for the whole family to experience the great outdoors, appreciate nature at its finest, to gaze at the breathtaking vistas. If you're quiet you may even see some of the Catskills abundant wildlife. So come on out and take a walk on the wildside in natures own theme park!

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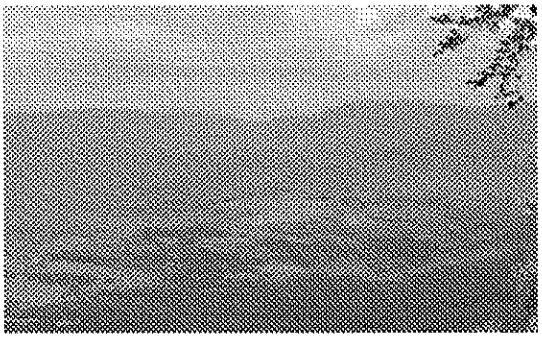

About Area Events Spring Summer Fall Winter

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CRC 77

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BELLEAYRE MOUNTAIN

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Belleayre's Map is a "hot spot" image map. Click on the area to get a closer view of that area.

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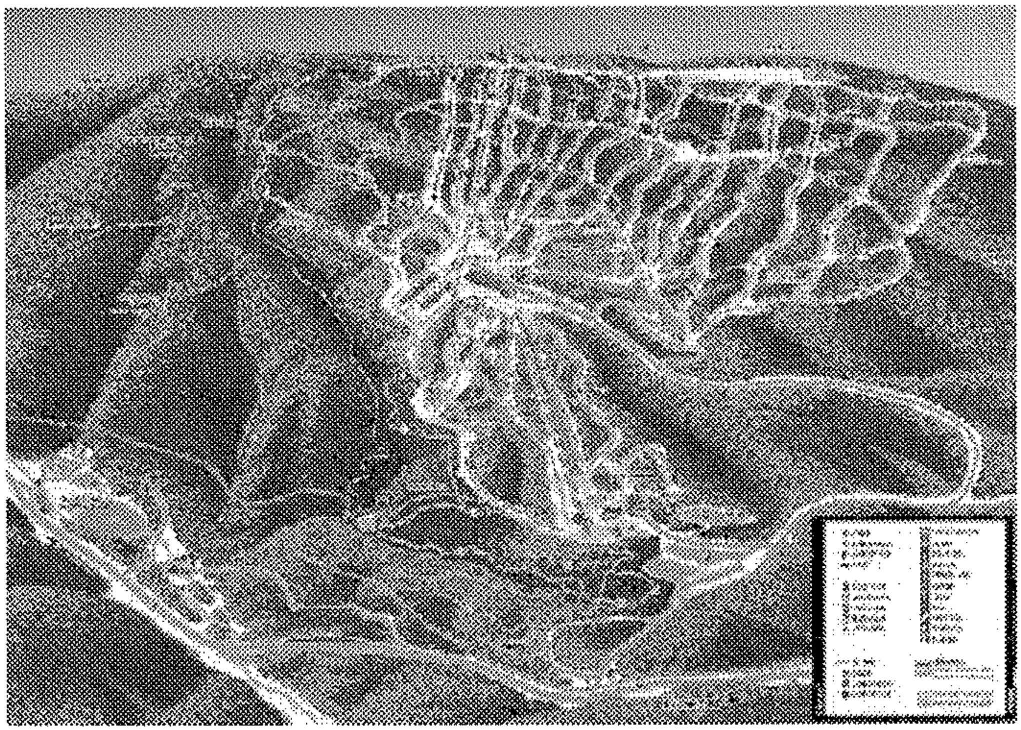

This page was last updated on Saturday, February 28, 2004 9:11 AM
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Belleayre Mountain is owned and operated by the New York State Department of Environmental Conservation

BELLEAYRE
MOUNTAIN

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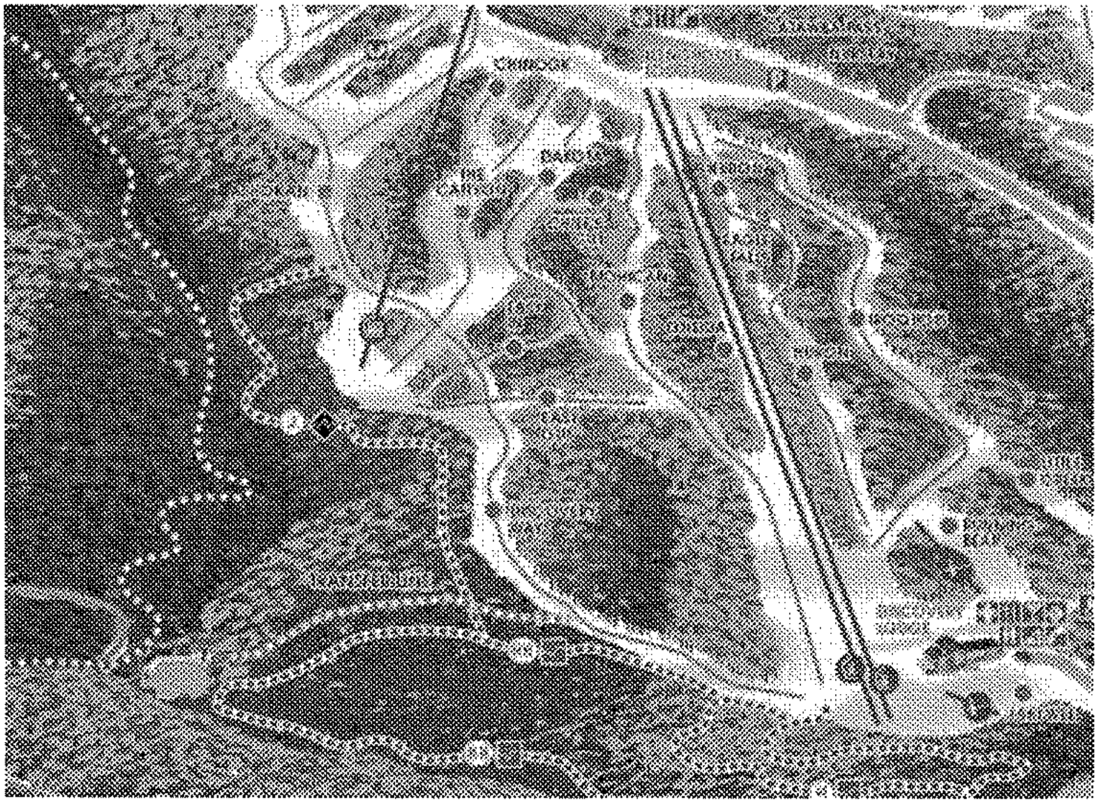

These beginner
trails are locate
discovery lodge

BELLEAYRE
MOUNTAIN

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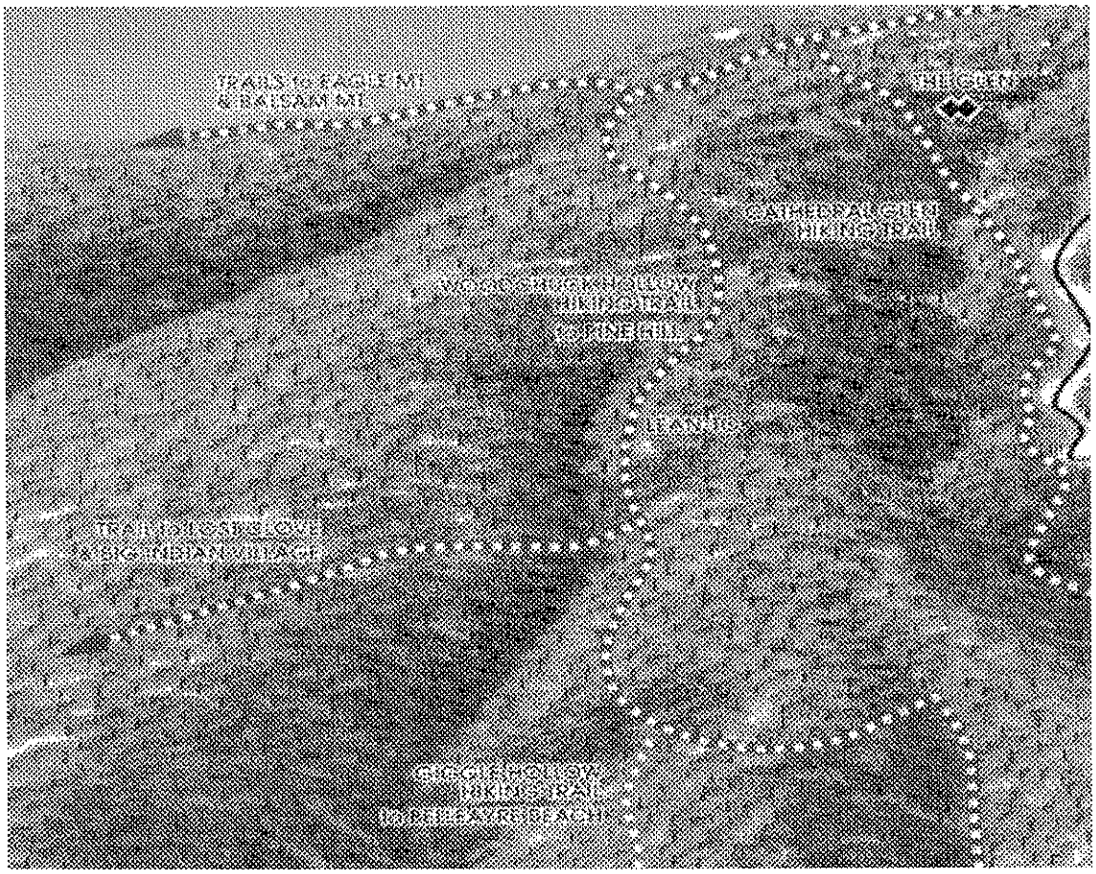

Hiking at Belleayre
the heart of the Ca
Forest preserve. F
information on our
- please visit our hi

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CPC Exh 78

Audubon NEW YORK

200 Trillium Lane
Albany, NY 12203
Tel: 518-869-9731
Fax: 518-869-0737
nasnys@audubon.org
http://ny.audubon.org

21 July 2004

Ms. Cheryl A. Roberts, Esq.
The Law Office of Marc S. Gerstman
313 Hamilton Street
Albany, NY 12210

Dear Ms. Roberts,

For the record of the issues conference regarding the Crossroads Ventures proposed development on Belleayre Mountain, I offer this letter detailing what Important Bird Areas (IBAs, including the Catskills IBA) represent; how, when, and why they were reassessed and identified by Audubon New York; and that the proposed Crossroads Ventures project in no way influenced the expansion of the Catskills IBA.

Important Bird Areas are sites, i.e., habitats, that support significant numbers of birds that are deemed to be vulnerable due to their overall level of threat, restricted ranges, reliance on a limited habitat, or congregatory behavior. IBAs are identified through the application of criteria developed by BirdLife International in Europe in the 1980s.

As the official partner of BirdLife International, National Audubon Society identifies IBAs in the United States. As an organization with a dispersed structure, Audubon is implementing the IBA program on a state-by-state basis, through its state programs where they exist. Audubon New York, the state program of the National Audubon Society, completed the first round of IBA identification in New York in 1997, before Audubon was BirdLife International's official partner. In 1999, when Audubon New York completed its first strategic plan, we determined that we would begin a second round of identifying IBAs five years after the first assessment was completed, or in about 2002.

Audubon New York began preparations for the second round of identifying IBAs in NY with a staff-level meeting in Ithaca on 28 January 2002. By August 2002, we had worked out the conceptual plan for aligning our NY IBA criteria more closely with BirdLife's global criteria, including that we would need to identify the largest, most intact habitats for assemblages of species for which NY has long-term conservation responsibility. In October 2002, we launched the IBA nomination process by mailing out dozens of nomination packets to Audubon Chapters, other conservation groups, and natural resource professionals. These nomination packets included criteria definitions and lists of species that are targeted by each criterion. For example, the nomination packet included the following:

> Criteria: The site supports an assemblage of species characteristic of a habitat type that is:
> (3a) rare, threatened, or unusual within the state or region.
> (3b) an exceptional representative of a natural or near-natural habitat within the state or region.
>
> This category is mainly meant to cover areas capable of supporting significant populations of bird species for which New York has a high responsibility for long-term conservation, even if they are not currently declining or threatened. These are species with a disproportionately high percentage of their total population in the Bird Conservation Regions (BCRs) comprising New York State (see map in Appendix B). Selection of sites will be based on avian assemblages within the habitat community types found within BCRs (see Appendix B for guidance), not on the habitat community types alone. Large areas that support significant populations of several species within the assemblages will be favored; however, small remnants of an exceptional habitat type that support fewer individuals or species may be included.

In fall of 2002, Audubon New York began assembling the IBA technical committee to oversee the IBA identification process and to approve or reject specific sites as IBAs. The members of the technical committee included some of the best professional and amateur ornithologists in NY and also leading conservation biologists. A list of the members of that committee has already been submitted for the record.

In March 2003, Audubon New York hired a Geographic Information Systems (GIS) specialist to complete a spatial analysis of bird and habitat data in order to identify the largest, most intact sites in the state supporting the greatest number of species in each assemblage of "responsibility species". The spatial analysis methodology eventually employed for this purpose was developed and implemented with the guidance and approval of a GIS-savvy sub-committee of the IBA technical committee, including Milo Richmond (Leader of the USFWS Cooperative Research Unit at Cornell University), David VanLuven (Executive Director of the New York State Natural Heritage Program) and William Ostrander (GIS professional with a private environmental consulting company). Subsequently, the full IBA technical committee approved the GIS methodology employed.

After gathering existing bird data, mostly from the current New York State Breeding Bird Atlas project, and conducting numerous new bird surveys using point counts and screech owl/chickadee mobbing scene recordings, information about potential IBAs under the "habitat" criterion was summarized and sent to the technical committee for review. The Catskills IBA (an expansion of the previous Catskill Peaks IBA as a result of the spatial analysis) was discussed and approved as an IBA by the technical committee on a conference call on 27 October 2003. The official public release of results of the second round of IBA identification will come in December 2004 with the publication of the second edition of *Important Bird Areas in New York State*.

IBAs meeting the "habitat" criterion (now known as the "responsibility species assemblage" criterion), are believed by Audubon and the IBA technical committee to include the most important sites for the assemblages of species for which NY has long-term conservation responsibility. Collectively, these IBAs make up about 10% of each of the habitat types in NY.

The Catskills IBA (approximately 306,000 acres of forest habitat) is the largest, most intact, and most important forest IBA in NY's portion of the Appalachian Mountains Bird Conservation Region, which includes approximately 6 ½ million acres of forest.

Regarding the question of whether the Crossroads Ventures site is wholly or partially within the Catskills IBA, the map I showed in my PowerPoint suggested only partial overlap. It is important to point out, however, that the data used for identifying IBAs came from the NY GAP project, which has a minimum mapping unit of 4 ha (almost 10 acres). Any unique feature (such as a ski slope) less than that in size (or possibly even larger than that depending on configuration, e.g. linear) would not appear in the GAP landcover data. These data are completely sufficient and, in fact, desirable for use in a statewide habitat assessment like the one Audubon did, which is one of the reasons why the technical committee approved the methods. However, identification of more precise feature locations, such as the exact boundaries of IBAs, should utilize more precise data, such as aerial photos. This was not a priority for IBA identification, and Audubon did not pursue it. According to the DEIS, the project site consists mostly of intact forest of the type we identified for the IBA and supports almost all of the bird species we were targeting. The project site is, therefore, "within" the IBA. Quibbling over whether it is wholly or only partially within the IBA is somewhat meaningless and does not lessen the potential adverse impact of this development on this IBA. Fragmentation of forest habitats on the project site will degrade the IBA's value as breeding habitat for forest birds.

Although I was vaguely aware that my Audubon colleague, Dr. Graham Cox in our Albany office, was following potential development issues "in Belleayre", it was not until 5 April 2004 that I (or anyone at Audubon New York, including Dr. Cox) learned that the Crossroads Ventures proposed development was within the new Catskills IBAs. On that day, Geoffrey Ryan of the New York City Audubon Society contacted me to find out if "Belleayre" was in an IBA. After telling Mr. Ryan that I did not know, I sought information on the location of the Crossroads Ventures site via the Internet and discovered that, although it was not in the original Catskill Peaks IBA (which was identified primarily for Bicknell's Thrush), it was in the new Catskills IBA. I immediately notified both Mr. Ryan and Dr. Cox about this discovery.

In no way did the existence of the proposed Crossroads Ventures or any other development in Belleayre contribute to or influence the identification of the newly expanded Catskills IBA by Audubon New York.

Sincerely,

Michael F. Burger, Ph.D.

Director of Bird Conservation
159 Sapsucker Woods Rd.
Ithaca, NY 14850

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EPC Exh. 79

Empire State Trails

Highlights of New York State

State of New York, George E. Pataki, *Governor*

NYS Office of Parks, Recreation & Historic Preservation, Bernadette Castro, *Commissioner*
Department of Environmental Conservation, Erin M. Crotty *Commissioner*
New York State Canals, Louis R. Tomson, *Chairman*

Big Indian Wilderness Area

Contact: Department of
Environmental Conservation
21 So. Putt Corners Rd.
New Paltz, NY 12561
(845) 256-3000

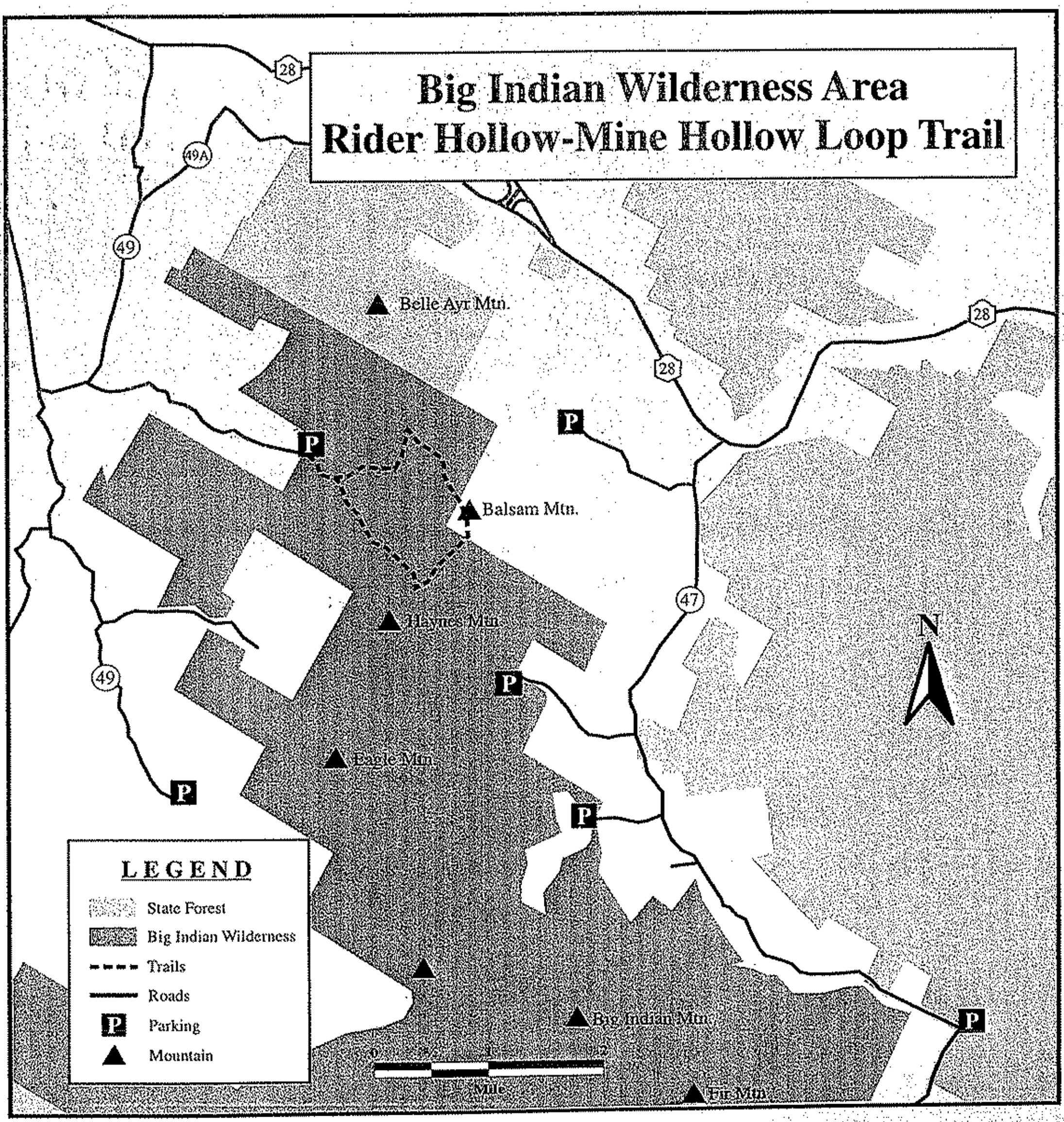
Rider Hollow-Mine Hollow Loop:
4.8 miles.

The Big Indian Wilderness Area encompasses over 35,000 acres of "forever wild" forest preserve land in the heart of the Catskill Park. The Big Indian Wilderness Area has the longest stretch of trail through uninterrupted virgin forest in the Catskill Mountains, offering numerous opportunities for solitude in a remote and rugged environment.

The Big Indian Wilderness Area lies in the northwest corner of Ulster County, just south of the hamlet of Pine Hill, nearly evenly divided among the neighboring towns of Denning, Hardenburgh and Shandaken. Crescent-shaped, the area also straddles the divide between the Delaware and Hudson River Basins.

The Big Indian Wilderness Area can best be described as a rugged, mountainous area marked by deep glacial cuts resulting in a series of parallel, steep-sided hollows. The area is host to eight prominent peaks including Balsam, Fir, Haynes and Eagle, as well as several unnamed mountain tops. Elevations range from 1,500-3,860 feet.

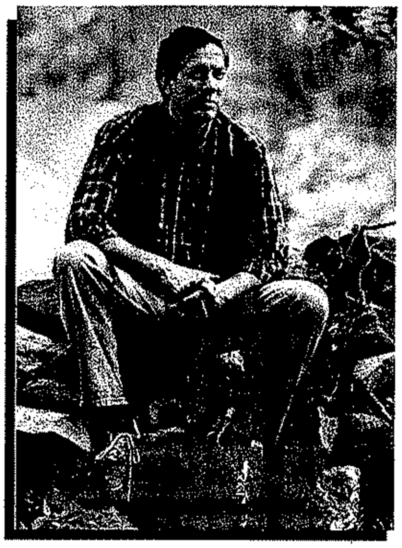
Access to the wilderness area can be obtained from a number of trailheads that have parking lots. For example, from the Rider Hollow Trailhead located in the town of Hardenburg on the Rider Hollow Road, follow red markers to the Mine Hollow junction. The trail turns northeast and follows yellow markers for a one-mile ascent to the Pine Hill-West Branch Trail. Turning south and following blue markers for two miles, the trail leads to the summit of Balsam Mountain. The hamlet of Big Indian can be seen from this point. At the junction of the McKenley Hollow-Rider Hollow Trail, the route turns northwest and follows red markers 1.4 miles back to the parking area.



Big Indian Wilderness Area
Rider Hollow-Mine Hollow Loop Trail

New York State and Its Trails

> *"The excellence of our 17,000 miles of Empire State Trails, one of the most extensive trails systems in the nation, is attributable to our partnerships with state and local governments, volunteers, farmers and other property owners, businessmen and interested citizens. Together we will continue to build upon this very special legacy."*
>
> *—George E. Pataki,*
>
> *National Trails Day Proclamation, 1999*



The Empire State has an extensive system of trails that offers a variety of opportunities for users throughout the seasons. New York's trails extend across wildlife areas, countryside, mountain peaks, waterfalls, lakesides, suburban walkways and historic sites. They connect open spaces and communities from Montauk to New York City, from the Battery to Buffalo, from Niagara Falls to the North Country, serving as foundations for environmental protection, historic preservation and recreation.

While many trails are popular and frequently used by outdoor enthusiasts, others have yet to be discovered. Broadening the purpose and availability of trails across our state will provide new experiences for users. In preparation for the future, New York State has and will continue to increase trail opportunities through the acquisition and protection of significant open space resources. Recently acquired land includes Sterling Forest, the Sanctuary adjacent to Montauk Point, the Whitney Estate and Champion Lands in the Adirondacks, Green Lakes State Park and Moreau Lake State Park additions, Woodlawn Beach on Lake Erie, Rockwood Hall along the shores of the Hudson River, Nissequogue State Park on Long Island Sound, and the Hudson River Park in New York City.

Time spent in the outdoor beauty of our state leads to enjoyable and educational experiences and some of the best memories of a lifetime. Like so many environmental enthusiasts, I appreciate all that New York State's natural resources offer--from hiking to studying the habits of birds and other wildlife--and am committed to preserving and protecting our natural treasures for the people of today and those of tomorrow. Through strong partnerships, forward-thinking programs, and stewardship of our resources, we are continually improving the environment to ensure that it remains a well-balanced and healthy system that serves New Yorkers well into the future.

I invite everyone to become a part of a strong environmental tradition by discovering the fun and excitement of the remarkable trails system in New York State.

George E. Pataki, Governor

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CPC Exh 80

GROUNDWATER IMPACTS OF THE BELLEAYRE RESORT

by
Andrew Michalski, Ph.D., CGWP
Michalski & Associates, Inc.
South Plainfield, NJ

Summary of Major Groundwater Comments on the DEIS

1. Proposed pumping rates from Rosenthal supply wells (currently 149 gpm) cannot be sustained in the long run. Long-term stabilization of pumping groundwater levels is not likely at such rates.
2. The pumping from Rosenthal wells would subtract the baseflow to Birch Creek. Likewise, the proposed use of Fleischmanns wells would reduce baseflow in Emory Brook.
3. Extensive lowering of bedrock groundwater water levels over a large area will adversely impact other groundwater users within several miles. Cumulative impacts and interference from new large withdrawals at the two proposed resorts, ski area, and other developments need to be considered, as they all compete for a limited groundwater resource.
4. Additional hydrogeologic information and data are necessary for the entire area, in order to adequately assess impacts on groundwater resources, and develop reliable monitoring of water quality changes.

Conceptualizations of Bedrock Hydrogeology

In the DEIS, bedrock is implicitly treated as a single aquifer unit without any distinct features. Only old county water-supply reports for mentioned. No reference to recent USGS hydrogeologic studies in the Catskills. No illustrations of site-specific hydrogeology, by means of maps or sections, provided.

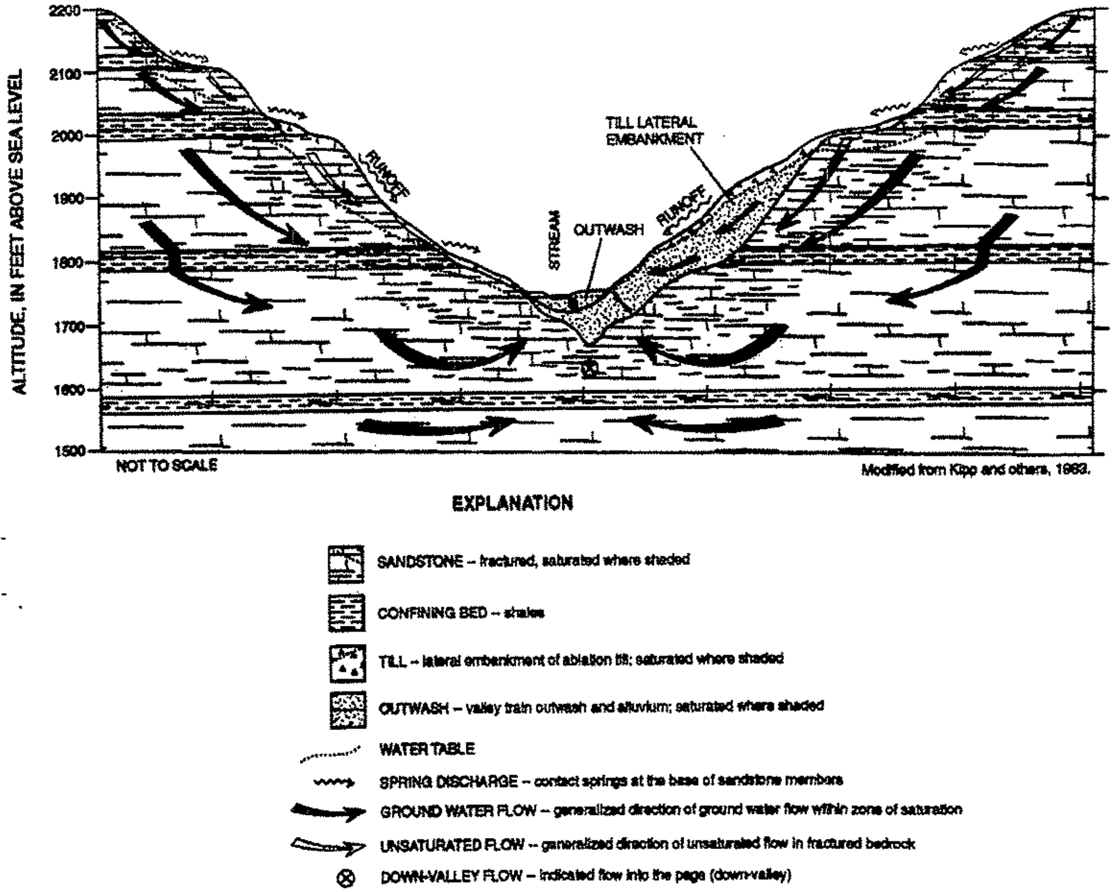
Reynolds' (2000) portrayal of the Catskill Formation directly south of the project area–Bedrock as a series of stacked aquifers and confining units (Attachment 1).

Heisig (2002) study in the Batavia Kill valley (Attachment 2) – Preferential flow along few low-angle bedding fractures that act as major water-bearing units. Bedrock has little storage, and pumping effects extend a mile up and down the valley. Short-circuiting of groundwater along open holes important. Overpumping can induce upwelling of saline water.

Some on-site indications consistent with the Heisig concepts: Records for Pine Hill Well #1; water-bearing fracture in R2 and response of residential well #4 to pumping at the Rosenthal wells ; water cascading in W #2; anomalous water level W#3; disappearance of flow in a stream below the Marlowe mansion.

GROUNDWATER FLOW CONCEPTUALIZATION BY REYNOLDS, 2000

ATTACHMENT 1



Modified from Kipp and others, 1983.

Figure 8. Conceptual ground-water flow within the Beaver Kill Basin, New York.

Wellbore Short-Circuits in a Fractured-Rock Aquifer, Catskill Mountains, New York -- Management Considerations

By Heisig, Paul M., U.S. Geological Survey, 425 Jordan Rd., Troy, NY 12180

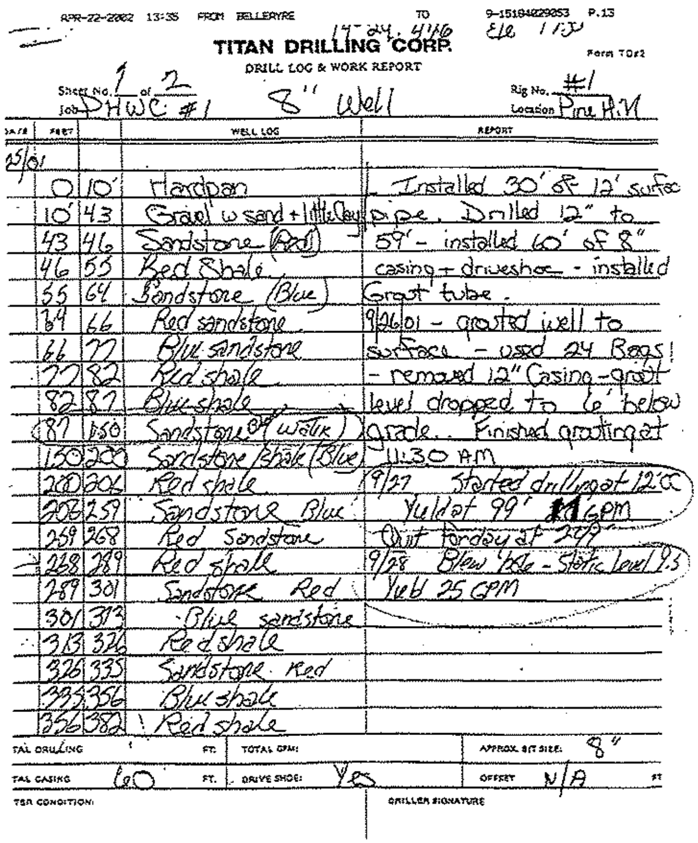
The 0.3 mile wide Batavia Kill valley in the Catskill Mountains of southeastern New York is underlain by a fractured-rock aquifer consisting of gently dipping sandstones, siltstones, and mudstones in repeating, 50-100 ft fining-upward cycles. Local relief is about 1,500 ft. The predominant water-bearing zones in the valley are hydraulically separate, low-angle bedding-plane fractures within the upper 200 to 300 ft of bedrock. Hillside areas are most fractured within the upper 150 ft and have nearly equal occurrences of low-angle and high- angle fractures. Reported yields from driller's logs indicate that-fractured bedrock is most productive within, or adjacent to, the valley bottom area. Saline water in deeper fractures in valley-bottom and hillside areas represents the lower boundary of the aquifer.

Data on the fractured bedrock-aquifer indicates that open wellbores in the bedrock can act as short circuits within the ground-water flow system. Borehole-geophysical logs and depth-specific, water-quality analyses indicate that such wellbores can interconnect previously isolated fracture zones of differing water chemistry and hydraulic head. Water-level responses during a 48-hour aquifer test (75 gal/min) indicate that the bedrock aquifer has very little storage. Measured and estimated vertical flow in nine observation wells suggest as much as 25 percent of the pumped discharge is from short-circuited flow. This water is drawn (short circuited) from zones that were naturally isolated from zones that the production well draws water from. Some parts of the aquifer may risk contamination as a result of vertical borehole flow. Pumping of supply wells could induce saline water at depth in some wells may be induced to flow up the wellbores and into fractures containing fresh water.

Based on the results of geohydrologic testing, the following water-management considerations are presented:
1. Reported yields of bedrock wells that tap the same fracture zone(s) are probably not realistic because of aquifer storage is limited; therefore, aquifer testing at a proposed supply well warrants water-level measurements in bedrock wells as far as 1 mi up- and down-valley, and use of multiple withdrawal rates (in conjunction with withdrawals from local supply wells) that can be used to identify (bracket) yields that can be maintained without depleting the aquifer.
2. Borehole-flow data imply that borehole short circuits at new outlying wells could increase the yields of bedrock supply wells that tap only deep fractures. The most productive short circuits interconnect shallow fractures, in hydraulic connection with overlying saturated valley-fill, with deeper isolated fractures.
3. Borehole profiling of specific conductance at new and existing wells can indicate the presence for saline water, and filling such wells with grout and abandoning them would prevent upward movement and contamination of the aquifer.

Citation: Heisig, Paul M., 2002, Wellbore short-circuits in a fractured-rock aquifer, Catskill Mountains, New York -- Management considerations [abs]: in Fractured-Rock Aquifers 2002, Denver, Colo., 2002, Proceedings:

DRILLER LOG FOR PINE HILL WELL#1 DOCUMENTS THAT THE MAIN WATER-BEARING FRACTURE @90 FT PRODUCED 20 GPM VERSUS 30 GPM FROM THE ENTIRE 400 FEET OF THIS DEEP BEDROCK WELL. ALSO NOTE THAT WATER LEVEL DECREASED WITH DEPTH (DOWNWARD HYDRAULIC HEAD AND FLOW)



APR-22-2002 13:35 FROM BELLEAYRE TO 9-15184029053 P.13

14-24, 4'16 Ele 1130

TITAN DRILLING CORP.

DRILL LOG & WORK REPORT

Form TD#2

Sheet No. 1 of 2

Job PHWC #1 8" Well

Rig No. #1

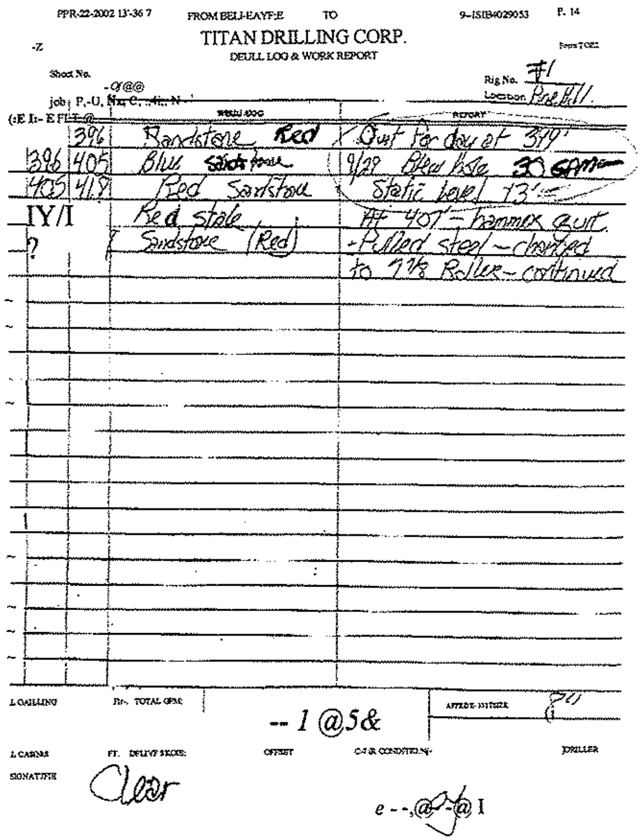
Location Pine Hill

DATE	FEET		WELL LOG	REPORT
25/01				
	0	10'	Hardpan	Installed 30' of 12' surfac
	10'	43	Gravel w sand + little clay	pipe. Drilled 12" to
	43	46	Sandstone (Red)	59' - installed 60' of 8"
	46	55	Red Shale	casing + driveshoe - installed
	55	64	Sandstone (Blue)	Grout tube.
	64	66	Red sandstone	9/26/01 - grouted well to
	66	77	Blue sandstone	surface - used 24 Bags!
	77	82	Red shale	- removed 12" Casing - grout
	82	87	Blue shale	level dropped to 6' below
	87	150	Sandstone 89 (water)	grade. Finished grouting at
	150	200	Sandstone/Shale (Blue)	11:30 AM
	200	208	Red shale	9/27 Started drilling at 12:0
	208	259	Sandstone Blue	Yield at 99' 20 GPM
	259	268	Red Sandstone	Quit for day at 279'
	268	289	Red shale	9/28 Blew hole - Static level 9.5
	289	301	Sandstone Red	Yield 25 GPM
	301	313	Blue sandstone	
	313	326	Red shale	
	326	335	Sandstone Red	
	335	356	Blue shale	
	356	382	Red shale	

TAL DRILLING FT. TOTAL GPM: APPROX. BIT SIZE: 8"

TAL CASING 60 FT. DRIVE SHOE: Yes OFFSET N/A FT

TER CONDITION: DRILLER SIGNATURE



PPR-22-2002 13'-36 7 FROM BELLEAYRE TO 9-15184029053 P. 14

TITAN DRILLING CORP.

DRILL LOG & WORK REPORT

Form TD#2

Sheet No.

Job P.-U, ~~No. C. .4i.. N~~

Rig No. #1

Location Pine Hill

DATE	FEET		WELL LOG	REPORT
		396	Sandstone Red	Quit for day at 319'
	396	405	Blue Sandstone	9/29 Blew hole 30 GPM
	405	418	Red Sandstone	Static level 73'
	IY/I		Red shale	At 407' - hammer quit
	?		Sandstone (Red)	- Pulled steel - changed
				to 7 7/8 Roller - continued

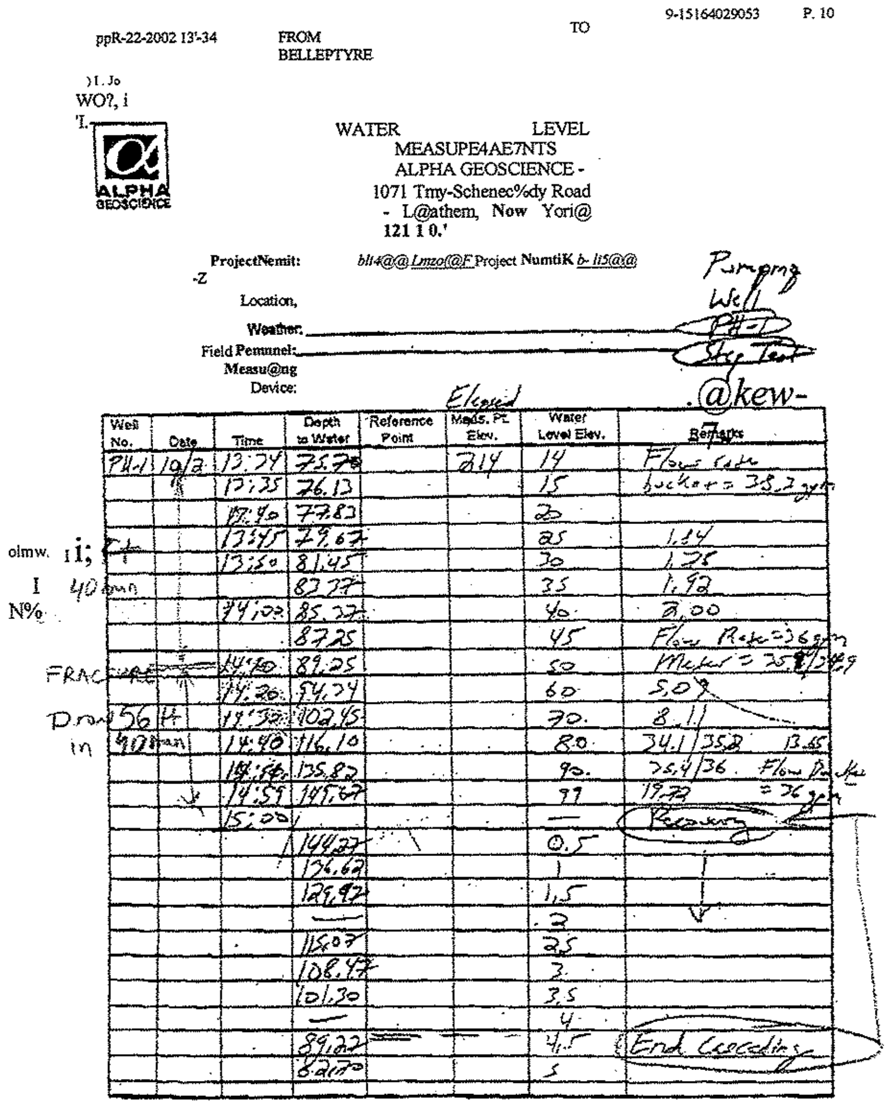
TOTAL DRILLING FT. TOTAL GPM -- 1 @5& APPROX. BIT SIZE 8"

TOTAL CASING FT. DRIVE SHOE OFFSET CASING CONDITION DRILLER

SIGNATURE Clear

e --@-@ I

ALPHA'S FIELD RECORDS FOR PORTION OF STEP-DRAWDOWN AND RECOVERY TESTS IN WELL PH-1 DOCUMENTS POORER WELL PERFORMANCE AND CASCADING BELOW THE FRACTURE @90 FT



ppR-22-2002 13'-34 FROM BELLEPTYRE TO 9-15164029053 P. 10

)1. Jo
WO?, i
'I.

ALPHA GEOSCIENCE

WATER LEVEL
MEASUPE4AE7NTS
ALPHA GEOSCIENCE -
1071 Tmy-Schenec%dy Road
- L@athem, Now Yori@
121 1 0.'

ProjectNemit: bli4@@ Lmzo@F Project NumtiK b- li5@@
-Z

Location,

Weather: Pumping Well PH-1

Field Pemnnel: Step Test

Measu@ng Device: .@kew-

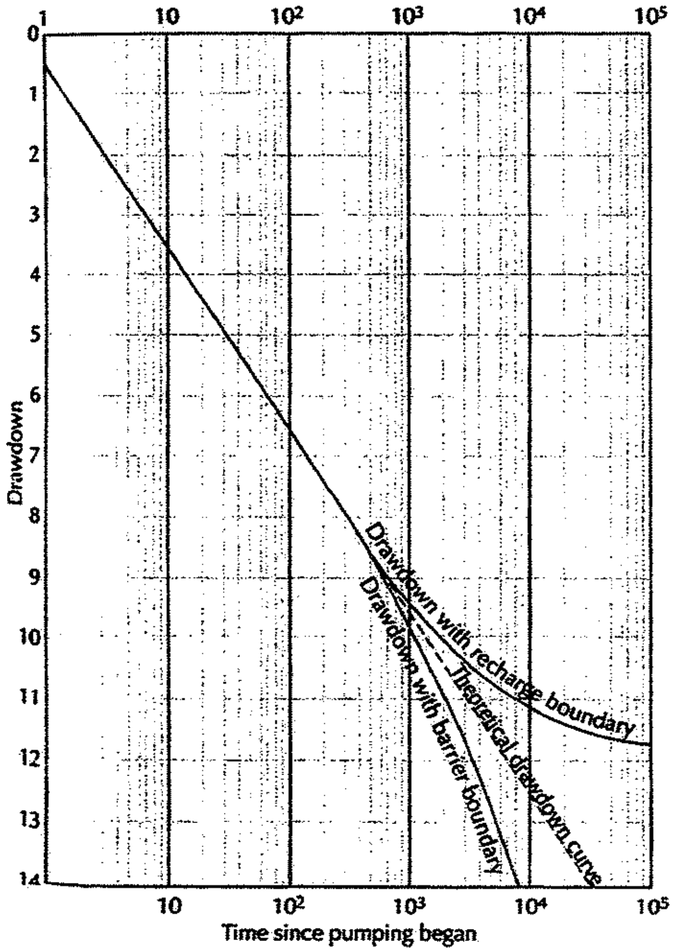
olmw. i1; Ft
I 40 min
N%

FRACTURE

Drw 56 ft in 40 min

Well No.	Date	Time	Depth to Water	Reference Point	Elapsed Meas. Pt. Elev.	Water Level Elev.	Remarks
PH-1	10/2	13:24	75.78		214	14	Flow rate
		13:35	76.13			15	bucket = 38.2 gpm
		13:40	77.83			20	
		13:45	79.67			25	1.14
		13:50	81.45			30	1.78
			83.77			35	1.92
		14:00	85.27			40	2.00
			87.25			45	Flow Rate = 36 gpm
		14:10	89.25			50	Meter = 25.8/24.9
		14:20	94.24			60	5.09
56 ft		14:32	102.45			70	8.11
40 min		14:40	116.10			80	34.1/35.8 13.65
		14:50	135.82			90	25.4/36 Flow Rate
		14:55	145.67			99	19.72 = 26 gpm
		15:00				—	Recovery
			144.27			0.5	
			136.62			1	
			129.92			1.5	
			—			2	
			115.07			2.5	
			108.47			3	
			101.30			3.5	
			—			4	
			89.22			4.5	End Cascading
			82.70			5	

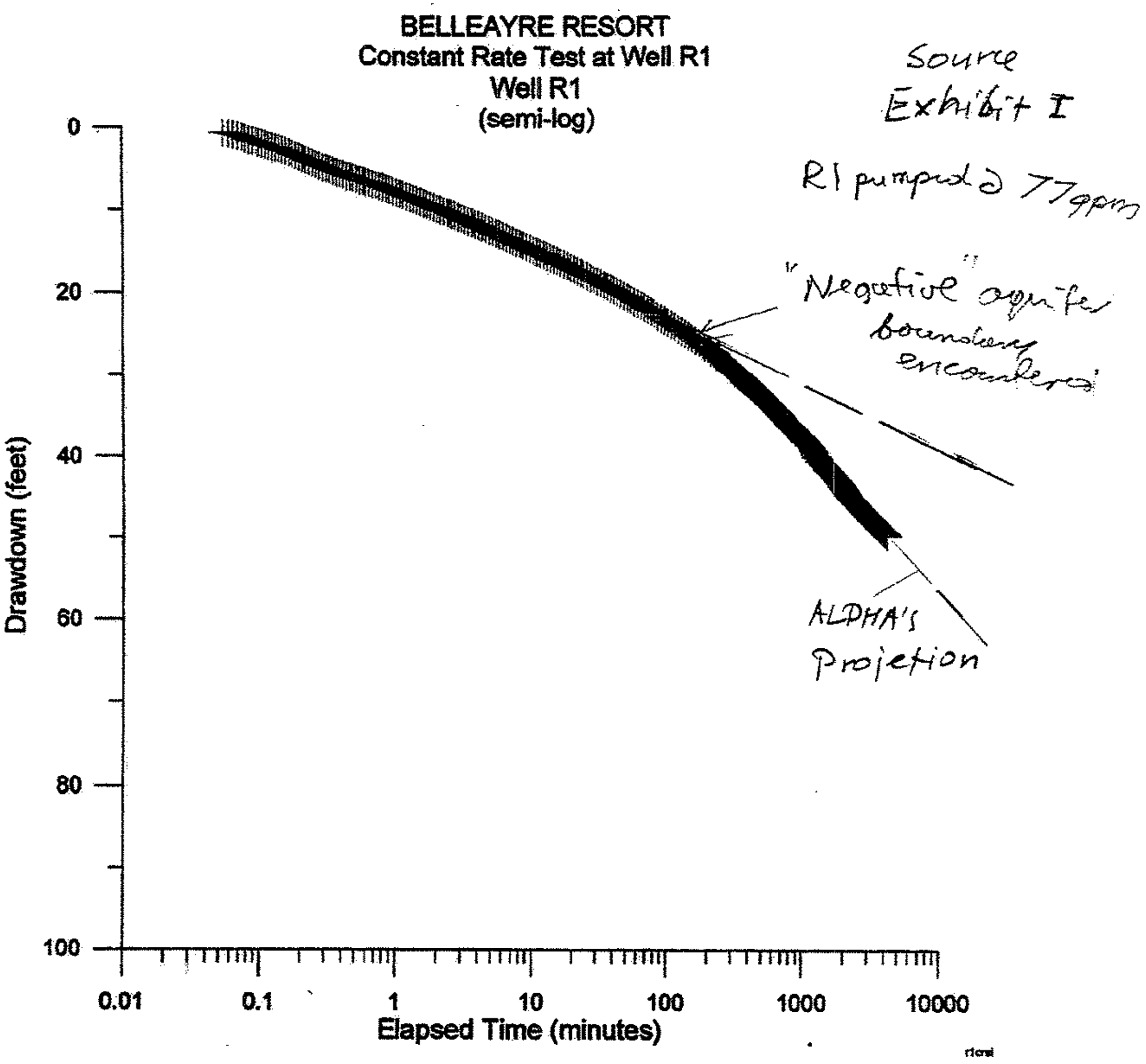
PROTOTYPE PLOTS OF SEMILOG TIME VERSUS DRAWDOWN



◄ **FIGURE 5.32**
Impact of recharge and barrier boundaries on semilogarith drawdown-time curves.

FETTER, 2001

PLOT OF SEMILOG TIME VERSUS DRAWDOWN FOR WELL R1



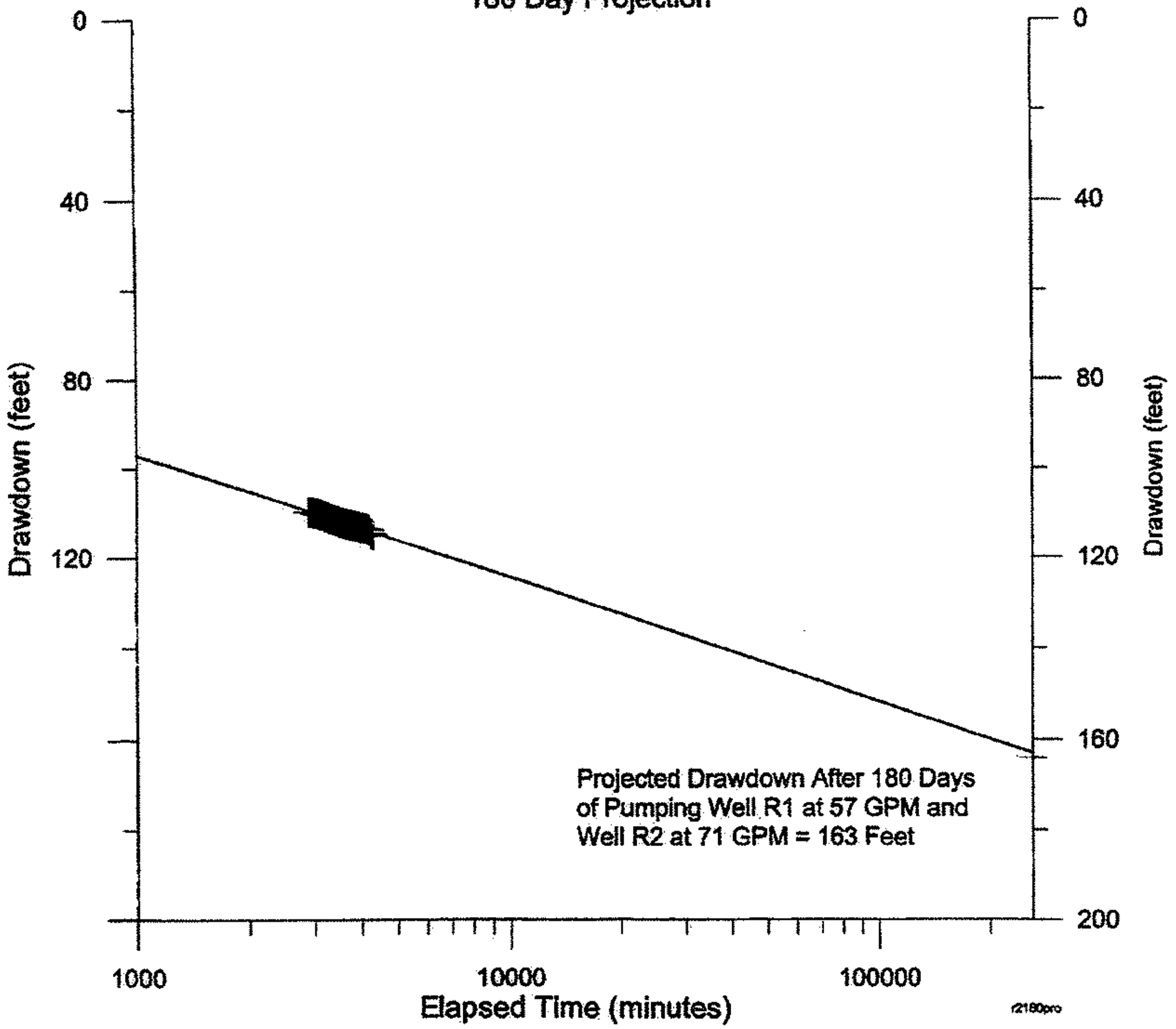
Source
Exhibit I

R1 pumped @ 77gpm

"Negative" aquifer boundary encountered"

ALPHA's Projection

DRAWDOWN PROJECTION BY ALPHA GEOSCIENCE FOR WELL R2 AFTER 180 DAYS OF SIMULTANEOUS PUMPING AT WELLS R1 AND R2



BELLEAYRE RESORT
Simultaneous Testing of Wells R1 and R2
Well R2
180 Day Projection

Note:

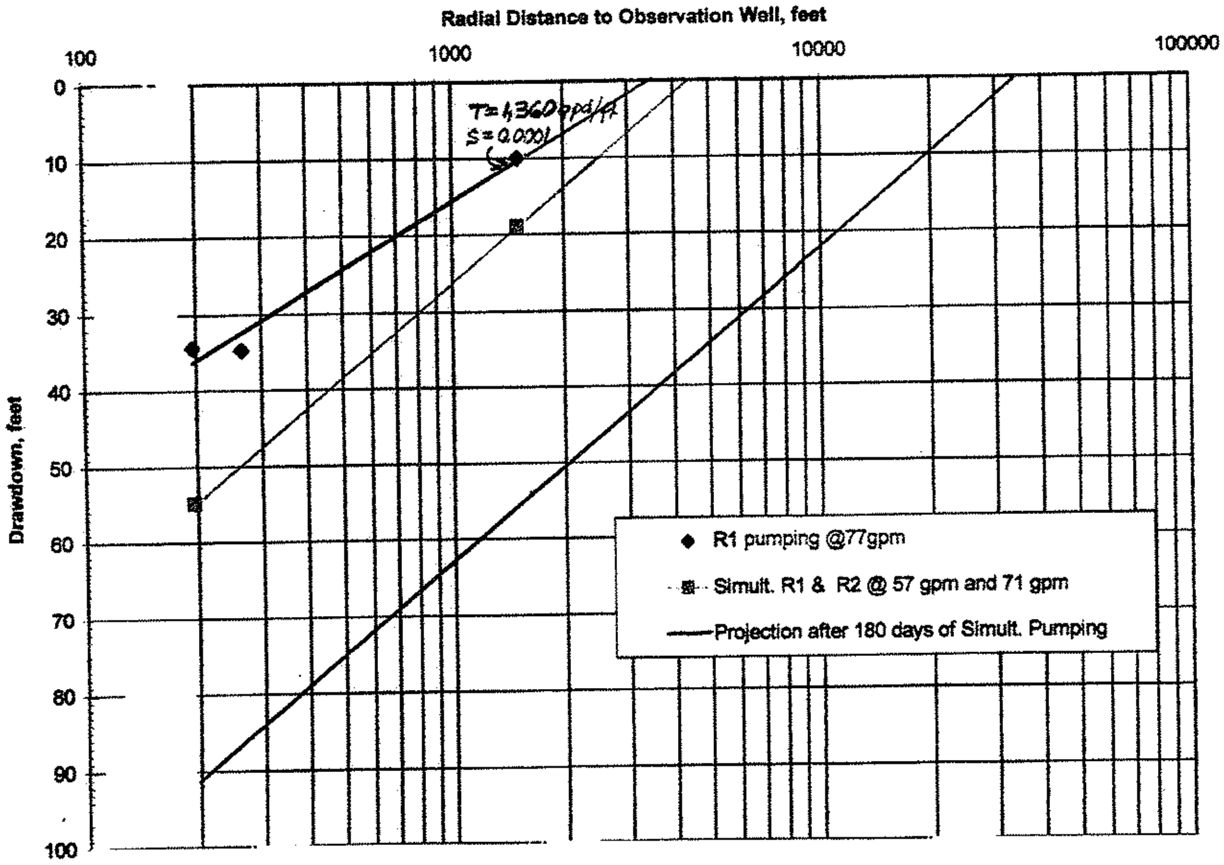
During the recent (April 2004)

simultaneous pumping test

drawdown in R2 after 1000 min

already reached 122 ft

DISTANCE – DRAWDOWN ANALYSIS OF TWO PUMPING TESTS
Attachment 3 of Comments by A. Michalski



ATTACHMENT 3

CUMULATIVE IMPACTS OF GROUNDWATER PUMPING NOT ADDRESSED BY THE APPLICANT

- THE PROPOSED PUMPING AT ROSENTHALWELLS WOULD CAUSE AN EXTENSIVE LOWERING OF BEDROCK GROUDWATER LEVELS FOR MILES (WITH 50 FEET OF DRAWDOWN WITHIN A 0.5 MILE RADIUS).
- COALESCING CONES OF DEPRESSION FROM THE NEW PUMPING CENTERS AT ROSENTHAL WELLS (150 GPM PROPOSED) AND FLEISCHMANNS WELLS (250 GPM), TOGETHER WITH EXISTING CENTERS (40 GPM AT SKI AREA) WOULD RESULT IN EXTENSIVE REGIONAL LOWERING OF GROUNDWATER LEVELS FROM BIG INDIAN TO FLEISCHMANNS.
- OTHER GROUNDWATER USERS WOULD BE ADVERELY IMPACTED BY RESULTING YIELD REDUCTION IN WELLS AND SPRINGS, HIGHER PUMPING COST, UPWELLING OF SALINE WATER. SURFACE WATER WOULD ALSO BE IMPACTED.

THE PROPOSED PUMPING AT ROSENTHAL WELLS WOULD REDUCE FLOW IN BIRCH CREEK THROUGH THESE TWO MECHANISMS:

- Suppressing (intercepting) bedrock groundwater contribution to streamflow, and
- Pumping-induced water infiltration from the streambed and saturated overburden (evidenced by data from observation wells R1 and W2).

These mechanisms define long-term source(s) of water pumped from the Rosenthal wells.

EVIDENCE FOR PUMPING-INDUCED FLOW ACCROSS OVERBURDEN DURING RECENT (April 2004) PUMPING TEST:

- WATER LEVEL IN RES-1, A SHALLOW RESIDENTIAL WELL, DECLINED BY 3.2 FEET DURING THE PUMPING;
- WP-1, A WELLPOINT LOCATED NEAR BIRCH CREEK AND R2, DECLINED BY 0.5 FEET DURING THE TEST (TWO OTHER WELLPOINTS DID NOT RESPOND);
- THE SAME TEST CAUSED 23 FEET OF DRAWDOWN IN RES4, BEDROCK RESIDENTIAL WELL LOCATED 1,500 FEET FROM R1.

RESIDENTIAL WELL RES-1 DATA

RES-1 –
completed in
unconsoliated
deposits
~ 50 ft deep
and ~675 ft away
from R1

TABLE 8
Belleayre Resort at Catskill Park
Simultaneous Pumping Test of Wells R1, R2 and R3
Residential Well 1 Data

Date	Time	Depth to Water (feet)	Remarks
3/29/2004	9:00	18.7	
3/30/2004	14:30	18.8	
3/31/2004	18:00	18.7	
4/1/2004	13:00	18.7	
4/2/2004	10:00	18.58	
4/3/2004	12:00	18.6	
4/4/2004	14:00	18.4	
4/5/2004	10:00	18.5	
4/6/2004	18:00	18.21	
4/7/2004	9:50	18.6	R1, R2, R3 Pumps on at 10:00
4/7/2004	13:33	19.14	
4/8/2004	12:00	20.9	DECLINE BY 3.24'
4/9/2004	10:00	21.6	due to pumping
4/9/2004	18:00	21.6	
4/10/2004	10:54	21.84	R1, R2, R3 Pumps off at 13:00
4/12/2004	11:00	19.76	Recovery
4/13/2004	16:22	19.35	

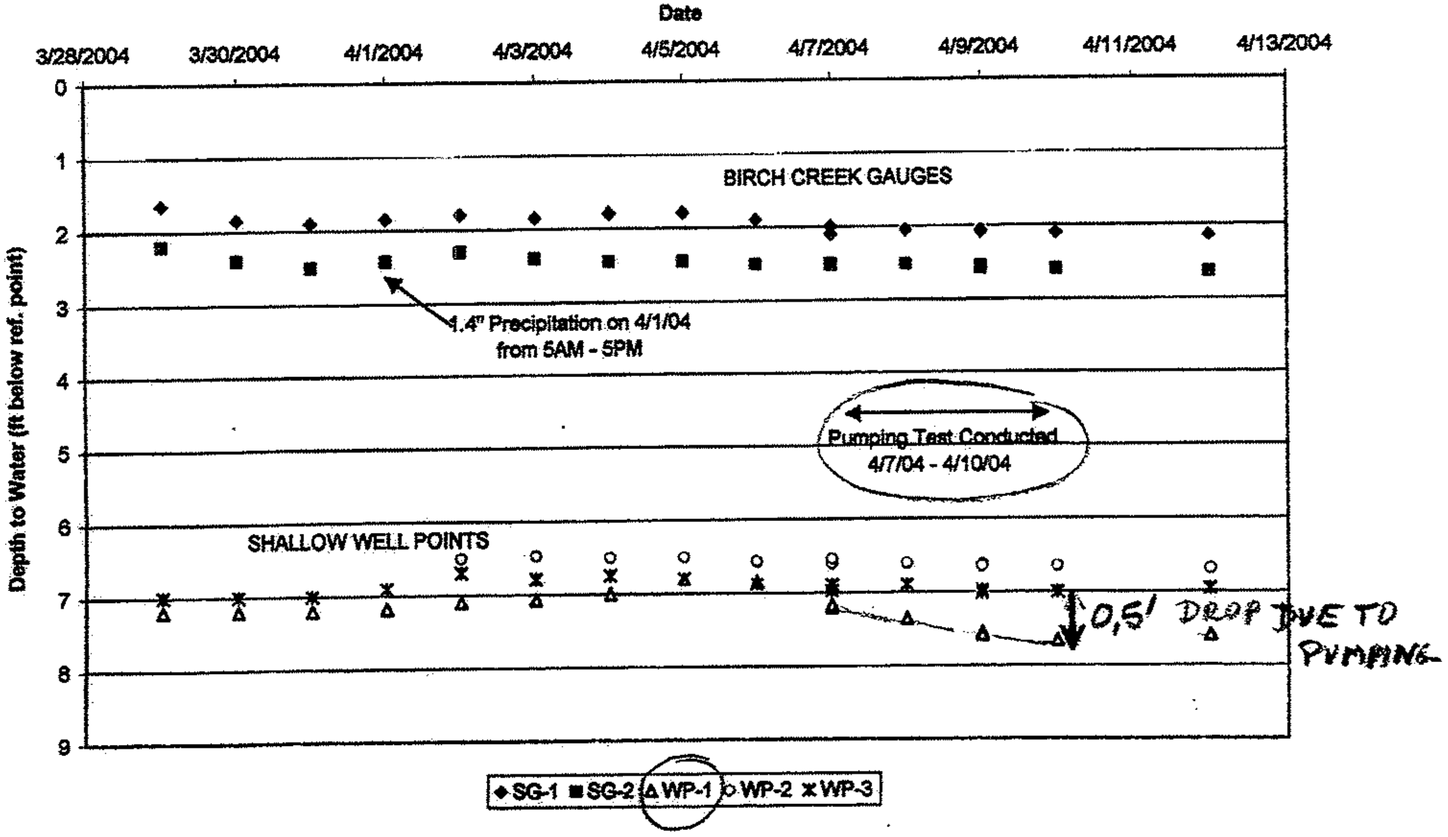
Note: Well used to supply residence throughout testing period. Water levels measured from top of casing.

WP-1 RESPONSE DATA

FIGURE 4
Simultaneous Testing of Wells R1, R2, and R3

Water Level Data
Birch Creek & Shallow Well Points

From Alpha, May 2004



Note: Data points do not represent water level elevations.

04101\tables\Water quality\WL Graph - shallow

EVIDENCE FOR PUMPING-INDUCED REACHARGE ACROSS OVERBURDEN – CONT.

THE OBSERVED PATTERN OF OBSERVATION WELL RESPONSES DURING THE PUMING TESTS SHOWS THAT OVERBURDEN AND BEDROCK **HETEROGENEITIES CONTROL THE FLOW**.

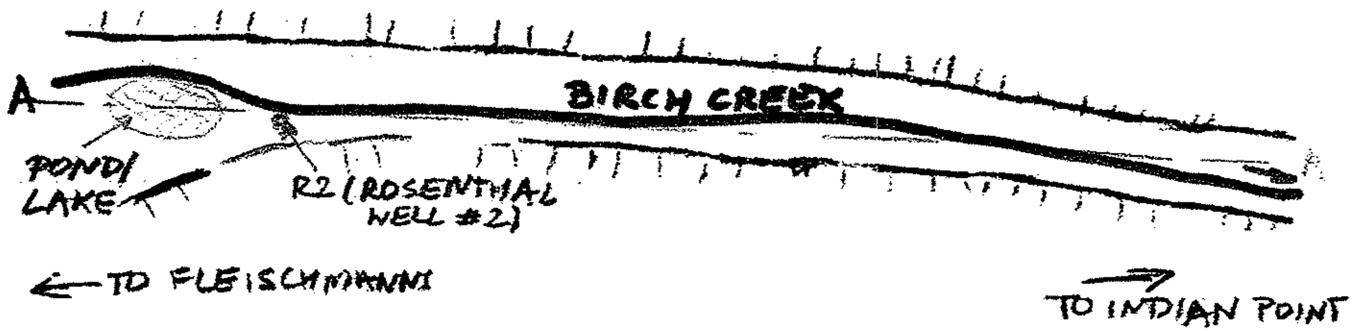
THE VARIABILITY OF OVERBURDEN IS ILLUSTRATED BY CROSSSECTIONS IN REYNOLDS, 2002 (Figure 5 and 6).

SIGNIFICANT RECHARGE TO THE BEDROCK WELLS OCCURS AT SUBCROPS OF CONDUCTIVE BEDDING FRACTURES BENEATH BIRCH CREEK THOUSANDS OF FEET DOWNSTREAM (see the next slide)

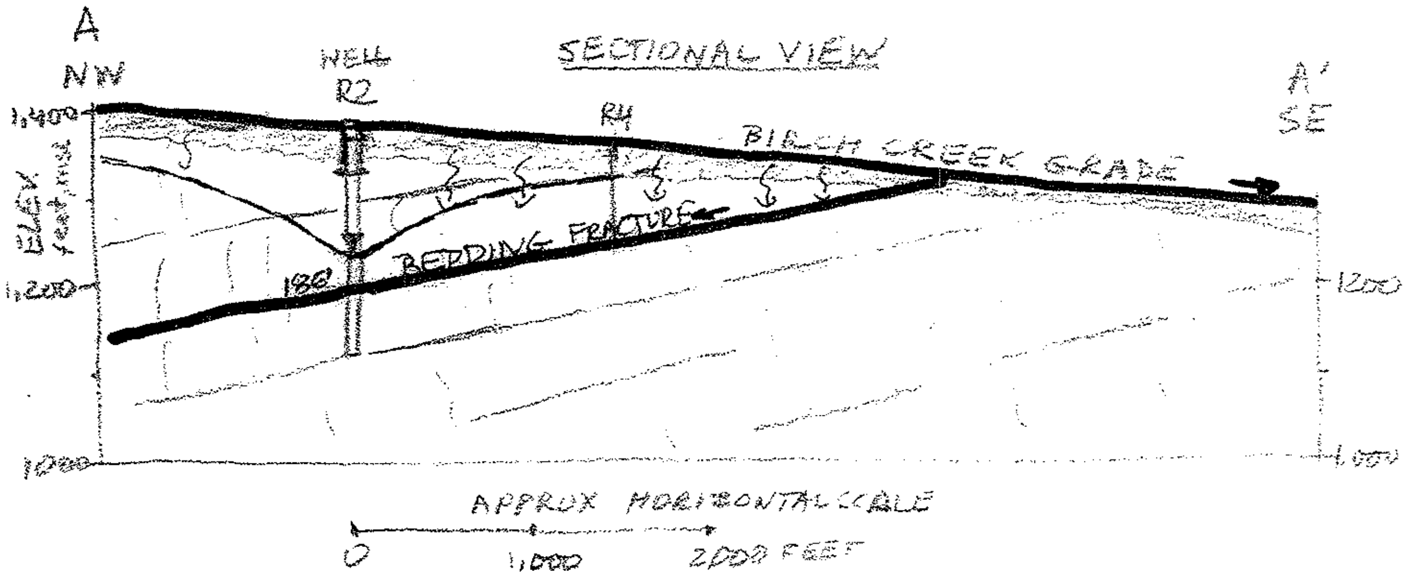
APPLICANT'S CLAIMS THAT BIRCH CREEK WOULD NOT BE IMPACTED BY THE PROPOSED PUMPING ARE BASED ON IMPROPER INTERPRETATIONS OF ARGUMENTS ON A CONFINED CHARACTER OF THE BEDROCK, A PRE-PUMPING DIFFERENCE OF WATER LEVELS IN BEDROCK AND OVERBURDEN WELLS, AND WATER QUALITY DATA FOR PUMPED WATER AND THE CREEK IN APRIL 2004.

DISTANT RECHARGE FROM BIRCH CREEK TO SUPPLY WELL R2

PLAN VIEW



SECTIONAL VIEW

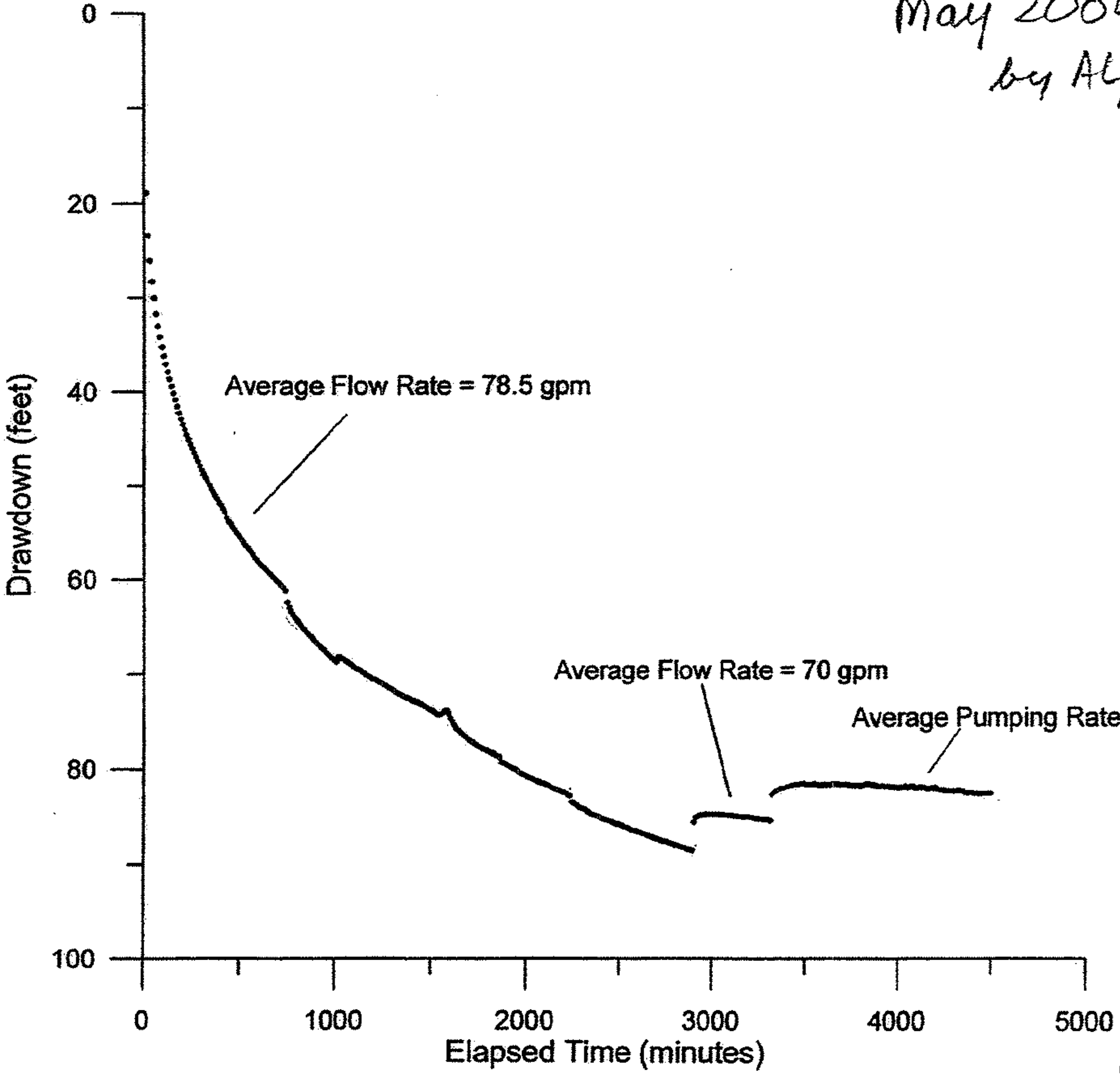


The April 2004 simultaneous pumping of wells R1, R2 and R3 – What does it really show?

- Crossroads claims the test shows that a sustained yield of 149 gpm is obtainable from these wells with drawdown stabilization and no adverse impacts on other groundwater users and surface water.
- This claim is based on inappropriate testing procedure that produced misleading results: The pumping was not conducted at constant pumping rate (as required by the principles of hydraulic analysis). The pumping rate was decreased during test. This manipulation allowed for a partial recovery and apparent drawdown stabilization near the the end of the 3-day test (see Plot for R1).
- Had this test continued for months, the pumping rate would have been needed to cut back more and more to keep the drawdown “stabilized.”
- Slow and incomplete recovery of the water levels after the April 2004 test indicates insufficient recharge to the bedrock wells *even at the wettest time of the year with 0.9 " of rain during the recovery*.

BELLEAYRE RESORT at CATSKILL PARK
Simultaneous Pumping Test of Wells R1, R2 and R3
Well R1
(linear)

May 2004 Repor
by Alpha



04101/Belleayre/Simult

Baseflow versus Runoff

- Rapid, "flashy" runoff is typical of the site. Daily flow in Birch Creek can increase 1,000 fold in 1 day to drop by 2 orders of magnitude in 10 days.
- Baseflow (the discharge that is exceeded 90% of the time) is a measure of groundwater contribution to a stream.
- For a typical small Catskill mountain stream, the summer baseflow makes only <2.5% of the total runoff and <2% of the total rainfall (Reynolds, 2000).
- The above shows how small the baseflow (contribution from groundwater) is in this specific setting. During prolonged dry weather spells, the creek and proposed water supply wells would compete for the same limited groundwater resource.
- Recharge estimates from annualized water budget and generic soil types are misleading in that regard.

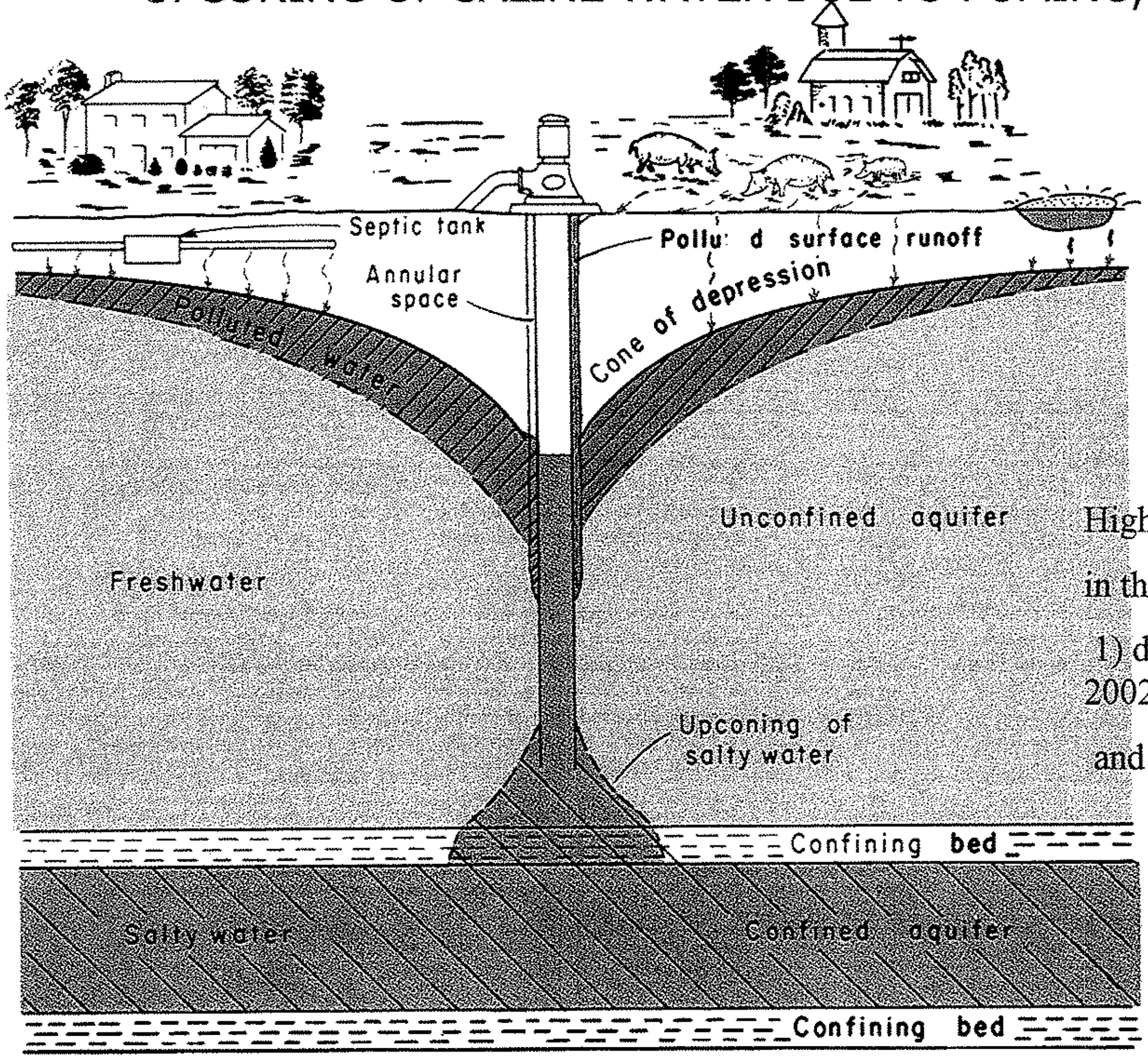
SUMMARY OF OUR EVALUATION OF STREAMFLOW MEASUREMENTS FOR DRY SEASON (Table 1A of Exhibit G)

The **lower segment of Crystal Spring** (above its confluence with Birch Creek) loses some of its flow (224 gpm to 363 gpm). Subsurface water transfer to the Emery Creek, via transmissive fractures and open bedrock holes, may account for much of this loss. Pumping at Fleischmann's Wells would exacerbate the loss.

When water is not diverted for snow making, **Birch Creek** is barely gaining flow within a 2-mile segment below its confluence with Crystal Spring and Indian Point.This low groundwater contribution is attributed to poorer groundwater resources of the area and to effect of open bedrock holes/wells short-circuiting flow to those conductive bedding fractures that intersect streambed downstream at lower elevations.

SUPPLY-WELL PROBLEMS—CHANGES IN WATER QUALITY

UPCONING OF SALINE WATER DUE TO PUMING, after Heath, 1989



High risk for salt water upconing

in the area indicated by

1) data from the Batavia creek (Heisig, 2002),

and 2) High EC values (900 uS/cm) in W1.

MONITORING OF RESORTS IMPACTS ON GROUNDWATER QUALITY

- PROPOSED USE VERY DEEP BEDROCK WELLS (698 FT DEEP MIDROAD WELL AND 475 FT RASHID WELL) TO MONITOR FOR NITRATES AND PESTICIDES IS INADEQUATE. SHALLOW MONITORING WELLS SHOULD BE USED.
- MONITORING FOR PUMPING-INDUCED SALINITY NEEDS TO BE INCLUDED, STARING WITH A BASELINE SALINITY ASSESSMENT.
- SPRING MONITORING REQUIRES A REALISTIC HYDROGEOLOGIC ASSESSMENT OF SUBSURFACE FLOW PATHWAYS. DEFINING FLOW CONTRIBUTING AREAS TO SPING BASED ON TOPOGRAPGIC FEATURES ALONE IS INADEQUATE (Example of a losing stream below Marlowe mansion).

CPC Exh 80q **ATTACHMENT 2**

Wellbore Short-Circuits in a Fractured-Rock Aquifer, Catskill Mountains, New York -- Management Considerations

By Heisig, Paul M., U.S. Geological Survey, 425 Jordan Rd., Troy, NY 12180

The 0.3 mile wide Batavia Kill valley in the Catskill Mountains of southeastern New York is underlain by a fractured-rock aquifer consisting of gently dipping sandstones, siltstones, and mudstones in repeating, 50-100 ft fining-upward cycles. Local relief is about 1,500 ft. The predominant water-bearing zones in the valley are hydraulically separate, low-angle bedding-plane fractures within the upper 200 to 300 ft of bedrock. Hillside areas are most fractured within the upper 150 ft and have nearly equal occurrences of low-angle and high- angle fractures. Reported yields from driller's logs indicate that-fractured bedrock is most productive within, or adjacent to, the valley bottom area. Saline water in deeper fractures in valley-bottom and hillside areas represents the lower boundary of the aquifer.

Data on the fractured bedrock-aquifer indicates that open wellbores in the bedrock can act as short circuits within the ground-water flow system. Borehole-geophysical logs and depth-specific, water-quality analyses indicate that such wellbores can interconnect previously isolated fracture zones of differing water chemistry and hydraulic head. Water-level responses during a 48-hour aquifer test (75 gal/min) indicate that the bedrock aquifer has very little storage. Measured and estimated vertical flow in nine observation wells suggest as much as 25 percent of the pumped discharge is from short-circuited flow. This water is drawn (short circuited) from zones that were naturally isolated from zones that the production well draws water from. Some parts of the aquifer may risk contamination as a result of vertical borehole flow. Pumping of supply wells could induce saline water at depth in some wells may be induced to flow up the wellbores and into fractures containing fresh water.

Based on the results of geohydrologic testing, the following water-management considerations are presented:
1. Reported yields of bedrock wells that tap the same fracture zone(s) are probably not realistic because of aquifer storage is limited; therefore, aquifer testing at a proposed supply well warrants water-level measurements in bedrock wells as far as 1 mi up- and down-valley, and use of multiple withdrawal rates (in conjunction with withdrawals from local supply wells) that can be used to identify (bracket) yields that can be maintained without depleting the aquifer.
2. Borehole-flow data imply that borehole short circuits at new outlying wells could increase the yields of bedrock supply wells that tap only deep fractures. The most productive short circuits interconnect shallow fractures, in hydraulic connection with overlying saturated valley-fill, with deeper isolated fractures.
3. Borehole profiling of specific conductance at new and existing wells can indicate the presence for saline water, and filling such wells with grout and abandoning them would prevent upward movement and contamination of the aquifer.

Citation: Heisig, Paul M., 2002, Wellbore short-circuits in a fractured-rock aquifer, Catskill Mountains, New York -- Management considerations [abs]: in Fractured-Rock Aquifers 2002, Denver, Colo., 2002, Proceedings: National Ground Water Association, p. 177-178

Back to USGS in New York State

S-1

14-24, 446 Ele 1150

TITAN DRILLING CORP.

Form TD#2

DRILL LOG & WORK REPORT

Sheet No. 1 of 2

Job PHWC #1 8" Well

Rig No. #1

Location Pine Hill

ATE	FEET		WELL LOG	REPORT
25/01				
	0	10'	Hardpan	Installed 30' of 12' surfac
	10'	43	Gravel w sand + little clay	pipe. Drilled 12" to
	43	46	Sandstone (Red)	59' - installed 60' of 8"
	46	55	Red Shale	casing + driveshoe - installed
	55	64	Sandstone (Blue)	Grout tube.
	64	66	Red sandstone	9/26/01 - grouted well to
	66	72	Blue sandstone	surface. - used 24 Bags!
	72	82	Red shale	- removed 12" Casing - grout
	82	87	Blue shale	level dropped to 6' below
	87	150	Sandstone Blue (water)	grade. Finished grouting at
	150	200	Sandstone/Shale (Blue)	11:30 AM
	200	206	Red shale	9/27 Started drilling at 12:00
	206	259	Sandstone Blue	Yuld at 99' 11 GPM
	259	268	Red Sandstone	Quit for day at 299
	268	289	Red shale	9/28 Blew hole - Static level 9.5
	289	301	Sandstone Red	Yield 25 GPM
	301	313	Blue sandstone	
	313	326	Red shale	
	326	335	Sandstone Red	
	335	356	Blue shale	
	356	382	Red shale	

TAL DRILLING FT.	TOTAL GPM:	APPROX. BIT SIZE: 8"
TAL CASING 60 FT.	DRIVE SHOE: Yes	OFFSET N/A FT

TER CONDITION:

DRILLER SIGNATURE

S2

TITAN DRILLING CORP.

DRILL LOG & WORK REPORT

Form TD#2

Sheet No. ____ of ______

Job PHWL #1

Rig No. #1

Location Pine Hill

TE	FEET		WELL LOG	REPORT
	382	396	Sandstone Red	Out for day at 399'
	396	405	Blue sandstone	9/28 Blew hole 30 GPM
	405	418	Red Sandstone	Static level 13'
	418	428	Red shale	At 407' - hammer quit
	428	444	Sandstone (Red)	- Pulled steel - changed
				to 7 7/8 Roller - continued

L DRILLING 444 FT.

TOTAL GPM: 25

APPROX. BIT SIZE: 8"

L CASING 60 FT.

DRIVE SHOE: Yes

OFFSET FT

R CONDITION: Clear

DRILLER SIGNATURE Troy

S-3

11.10
72.15

WATER LEVEL MEASUREMENTS

ALPHA GEOSCIENCE
1071 Troy-Schenectady Road
Latham, New York 12110

Project Name: Pine Hill Water Company
Project Number: 01134
Location:
Weather:
Field Personnel:
Measuring Device:

Pumping Well PH-1
Step Test
Sheet 5 of 7

Well No.	Date	Time	Depth to Water	Reference Point	Elapsed Meas. Pt. Elev.	Water Level Elev.	Remarks
PH-1	10/2	13:24	75.70		214	14	Flow rate
		13:35	76.13			15	bucket = 38.3 gpm
		13:40	77.83			20	
		13:45	79.67			25	1.84
		13:50	81.45			30	1.78
			83.37			35	1.92
		14:02	85.27			40	2.00
			87.25			45	Flow Rate = 36 gpm
		14:10	89.25			50	Meter = 35.[illegible]/34.9
		14:20	94.74			60	5.09
		14:30	102.45			70	8.11
		14:40	116.10			80	34.1/35.8 13.65
		14:50	135.82			90	35.4/36 Flow Bucket
		14:59	145.67			99	19.72 = 36 gpm
		15:00				—	Recovery
			144.27			0.5	
			136.62			1	
			129.97			1.5	
			—			2	
			115.07			2.5	
			108.47			3	
			101.30			3.5	
			—			4	
			89.27			4.5	End Cascading
			82.70			5	

draw 15 ft in 40 min above 90'

FRACTURE

Draw 56 ft in 40 min below 90'

54

ALPHA GEOSCIENCE

Alpha Geoscience
1071 Troy-Schenectady Rd
Latham, New York 12110

DRILLING LOG

Boring ID. R-2

Page 4 of 5

Project Number/Name: 01135/Belleayre Wells

Location: Friendship Manor Road, Pine Hill, NY

Depth (Ft)	Sample No.	DESCRIPTION	REMARKS
160.5	S-14	Red grey sandstone, rare red brown shale	
170 170.5	S-15	Medium grey sandstone rare red grey sandstone	
180 180.5	S-16	Red brown shale, rare red grey and medium grey sandstone	182' fracture
190 190.5	S-17	Red grey sandstone	186' fracture, with substantial water production 190' sulfur odor Blow test at 199' yields 66 gpm
200 200.5	S-18	Red grey sandstone, rare red brown shale	
210 210.5	S-19	Medium grey sandstone	
220			

!

S-5

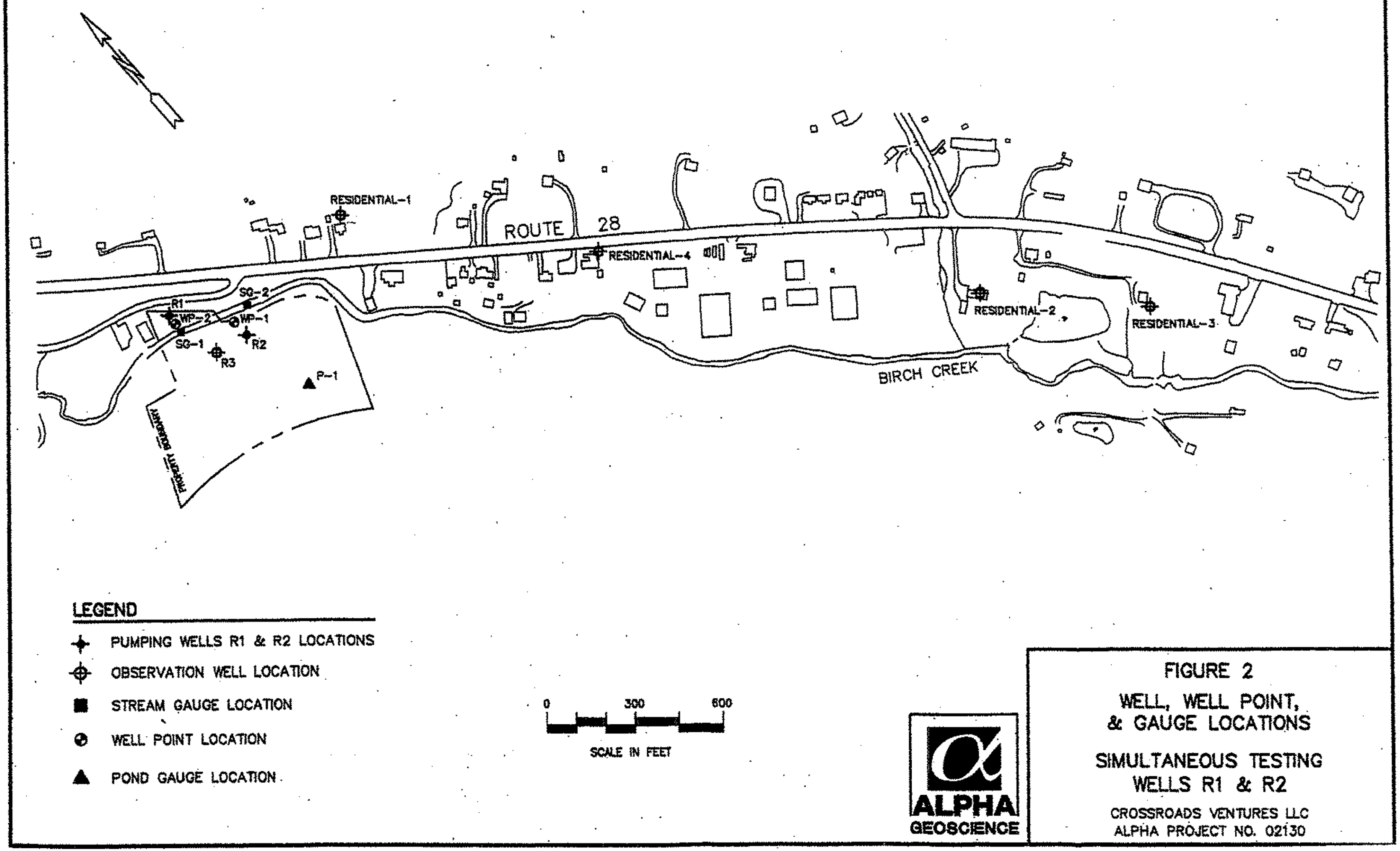


FIGURE 2

WELL, WELL POINT,
& GAUGE LOCATIONS

SIMULTANEOUS TESTING
WELLS R1 & R2

CROSSROADS VENTURES LLC
ALPHA PROJECT NO. 02130

02130-03.DWG

58

TABLE 10
Belleayre Resort at Catskill Park
Simultaneous Pumping Test of Wells R1, R2 and R3
Residential Well 4 Data

RES-4
BEDROCK WELL
~1,500 FT from
R1

Date	Time	Depth to Water (feet)	Remarks
3/29/2004	9:00	10.4	
3/30/2004	15:30	10.45	
3/31/2004	18:04	10.4	
4/1/2004	13:00	10.4	
4/2/2004	10:00	10.15	
4/3/2004	12:00	10.13	
4/4/2004	14:00	10.15	
4/5/2004	10:00	10.48	
4/6/2004	18:00	10.5	
4/7/2004	9:50	10.1	R1, R2 and R3 Pumps on at 10:00
4/7/2004	13:30	14.45	
4/8/2004	12:00	27.3	DECLINE BY 23.7'
4/9/2004	10:00	32.92	
4/9/2004	18:00	33.39	
4/10/2004	10:50	33.76	R1, R2, and R3 Pumps off at 13:00
4/12/2004	11:00	14.1	
4/13/2004	16:33	12.21	

Note: Water levels measured from top of casing.

(S-7)

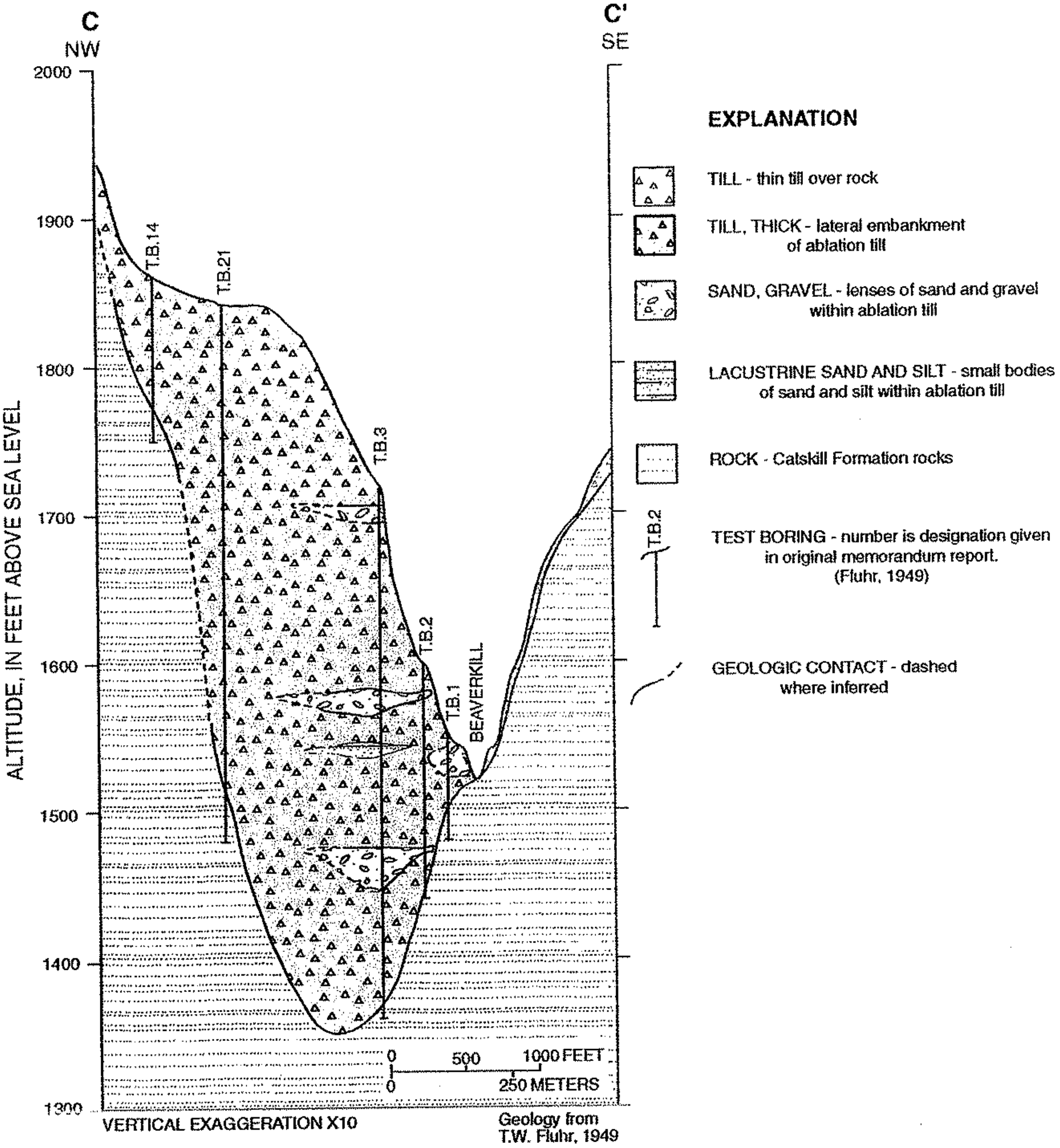


Figure 5. Geologic section C-C across the Beaver Kill valley at Jersey Brook, Sullivan County, N.Y. Trace of section shown in figure 2 (Modified from Fluhr, 1948).

5-8

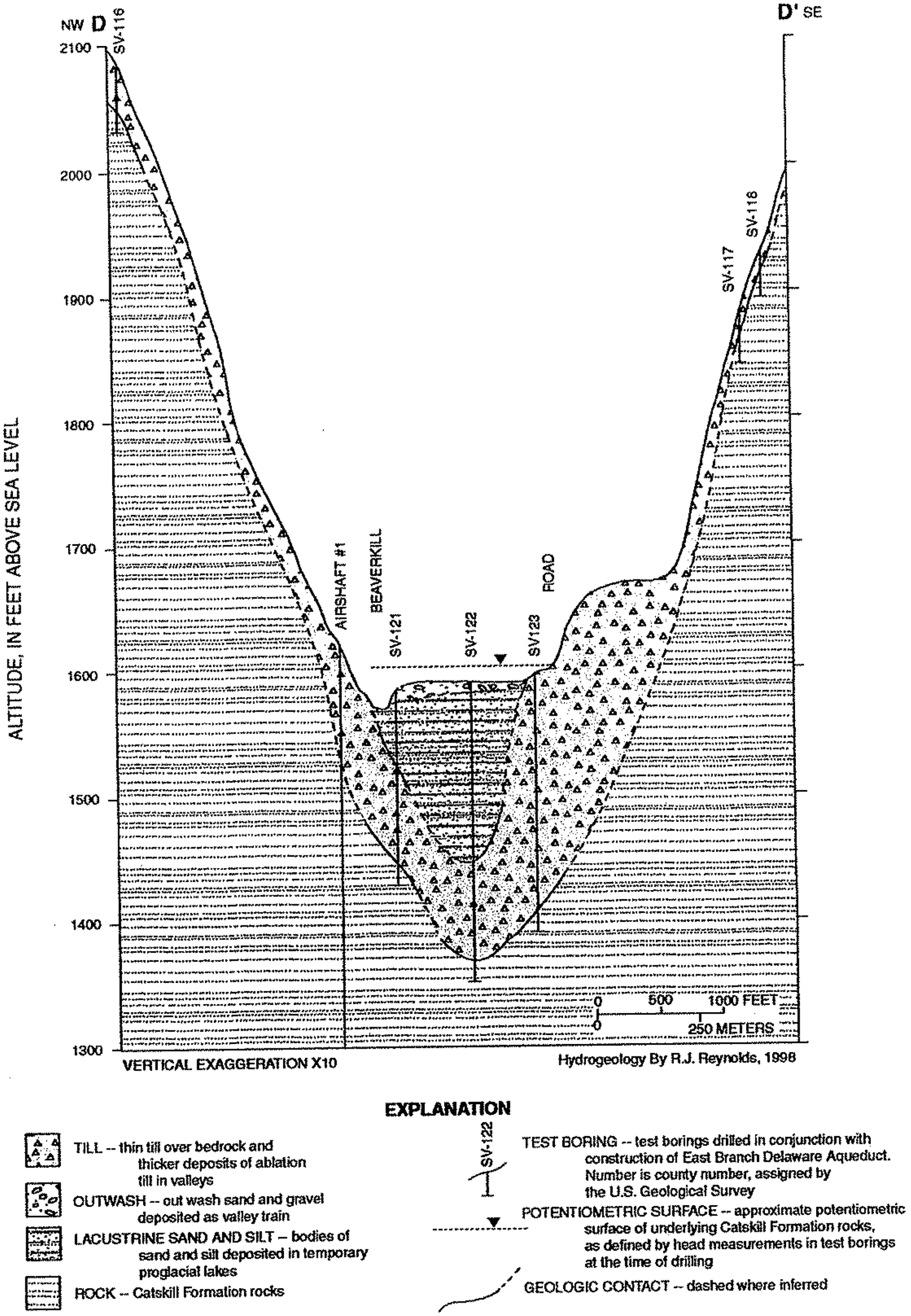
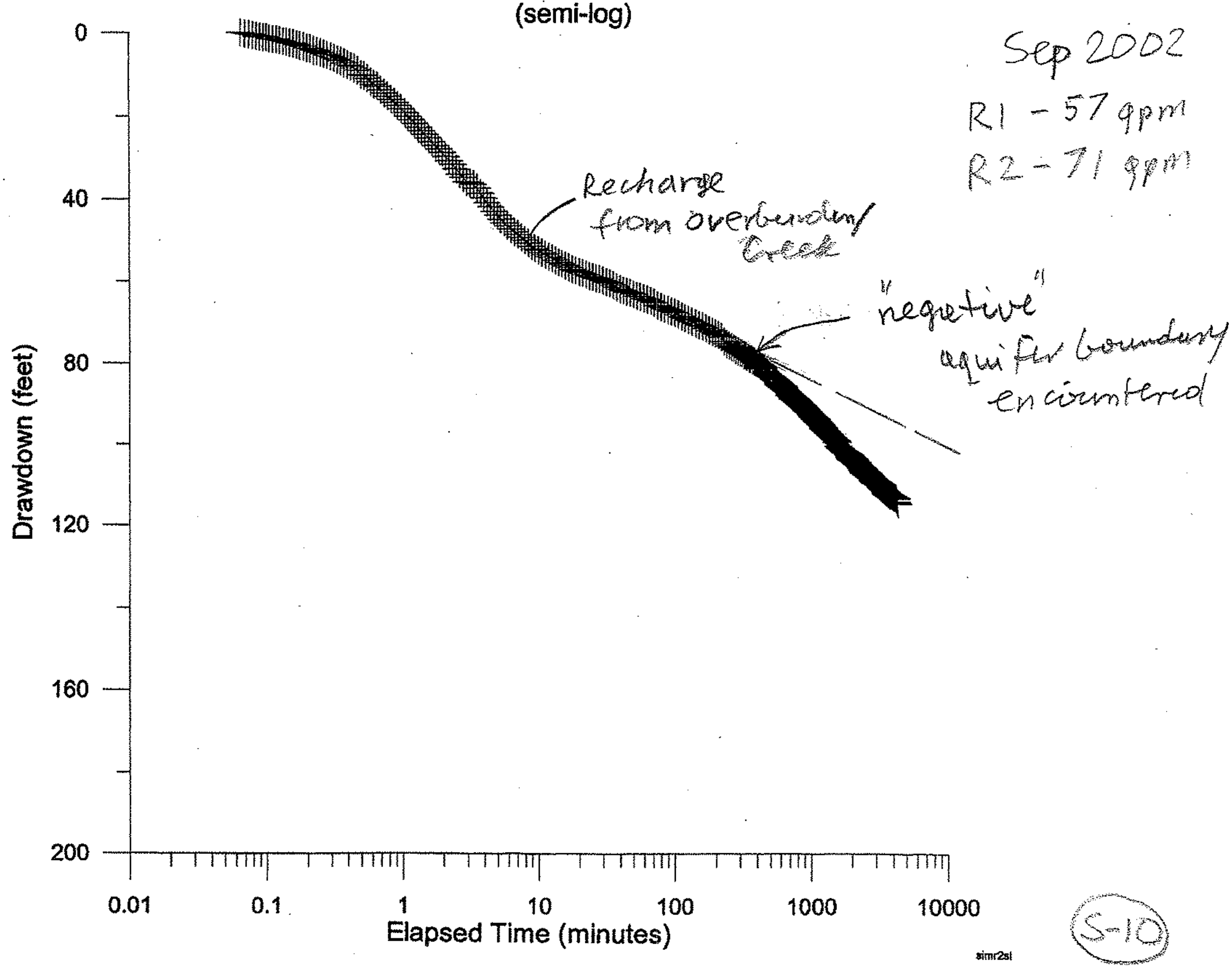


Figure 6. Geologic section D-D' along the East Branch Delaware aqueduct crossing of the Beaver Kill valley at Lewbeach, Sullivan County, N.Y. (Trace of section shown in figure 2.)

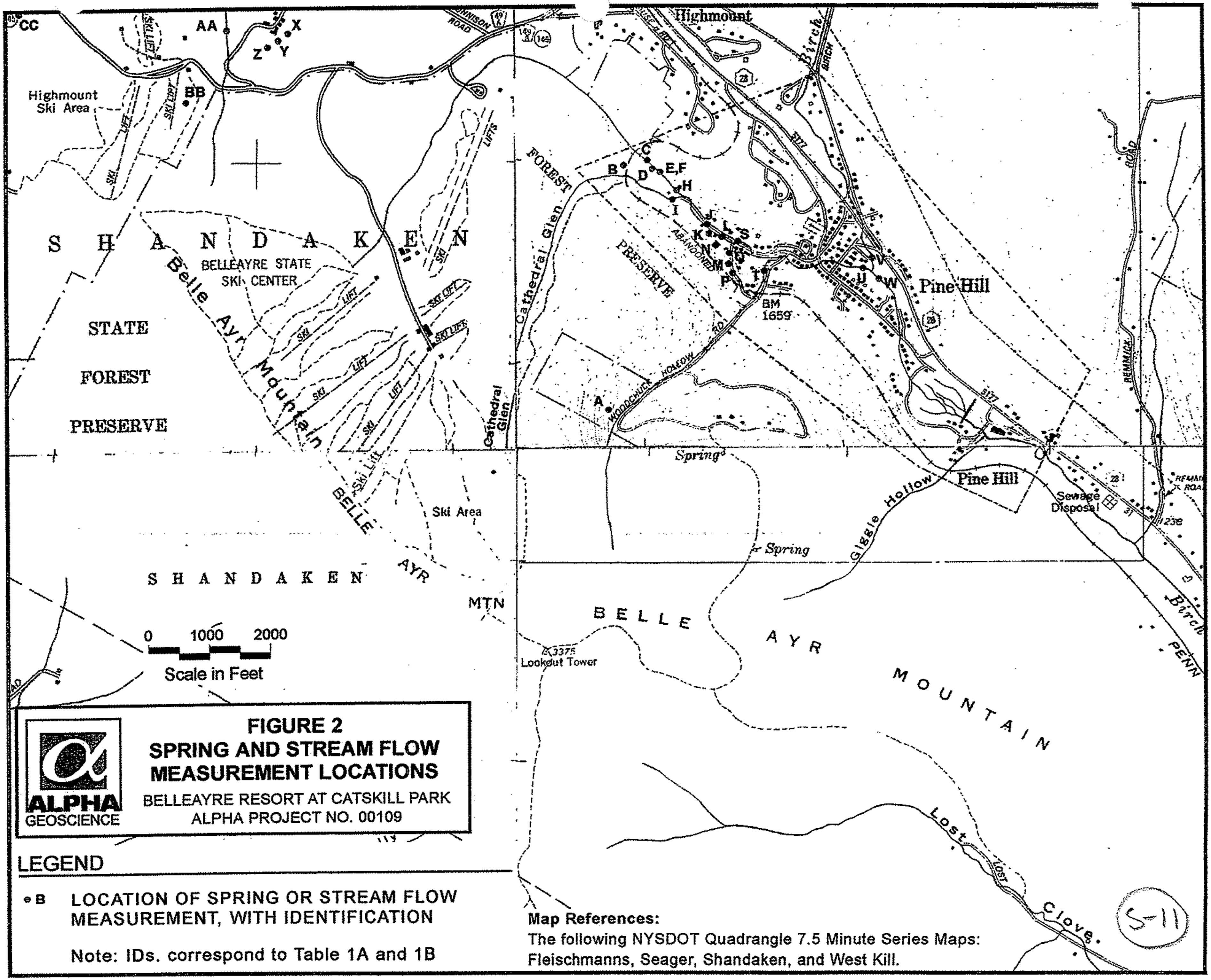
Exhibit F
App. B

Sep 2002
R1 - 57 gpm
R2 - 71 gpm

BELLEAYRE RESORT
Simultaneous Testing of Wells R1 and R2
Well R2
(semi-log)



S-10



ALPHA GEOSCIENCE

FIGURE 2
SPRING AND STREAM FLOW MEASUREMENT LOCATIONS

BELLEAYRE RESORT AT CATSKILL PARK
ALPHA PROJECT NO. 00109

LEGEND

● B LOCATION OF SPRING OR STREAM FLOW MEASUREMENT, WITH IDENTIFICATION

Note: IDs. correspond to Table 1A and 1B

Map References:
The following NYSDOT Quadrangle 7.5 Minute Series Maps:
Fleischmanns, Seager, Shandaken, and West Kill.

S-11

T
2000-20
SPRING AND STREA
Gallo

Belle
Alpha P

Stream/Spring	2000								
	18-Jan	2-Mar	27-Mar	20-Apr	22-May	26-Jun	26-Jul	29-Aug	28-Se
Woodchuck Hollow Spring	NM^{6}	NM	NM	NM	NM	87	27	28	2
Railroad Spring^{1}	NM	NM	NM	NM	386	351	193	247	8
Crystal Spring Brook-above Bonnie View Spg.	73	1005	777	879	899	655	122	120	4
Bonnie View side ditch^{2}	19	39	24	56	49	49	29	20	1
Pine Hill H_20 Supply (meter)	0	NM	118	118	0	118	114	114	11
Pine Hill H_20 Supply overflow	48	11	10	10.5	102	7.5	0.7	.25 est.	(
Crystal Spring Brook-above Cathedral Glen Brook	127	1,456	1,072	1,104	1,121	990	197	297	14
Cathedral Glen Brook-above CSB	242	3,499	3,730	2,531	2,889	2,317	730	843	28
Black ABS Pipe-above Silo A	NM	NM	19	19.7	18	18	9.9	5.1	2.
Silo A	120	212	150	175	178	125	104	98	8
Crystal Spring Brook-below Silo A	435	4,941	4,618	4,857	4,307	3,157	1,391	1,074	79
Silo B 4" Pipe	NM	NM	NM	NM	NM	NM	96	94	51
Silo B Overflow	29	25	28	24	26	25	25	26	2
Silo B (M + N)	NM	NM	NM	NM	NM	NM	121	120	7
Station Rd. ditch-above Depot Spg.	35	101	55	226	287	164	89	26	(
Station Rd. ditch-below Depot Spg.	107	433	167	402	372	426	220	245	9
Depot Spring Total^{3,4}	101	357	140	200	111	287	156	246	11
Crystal Spring Brook-below Depot Spg. — S	780	5,565	4,316	4,939	4,570	4,158	1,677	1,172	1,04
ailey Brook-above Crystal Spring Brook^{5} + T	NM	NM	NM	NM	925	509	127	60	2
rystal Spring Brook-above Birch Creek — U	NM	NM	NM	6,437	6,032	5,045	1,866	1,116	84
Birch Creek-above Crystal Spring Brook	NM	NM	NM	11,209	10,421	6,463	4,347	2,528	1,08
Birch Creek-below Crystal Spring Brook	NM	NM	NM	15,984	17,343	9,884	6,362	3,978	1,917
Wildacres #1 Spring	1	10.7	1.7	10	10.6	5.8	3.3	2.9	1
Wildacres #2 Spring	5.6	15	0.6	5.5	7.1	4.6	2.5	1.3	0.
Wildacres #3 Spring	8.4	17.5	6.8	17.5	5.8	5.3	10.3	11.5	4.
Davenport Spring	3.2	10.1	5.6	12.4	12.5	6.7	2	1.8	1.1
Highmount Spring	3.8	11.5	10	23	18.7	10.2	2.4	1.8	0.
Leach Spring	3.4	4.4	6.1	13	5.1	6.9	11.1	6.3	5.
Birch Creek at USGS Big Indian Gauging Station^{7}	5,835	41,741	19,300	25,134	26,481	13,914	6,284	4,488	2,154
Esopus Creek at USGS Allaben Gauging Station^{7}	50,718	235,187	76,301	107,719	132,854	80,789	33,662	24,686	11,22

Railroad Spring drains into Cathedral Glen Brook, upstream from its confluence with Crystal Spring Brook

Bonnie View Side Ditch = Water from Bonnie View Spring that does not enter piping to Bonnie View Spring collection system.

Depot Spring flow = Station Rd ditch flow below DepotSpring, minus Station Rd. ditch flow above Depot Spring, plus Silo B overflow

Silo B overflow to reservoir disconnected in March 2001. For March 2001 and subsequent dates, total Depot Spring flow = Station Rd Ditch below Depot Spring, minus Station Rd. Ditch above Depot Spring

Bailey Brook = Name given to unnamed stream in Woodchuck Hollow.

NM = Not Measured

Esopus Creek and Birch Creek flow values for September 2000 through December 2001 are "Provisional Data Subject To Revision" by the USGS

IA
NLY
EASUREMENTS
Minute

esort
lo. 00109

			2001										
6-Oct	28-Nov	27-Dec	30-Jan	28-Feb	29-Mar	25-Apr	30-May	29-Jun	30-Aug	1-Oct	13-Nov	29-Nov	14-Dec
56	38	39	NM	NM	NM	226	44	31	12	41	NM	NM	38
63	102	435	100	306	199	525	214	172	0	0	0	0	0
77	78	430	105	220	101	1644	97	80	30	16	NM	NM	NM
8	10	55	26	44	15	45	35	68	5	0	NM	NM	NM
112	113	NM	113	113.5	113.4	119	113.4	112	80	102.5	NM	95	100
0	0.7	9.5	NM	3	2.8	17.7	13.5	2.3	0	0	NM	NM	NM
184	230	542	235	372	459	1,913	322	280	45	69	NM	NM	NM
653	1,070	597	335	1,154	464	7,882	920	540	42	372	NM	NM	NM
2.2	1.7	11.5	5.6	9.4	12	20.6	9.9	5	1	0	NM	NM	NM
86	87	139	109	113	106	167	93.5	93	69.5	73	69.3	70.8	70.8
1,296	1,304	1,880	600	1,299	827	9,401	1,312	785	182	853	NM	NM	NM
121	113	150	133	161	176	189	187	185	27.5	159	NM	NM	165
25	26	28.5	25	26.5	0	0	0	0	0	0	NM	NM	0
146	139	178.5	158	187.5	176	189	187	185	27.5	159	NM	NM	165
50	11	226	0	67	49	311	0	4	0	0	NM	NM	NM
193	176	472	123	406	387	813	223	170	28	147	NM	NM	NM
168	192	275	148	365	338	502	223	166	28	147	NM	NM	NM
1,467	1,882	2,744	1,088	1,528	1,373	9,039	1,336	1,022	280	738	NM	NM	NM
87	104	446	41	71	84	1699	110	51	0	24	NM	NM	NM
3	1,835	2,827	851	1,699	1,445	12,156	1,460	946	188	601	NM	NM	1080
01	2,286	7,128	2,481	3,470	3,822	12,257	3,046	2,101	614	591	NM	NM	1435
4,385	4,833	9,502	3,874	4,980	5,505	25,096	4,453	3,214	696	1,225	NM	NM	2205
NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM
NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM
NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM
NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM
NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM
6.8	6.1	12.2	2.5	4.9	NM	5.6	4	12	0	0	NM	NM	NM
3,725	2,873	12,567	5,386	8,527	9,874	31,418	7,630	6,732	987	1,885	1,212	2,289	5,386
2,890	29,623	72,710	22,890	38,151	55,206	121,633	66,307	25,583	4,937	11,221	7,630	8,303	23,788

S-13

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Partial Paul Rubin Testimony

Hydrogeologic evaluation of well test data indicates that the planned water source for the Big Indian Plateau development may not be adequate. Rosenthal wells R1, R2, and R3 are the planned sources of water for the potable and irrigation water system for the Big Indian Plateau development. Currently, these wells are approved by the NYS DOH and the Ulster County Department of Health as having adequate yield. This approval hinges on the concept that a combined well test of at least 72 hours was conducted, and continued until all three wells demonstrate stabilized drawdown for at least 6 hours. This is detailed in John M. Dunn, P.E.'s NYS DOH letter of March 23, 2004 to Alexander Ciesluk, Jr. of the NYS DEC Region 3 office.

Specifically, Mr. Dunn's letter states:

"The NYSDOH draft Standards for Water Wells defines the stabilized water level as "the level of water in a well that has achieved equilibrium during a period of constant rate withdrawal of groundwater (i.e., stabilized drawdown)". The draft standards further state "the stabilized pumping water level shall not fluctuate more than plus or minus 0.5 foot for each 100 feet of water in the well" and "the plotted measurements shall not decrease during the constant flow test period". This definition allows for the water level to fluctuate a reasonable amount above or below the stabilized pumping level. It does not allow for the water level to continue dropping during the stabilization period."

It is important to point out that the Rosenthal well test was not conducted throughout at a constant withdrawal rate, thus negating the stated intent of the NYS DOH draft standards for Water Wells. Similarly, because a constant water withdrawal rate was not maintained throughout the drawdown test, it is not possible to assess that equilibrium conditions were met (i.e., this occurs when the rate of recharge within the area of pumping influence equals the rate of pumping, thus resulting in stabilized water levels throughout the area of influence). Because observation wells were not used throughout the well pumping test, it is not possible to assess how far outward the cone of depression extended during the pumping test, whether aquifer boundary conditions would have been encountered, or any measure of the potential quantity of groundwater available in the aquifer.

Assessed of aquifer equilibrium conditions is routinely assessed by hydrogeologists via the examination of a semi-logarithmic time-drawdown plot of the drawdown data - preferably the drawdown data as observed in an observation well. Semi-logarithmic plots of time-drawdown data are the standard means of portraying aquifer drawdown when assessing equilibrium conditions and can be extended to predict drawdown for a period of continuous pumping longer than the test itself (Driscoll, 1986). They are also used for calculating aquifer constants. The Applicant elected, instead, to only present drawdown data in an arithmetic graphing format vs. via standard graphical procedures. No observation wells were continuously monitored during the well test, thus it is not possible to assess whether equilibrium conditions would ultimately have been reached had the well test been continued for a longer period of time. Similarly, the Applicants failure to use observation wells precludes the analysis of the Coefficient of Storage or storativity - an aquifer parameter that assesses the volume of water an aquifer releases from or takes into storage per unit surface area of the aquifer per unit change in head. Storativity is important in assessing how much water is available for use in an aquifer. Sound hydrogeologic assessment of water availability requires determination of the coefficient of storativity. This was not possible because observation wells were not incorporated into the testing procedure.

As a hydrogeologist, I would not be comfortable stating that sufficient water quantity was available without assessment and evaluation of storativity and transmissivity, that are routinely assessed in water supply studies. Neither were determined by the Applicant. Thus, while "(T)est results are intended to indicate that the well will produce the yield flow rate (i.e., minimum sustained yield) for a long period" (p. 2 of 6, NYS DOH, Bureau of Water Supply Protection - Technical Guidance for Designers and Developers of Realty Subdivisions), once the drawdown data is correctly plotted, it is clear that 1) equilibrium conditions were not achieved, and 2) the well test at each new discharge rate was terminated shortly after the data indicates that the aquifer was not able to readily keep up with the pumping rate (Figure ?) As seen in the steep semi-log slopes on Figure ?).

> [For Reference Only - Storativity: Coefficient of Storage - The volume of water an aquifer releases from or takes into storage per unit surface area of the aquifer per unit change in head. Same as specific yield in unconfined aquifers. Units are dimensionless. Values of S for unconfined aquifers range from 0.01 to 0.3; values for confined aquifers range from 10 -5 to 10 -3.]

Mr. Dunn's letter further clarifies that the NYS DOH's definition of a stabilized pumping water level does not allow for the water level to continue dropping during the stabilization period. I suspect that the reason the NYS DOH acknowledges that their standards are "draft" is because it needs detailed refinement when it comes to the hydrogeologic assessment of "stabilized pumping level" or equilibrium conditions. In fact, six hours of water level data collected after reducing the discharge from a well is not likely to be able to demonstrate any kind of stabilization or equilibrium conditions. The Applicant has carefully and readily worked to take advantage of the "draft" nature of the NYS DOH draft standards, even though final sign-off, and probably evaluation, has not occurred. These draft standards, in their current form, are not based on a rigorous hydrogeologic foundation. They require significant modification and input from hydrogeologists. No project water supply should be approved based on a incomplete draft standard.

This NYS DOH and Ulster County Health Department well-test procedure used is very unconventional and has some serious flaws. I will detail some of the biggest problems:

1. First, the most serious flaw. When you pump at a high rate and then reduce the rate to get a steady state, it might seem that this is a valid worst-case approach, because the well is being stressed more than it would if only the smaller pumping rate had been used all along (see example Figure ?). However, when you decrease the pumping rate the water level rebounds a bit and takes a while to stabilize (Figure ?). THEN it begins to drop again. For example, if you pump at 1 cfs for 72 hours and then cut the Q to 0.5 cfs, the drawdown curve will rise, gradually level off, and then start dropping at about half the original rate. But in the transition between the two stable slopes there's an extended period when there's very little fluctuation in water level, when you could easily meet the NYS DOH requirements of less than 0.5 ft fluctuation. But the well has not yet begun to respond to the 0.5 cfs pumping rate and your test would be invalid. This situation is directly visible in the Well R1 semi-log plot (Figure ?). The reduced discharge simply has not had adequate time to demonstrate the steeply dropping drawdown data that would more fully resemble the Q = 78.5 gpm curve. Yet, by the time of culmination of both the reduced discharge rates (70 gpm and 63 gpm) the precipitous drop in water levels had already begun (Figures ? and ?). The short-term duration of the Belleayre Well Test at the two reduced pumping rates fails to provide sufficient data to reliably define the slope

and position of the time-drawdown graph needed to predict drawdown at different time intervals (i.e., the length of the lower discharge portions of the well test do not reasonably meet the intent of testing/stressing the aquifer at the new "lowered" pumping rate since the test was not actually conducted at a stabilized, constant, discharge rate). This straight alignment of drawdown points indicates little or no aquifer recharge. Thus, the six hour/ plus or minus 0.5 foot "acceptable" water level fluctuation currently in the NYS DOH draft standard requires significant revision as it will often result in a completely erroneous well yield figure (as has happened here). This is a major flaw in the current draft NYS DOH standard and can cause a serious overestimation of the well capacity (i.e., specific capacity = a well's yield per unit of drawdown (e.g., gpm/ft). This can be demonstrated with any groundwater software.

2. Altering the discharge during a well test complicates the assessment of long-term aquifer performance, but it's still possible to do so. Assessment of boundary effects, leakage, etc. are greatly complicated and the effects may be masked entirely by changing the Q. T and S can be calculated from the straight-line part of the time drawdown curve for the higher pumping rate - if any - but you'd have to wait a long time (perhaps days) for the reduced flow to stabilize enough to give a straight line. Thus, as seen in Figure ?, the aquifer has not had sufficient opportunity during the reduced discharge rate portions of the well test to reasonably assess T and S. Transmissivity is one of the two most important aquifer parameters any sound hydrogeologic characterization of a potential water supply must assess. The Applicant lacks the hydrogeologic data to characterize T and S - thus, potential approval of the Rosenthal wells as a major water source should not have been approved in the absence of comprehensive and properly conducted and analyzed aquifer testing in keeping with National Ground Water Association approved hydrogeological methods (e.g., see Driscoll, 1986, et al.) . At this time, project approval based on the analysis presented by the Applicant has the very real potential of resulting in a large-scale project without adequate water resources. I repeat - At this time, project approval based on the analysis presented by the Applicant has the very real potential of resulting in a large-scale project without adequate water resources.

> [For Reference Only - Transmissivity (*T*) - the transmission capability of the entire thickness of an aquifer (i.e., the rate of flow in gallons per minute through a vertical section of an aquifer one foot wide and extending the full saturated height of an aquifer under a hydraulic gradient of 1). The product of *Kb*. Units: m^3/day/m or m^2/day, gpd/ft; ft^2/day]

3. Non-pumping observation wells are essential for a truly valid assessment of S. Pumping results can be extrapolated beyond the immediate areas of the pumping wells, but not beyond the cone of depression, and this extrapolation is difficult and often flawed if no observation wells are used. The assessment of low-K or high-K boundaries, for example, relies strongly on multiple observation wells. Multiple pumping wells can also be used to some extent, but the data are not as reliable. Importantly, the entire Rosenthal test of the combined 3-well pumping only provides hydrogeologic data specific to the area immediately surrounding each of the three pumped wells AND none on what is going on in the surrounding bedrock aquifer, since no observation wells were used for the test. Project evaluation based on the proposed Rosenthal well water source must be based on a rigorous hydrogeologic assessment of the aquifer, such that standard calculations of T and S may be made. It is interesting to note that the Applicant did analyze for T & S in their evaluation of The Wildacres Resort and Highmount Golf Club/Highmount Estates Water Supply. Hydrogologic testing and limited non-conventional "draft" NYS DOH guidance, at this time, does not provide sufficient documentation of an adequate groundwater supply. Hydrogeologic testing of the Rosenthal wells should be completely redone in accordance with National Ground Water Association (NGWA) accepted procedures.

> [For Reference Only - Hydraulic Conductivity (*K*) {or permeability} - a measure of the ease with which water can be transmitted through a porous material. A material which permits water to easily flow through it has a higher hydraulic conductivity (is more permeable) than a material that more severely impedes water movement. Units: gpd/ft^2 or m/day or cm/sec]

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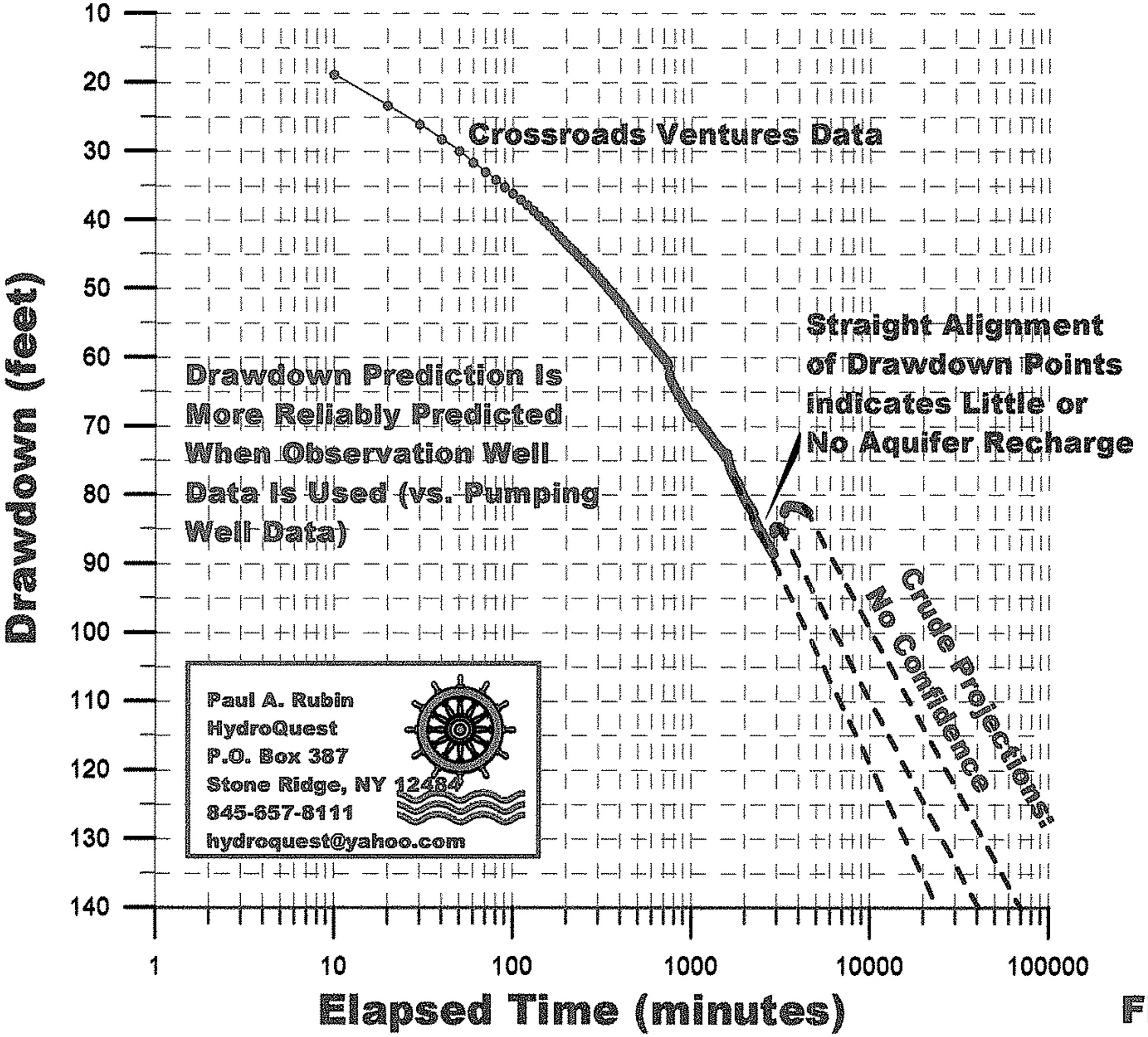
CPC Exh 82

Belleayre Resort Yield Test of Well R1

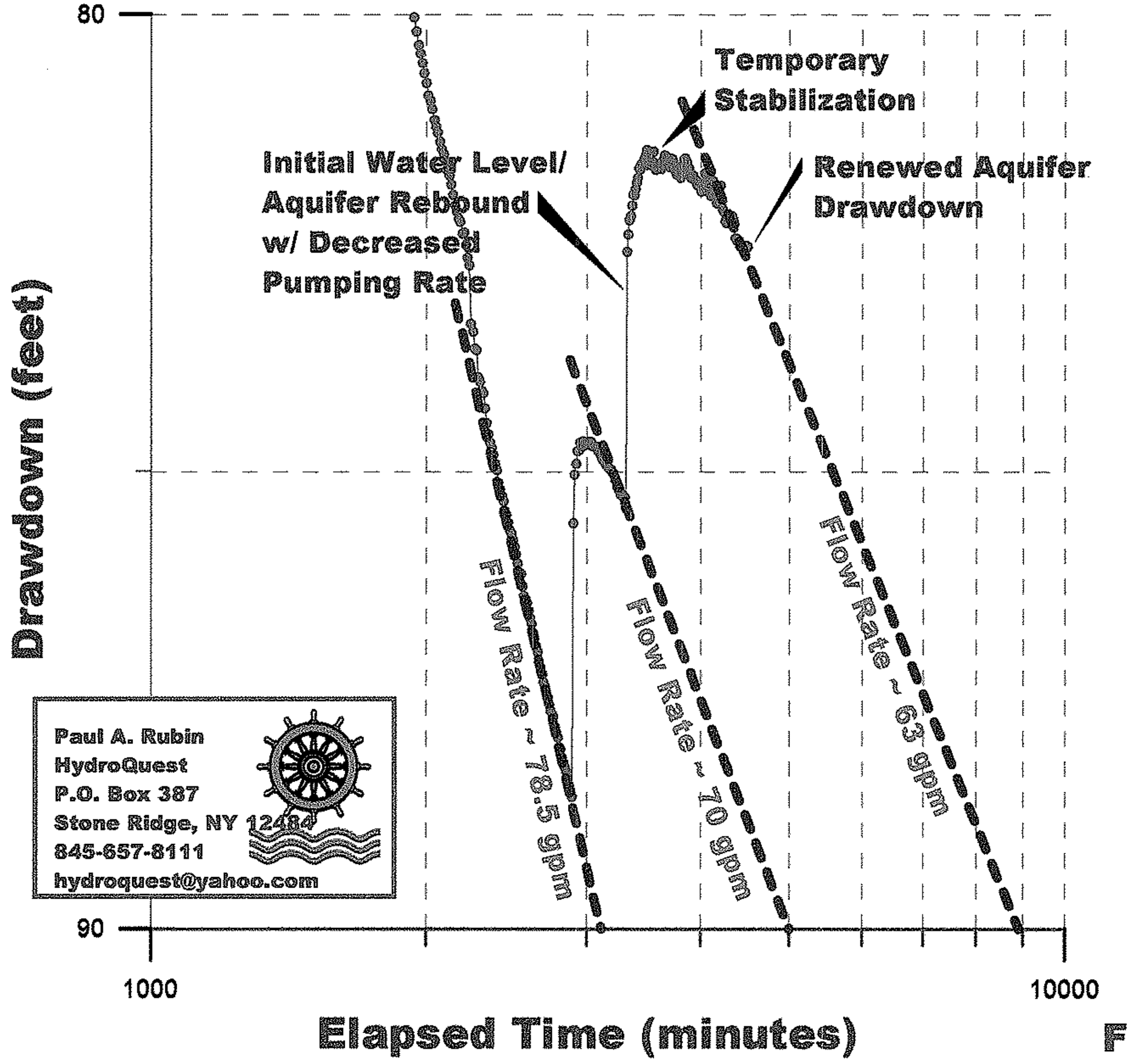


Figure

CPC Ex 82a

Belleayre Resort Yield Test of Well R1

(Blow-up: End of Drawdown Test with Decreased Yield)



Figure

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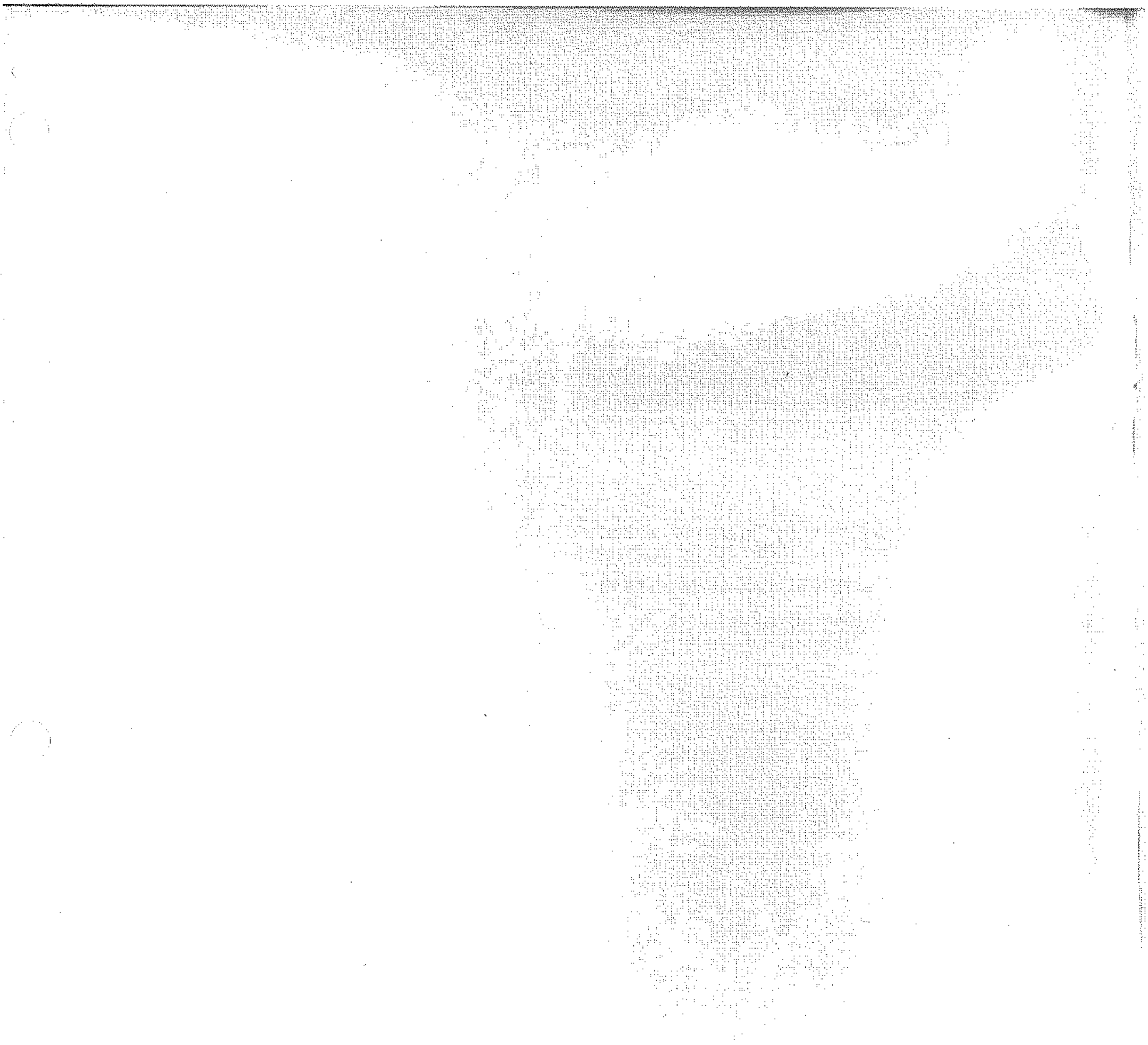

Cover: A covered bridge of the Town lattice-truss type spans the Beaver Kill at Cooks Falls, NY in January, 1918. Many of these covered bridges, built from the 1850's through the 1870's, provided crossings for local roads across the Beaver Kill and Willowemoc Creeks through the early 1900's. The U.S. Geological Survey has been collecting streamflow data at this site since July, 1913--making it one of the oldest stream-gaging sites in New York. (Photo from U.S. Geological Survey archives).

Hydrogeology of the Beaver Kill Basin in Sullivan, Delaware, and Ulster Counties, New York

By Richard J. Reynolds

U.S. GEOLOGICAL SURVEY

Water-Resources Investigations Report 00-4034

Prepared in Coooperation with the
Town of Rockland

Troy, New York
2000

U.S. DEPARTMENT OF THE INTERIOR
BRUCE BABBITT, Secretary

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U.S. Geological Survey
Information Services
Box 25286
Federal Center
Denver, CO 80225

CONTENTS

FIGURES

TABLES

CONVERSION FACTORS AND VERTICAL DATUM

Multiply	By	To obtain
	Length	
inch (in.)	2.54	centimeter
foot (ft)	0.3048	meter
mile (mi)	1.609	kilometer
foot per mile (ft/mi)	0.1894	meter per kilometer
	Area	
square mile (mi^2)	2.590	square kilometer
	Flow rate	
cubic foot per second (ft^3/s)	0.02832	cubic meter per second
cubic foot per second (ft^3/s)	28.32	liter per second
gallon per minute (gal/min)	0.06309	liter per second
gallon per day per square mile [(gal/d)/mi^2]	0.001461	cubic meter per day per square kilometer
million gallons per day (Mgal/d)	0.04381	cubic meter per second
million gallons per day (Mgal/d)	3,785	cubic meters per day
million gallons per day per square mile [(Mgal/d)/mi^2]	1,461	cubic meter per day per square kilometer
gallons per day per square mile [(gal/d)/mi^2]	0.001462	cubic meters per day per square kilometer
gallon per day per foot [(gal/d)/ft]	0.0001437	liter per second per meter
	Hydraulic Units	
transmissivity, feet squared per day (ft^2/d)	0.0929	meter squared per day
hydraulic conductivity, feet per day (ft/d)	0.3048	meter per day
specific capacity, gallons per minute per foot (gal/min)/ft	0.2070	liter per second per meter
pound per cubic foot (lb/ft^3)	0.01602	gram per cubic centimeter

Sea level: In this report, "sea level" refers to the National Geodetic Vertical Datum of 1929 (NGVD of 1929)—a geodetic datum derived from a general adjustment of the first-order level nets of both the United States and Canada, formerly called Sea Level Datum of 1929.

Hydrogeology of the Beaver Kill Basin, in Sullivan, Delaware, and Ulster Counties, New York

by Richard J. Reynolds

ABSTRACT

The hydrogeology of the 299-square-mile Beaver Kill basin in the southwestern Catskill Mountains of southeastern New York is depicted in a surficial geologic map and five geologic sections, and is summarized through an analysis of low-flow statistics for the Beaver Kill and its major tributary, Willowemoc Creek. Surficial geologic data indicate that the most widespread geologic units within the basin are ablation and lodgment till. Large masses of ablation till as much as 450 feet thick were deposited as lateral embankments within the narrow Beaver Kill and Willowemoc Creek valleys and have displaced the modern stream courses by as much as 1,000 feet from the preglacial bedrock-valley axis.

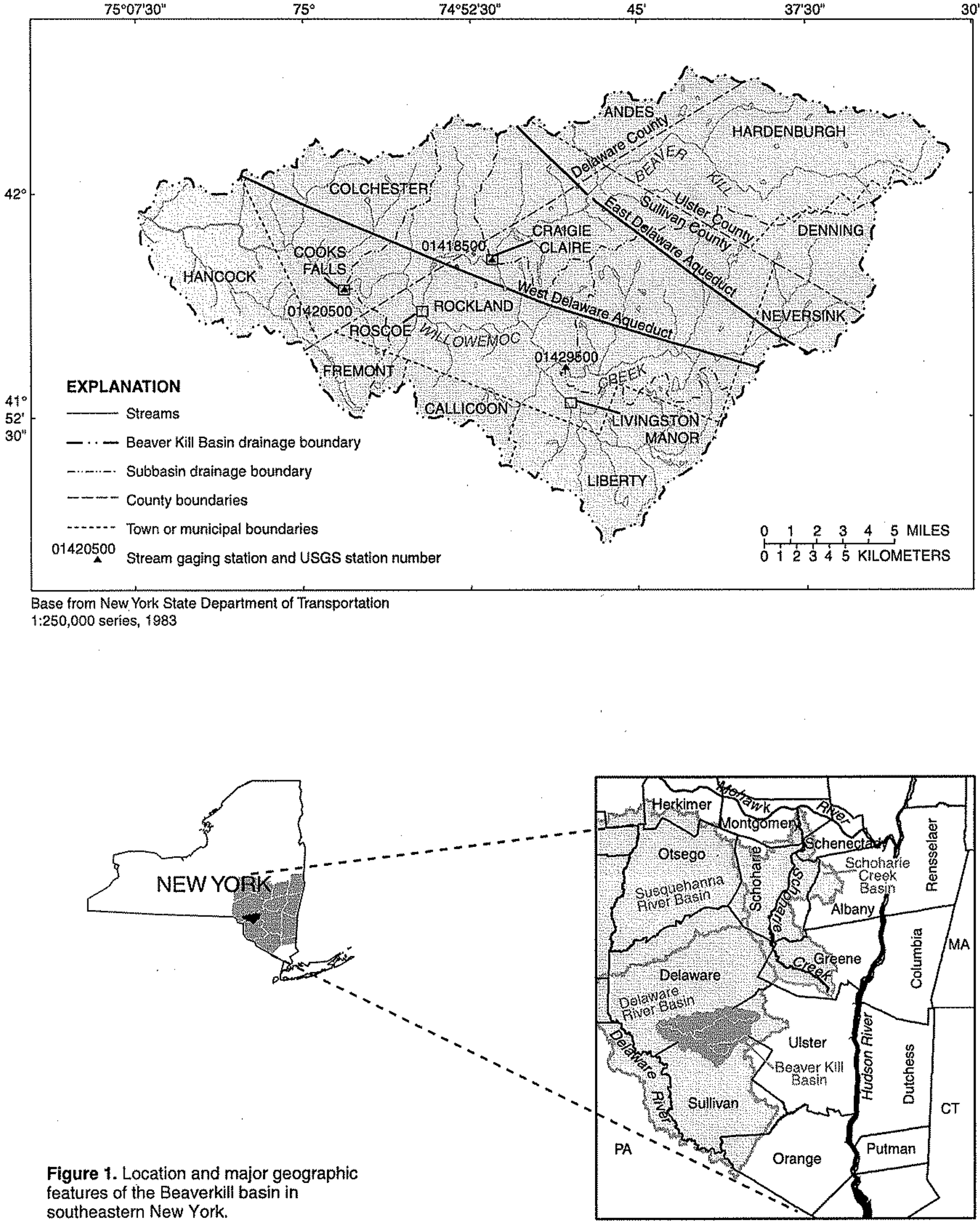
Low-flow statistics for the Beaver Kill and Willowemoc Creeks indicate that the base flows (discharges that are exceeded 90 percent of the time) of these two streams--0.36 and 0.39 cubic feet per square mile, respectively--are the highest of 13 Catskill Mountain streams studied. High base flows elsewhere in the glaciated northeastern United States are generally associated with large stratified-drift aquifers, however, stratified drift in these two basins accounts for only about 5 percent and 4.4 percent of their respective surface areas, respectively. The high base flows in these two basins appear to correlate with an equally high percentage of massive sandstone members of the Catskill Formation, which underlies the entire region. Ground-water seepage from these sandstone members may be responsible for the high base flows of these two streams.

INTRODUCTION

The Beaver Kill basin, which encompasses the drainage areas of the Beaver Kill, Willowemoc Creek, and several smaller tributaries, drains approximately 299 mi^2 of the rugged southwestern Catskill Mountains in Delaware, Sullivan, and Ulster Counties, N.Y. (fig. 1). The Beaver Kill, and its tributary, Willowemoc Creek, both support a large trout fishery that attracts many anglers each year. Recent concern among residents, natural-resource managers, and anglers over the health of this trout fishery prompted the Town of Rockland to enter into a cooperative agreement with the U.S. Geological Survey (USGS) in 1997 to characterize the hydrogeologic system within the Beaver Kill basin. The location and major geographic features of the Beaver Kill basin, are shown in figure 1.

Objectives and Approach

The primary objectives of this study were to (1) assemble all available surficial geologic maps for the thirteen 7.5-minute quadrangles that encompasses the Beaver Kill basin, (2) reconcile differences among mapped units delineated by various investigators, and (3) produce a 1:48,000-scale digital map of the surficial geology of the basin. All available surficial geologic mapping of the Beaver Kill basin was found to be generally on a reconnaissance level and was limited to those sections of the basin that were within the study areas of Kirkland (1973), Ozvath (1985), and Gubitosa (1980). Copies of some 1:24,000-scale quadrangles showing surficial geologic mapping by these three authors were obtained from the New York



Base from New York State Department of Transportation
1:250,000 series, 1983

Figure 1. Location and major geographic features of the Beaverkill basin in southeastern New York.

State Geological Survey. Major surficial geologic units in parts of the basin that were not mapped by these investigators, were delineated from 1:62,500-scale reconnaissance field maps produced by Soren as part of two USGS ground-water investigations in Sullivan and Delaware Counties (Soren, 1961, 1963).

Purpose and Scope

This report (1) describes the major surficial geologic units that occupy the basin, (2) briefly outlines the bedrock geology, (3) compares the hydrogeologic characteristics of the Beaver Kill basin with those of 12 other Delaware river drainage basins, and (4) relates mean annual base flow of the Beaver Kill and Willowemoc Creek to specific hydrogeologic characteristics of the Beaver Kill basin. The report also presents three previously published geologic sections by Fluhr (1948a,b; 1949) and two new ones to illustrate the stratigraphic relationships of major mapped units within the basin.

Previous Studies

Several previously published works discuss various hydrologic and geologic aspects of the Beaver Kill basin. The surficial geology and deglacial sequences of the western and central Catskill Mountains were first studied in depth by Rich (1935), who studied the western and central Catskills including the eastern upland part of the Beaver Kill and Willowemoc Creek subbasins, and concluded that there was evidence of two distinct drift sheets, which he termed "early" and "late" Wisconsinan. Later investigations of the glacial geology within this basin included doctoral dissertations by Kirkland (1973) and Ozvath (1985), and a Master's thesis by Gubitosa (1980). Of these three studies, only Kirkland's encompassed the entire Beaver Kill basin; Ozvath's study included only the northwesternmost part of the basin, and Gubitosa's study included only the southwesternmost part.

Two water-resource investigations by the USGS in the 1960's, in cooperation with the New York State Department of Conservation, produced reports on the ground-water resources of Sullivan and Delaware Counties (Soren, 1961, 1963), which contain part of the Beaver Kill basin. Geotechnical and engineering studies conducted by the New York City Board of Water Supply in the mid-to-late 1940's in conjunction with the planned construction of the Delaware Aqueduct System provided several unpublished memoranda reports describing the results of test borings at planned dam sites and aqueduct tunnel crossings (Fluhr, 1948a, b, 1949; Reed and Fluhr, 1948), and two published summary reports (Fluhr, 1953; Fluhr and Terenzio, 1984).

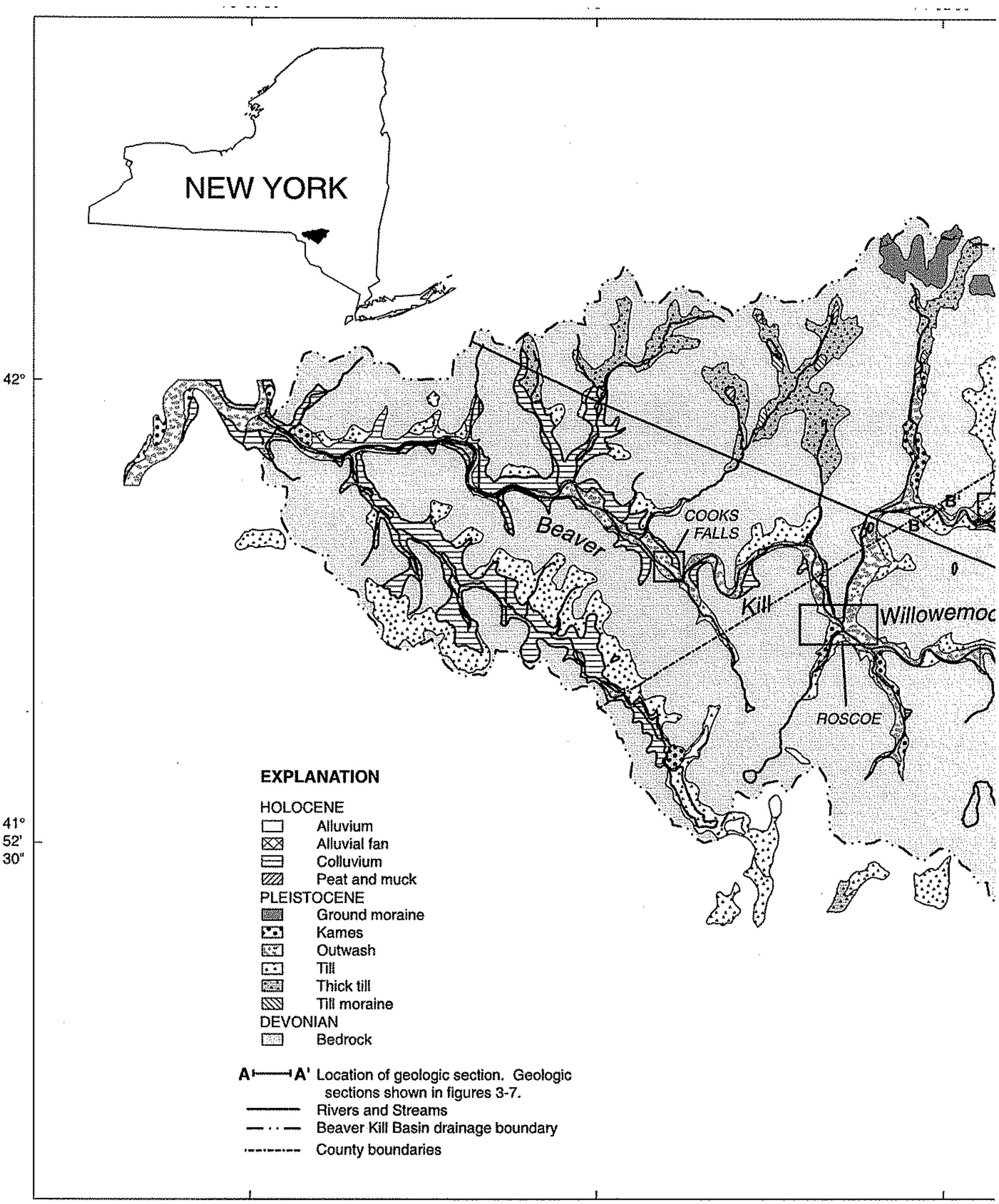
A USGS study of the entire Delaware Basin conducted in the early 1960's by Hely and Olmsted (1963) and Parker and others (1964), and a comparison study of Catskill and Susquehanna River basin streams by Coates (1971) provided streamflow and low-flow data and statistics for both the Beaver Kill and Willowemoc Creek.

GEOLOGY

The thickness, type and areal extent of surficial geologic units and bedrock units within the Beaver Kill basin are the main factors that determine (1) ground-water availability in the basin, and (2) the amount and distribution of ground water and surface runoff to the Beaver Kill and Willowemoc Creeks.

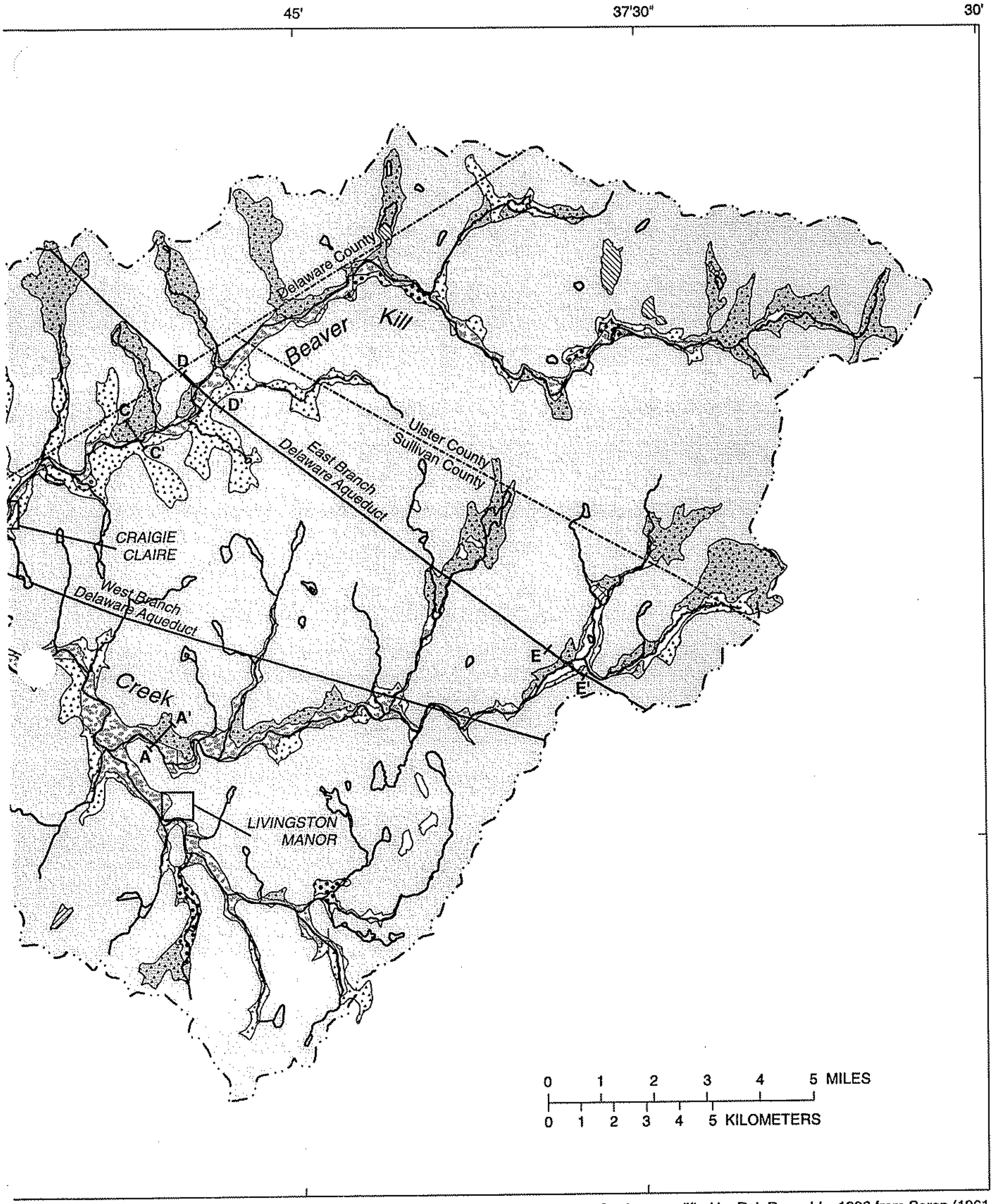
Surficial Geologic Units

The major surficial geologic units within the Beaver Kill basin are till, ice-contact stratified drift, outwash, recent alluvium, colluvium, and areas of exposed rock (fig. 2). Till is the most widespread unit within the basin by far and is mapped as six distinct forms: thin till over rock, till, thick till (greater than 5 ft), ground moraine, till moraine, and colluvium. Ice-contact stratified drift occurs as small, isolated kames, kame terraces, and kame deltas emplaced along the hillsides within the major valleys. Outwash and recent alluvium form a thin, narrow deposit of coarse gravel and sand that floors most of the Beaver Kill and Willowemoc Creek valleys. Colluvium, an unsorted mixture of redeposited till and postglacial sediments, is present along the base of many of the steep valley walls along the Beaver Kill and Willowemoc Creek. Bedrock is commonly exposed along steep hillsides and ridgetops. The origin and distribution of these major units are discussed below.



Base from New York State Department of Transportation
1:250,000 series, 1983

Figure 2. Distribution of major surficial geologic units within the Beaver Kill basin, and locations of geologic sections depicted in figures 3 through 7.



Geology modified by R.J. Reynolds, 1998 from Soren (1961, 1963); Kirkland (1973);Gubitosa (1980), and Ozrath (1985)

Till

Till is the predominant surficial geologic unit within the Beaver Kill basin and covers approximately 92 percent of the area within the basin. It occurs as (1) thin till over bedrock, (2) ablation and lodgment till in varying thicknesses, (3) areas of thick ground moraine, and (4) till moraine, deposited as distinctive landforms. The wide areal extent of till in the Beaver Kill basin is a direct result of the mode of deglaciation (thinning and melting of glacial ice) that occurred there. Continental glacial ice moving southward over the high northern drainage divide of the Beaver Kill basin became detached from the main ice sheet covering the Catskills and ceased to flow. This detached glacial ice that occupied the main Beaver Kill and Willowemoc valleys then stagnated and melted during what is known as "ice-stagnation retreat." This topographically controlled, massive ice stagnation resulted in the deposition of large amounts of ablation till in the valley bottoms and of lodgment till in high upland tributaries. Ozvath (1985) refers to the ablation till as "valley diamicton" and ascribes its deposition to the resedimentation of supraglacial and englacial debris during the melting of underlying ice. Large masses of ablation till in the western Catskills are commonly associated with, and may interfinger with, ice-contact stratified drift (kame) deposits. This interfingering resulted a wide variability in till composition, and was produced by the multiple depositional processes that occurred during ice ablation, such as resedimentation, meltwater runoff, and slope colluviation (Ozvath, 1985). The ablation till in this basin has been described as a massive, matrix-supported deposit of clasts of sand, silt, and gravel ranging from granule to boulder size. The matrix ranges from loamy silt to silty sand and is reported to be less compacted than adjacent upland ground moraine (Ozvath, 1985).

Thick deposits of ablation till in the western Catskills form a variety of recognizable landforms such as drumlins, morainal loops, ridges, knobs, and lateral embankments. Rich (1935) was the first to recognize such features as ablation till and to ascribe their occurrence as indicative of deposition by active ice margins. Later workers, notably Kirkland (1973) and Ozvath (1985), maintain that these features resulted from the disintegration of stagnant ice within the stream valleys, especially in valleys that are oriented perpendicular to the southwestward direction of continental ice flow. These large ablation till landforms have appreciably altered the courses of the Beaver Kill and Willowemoc Creek, as well as many other streams in the western Catskills. Test borings conducted in the 1940's by the New York City Board of Water Supply as part of geotechnical investigations for the East Branch and West Branch Delaware aqueducts and for several proposed dam sites reveal that large thicknesses of ablation till emplaced against the valley walls (lateral embankments) have displaced the postglacial valley axis as much as 1,000 ft from the preglacial bedrock valley axis. Geologic section A-A' (fig. 3) across shows approximately 750 ft of southwestward axis displacement to in the Willowemoc Creek valley at Roundtop (Fluhr, 1948b). Logs of test borings at this site indicate that nearly all of the valley-fill sediment is till with interbedded lenses of sand and gravel or sand and silt. A maximum till thickness of 360 ft was penetrated by test boring 2 (fig. 3).

Geologic section B-B′ (fig. 4) indicates the stratigraphy and valley geometry across the Beaver Kill valley at Craigie Claire to be similar to that in the Willowemoc Creek valley at Roundtop, except that the ablation till here contains more lenses of sand and gravel, and of silt and clay (fig. 4). The thickest section of till penetrated at this site is between test borings 3 and 4, where approximately 350 ft of till and interbedded lacustrine sand and silt was penetrated (Fluhr, 1948a). The lenses of lacustrine silt and sand are the result of small, short-lived glacial lakes that occupied the depressions between the valley wall, previously deposited till, and the disintegrating ice mass. The lenses of sand and gravel are the result of fluvial resedimentation and sorting of till by glacial meltwater. Fluhr called these lenses "modified glacial drift" and, although some individual beds are permeable, none are areally extensive. As at the Roundtop site, the lateral embankment of ablation till here has moved the course of the postglacial Beaver Kill about 1,000 ft north of the bedrock valley axis.

A third example of a thick lateral embankment of ablation till is depicted in geologic section C-C′ at a formerly proposed damsite across the Beaver Kill valley at Jersey Brook (fig. 5). This section shows a 480-ft-thick embankment of ablation till emplaced along the north wall of the Beaver Kill valley at this location and which completely fills the original bedrock valley. This lateral embankment has shifted the course of the Beaver Kill about 1,000 ft to the south, such that the stream now flows across a bedrock ledge.

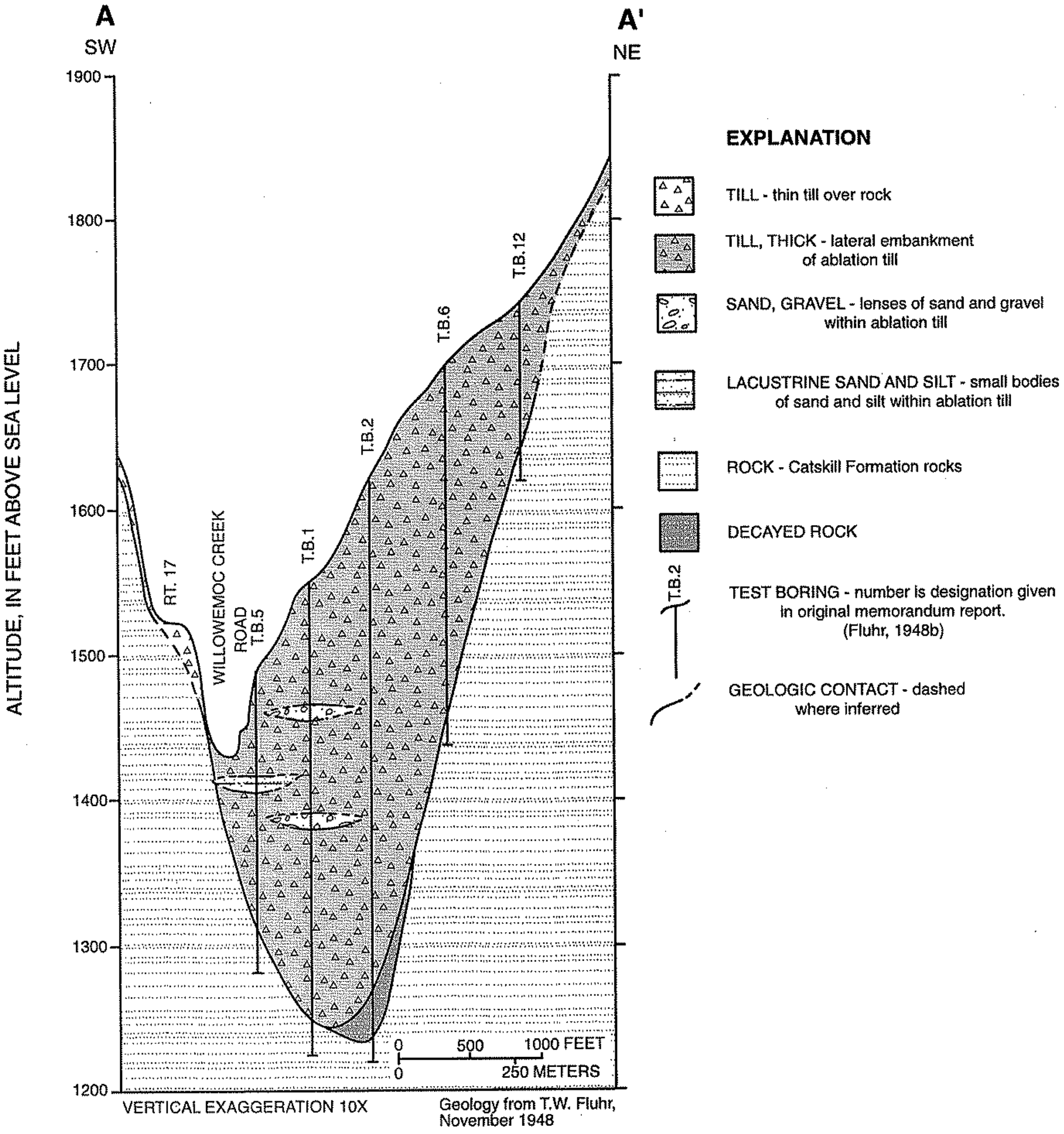


Figure 3. Geologic section A-A' across the Willowemoc Creek valley at Roundtop, N.Y. Trace of section is shown in figure 2 (Modified from Fluhr, 1948b).

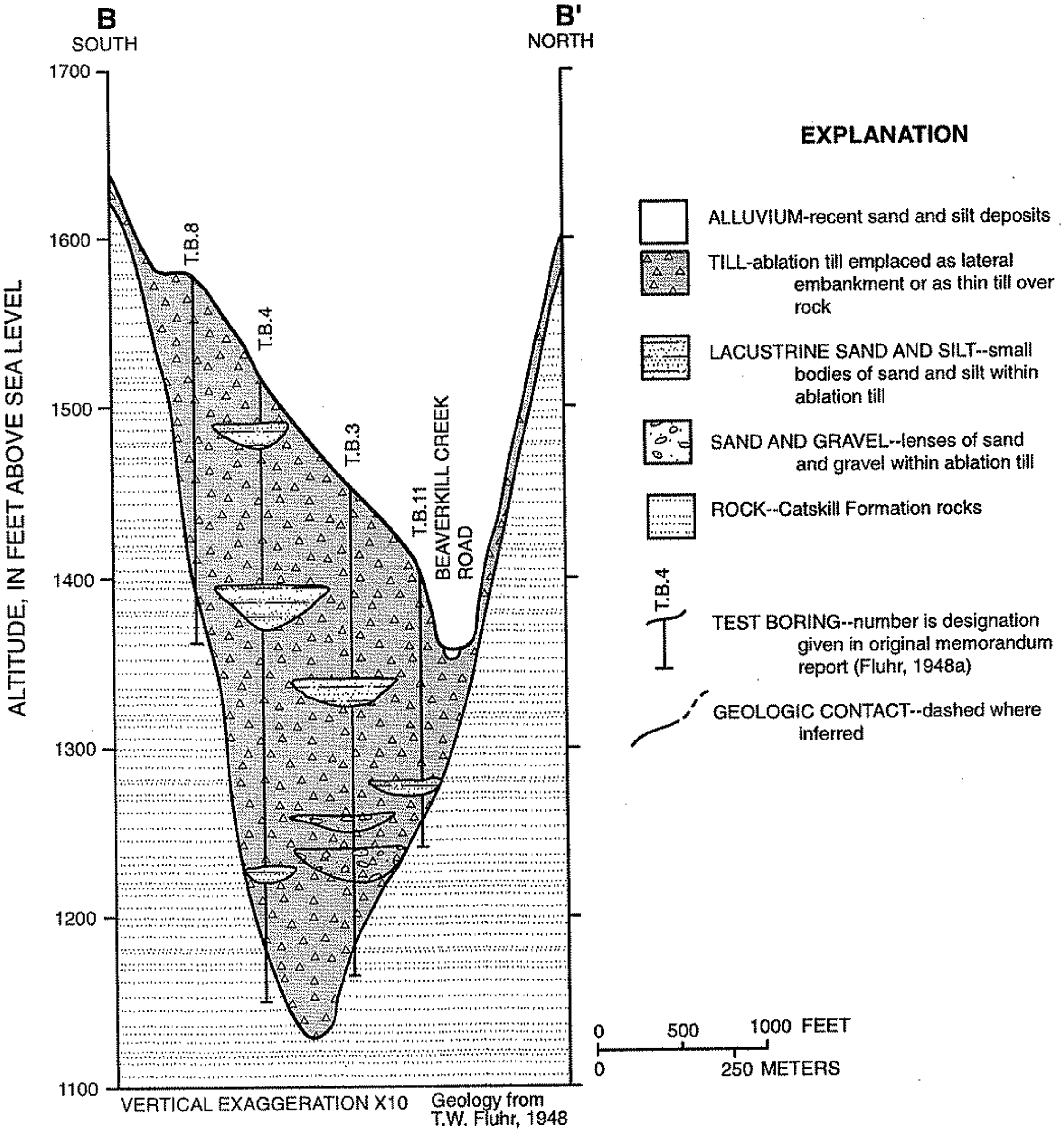


Figure 4. Geologic section B-B across the Beaver Kill valley at Craigie Claire, Sullivan County, N.Y. Trace of section shown in figure 2 (Modified from Fluhr, 1948a).

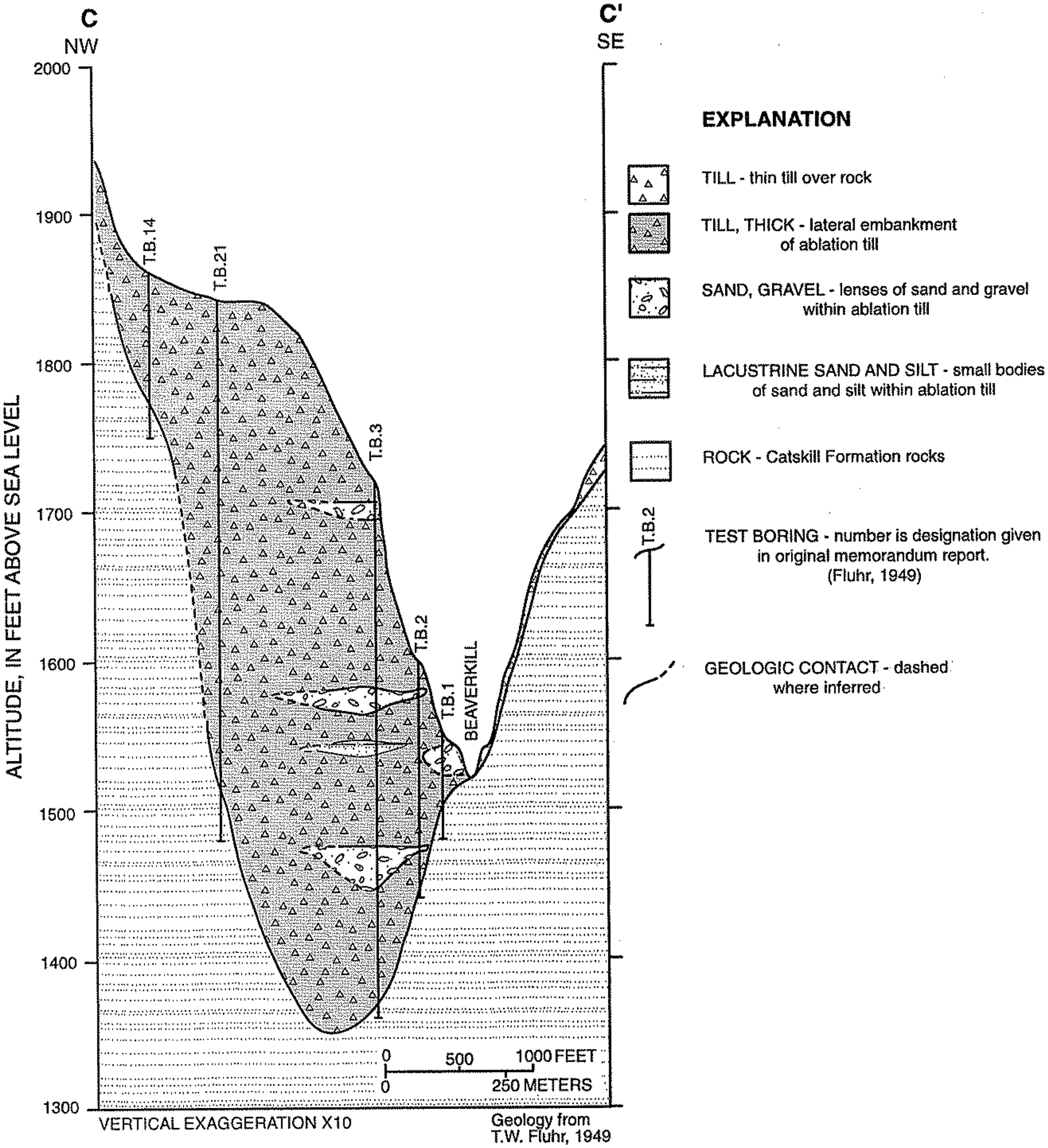


Figure 5. Geologic section C-C across the Beaver Kill valley at Jersey Brook, Sullivan County, N.Y. Trace of section shown in figure 2 (Modified from Fluhr, 1948).

As at the other two sites, this thick embankment of ablation till incorporates some isolated lenses of sand and gravel and lacustrine silt and clay.

Ground moraine

Ground moraine is found mostly in the upland areas of the Beaver Kill basin and occurs as a veneer of lodgment till over bedrock. The thickness of this till ranges to 6 ft in most upland areas but can exceed 60 ft in upland hollows and on south-facing slopes (Soren, 1963). Ground moraine in this area is a massive, matrix-supported diamicton with random gravel-sized clasts. The matrix ranges from sandy silt to silty loam with minor amounts of clay and is poorly sorted. Ground moraine was transported and deposited beneath the active glacier and, therefore, is much more compact than ablation till and is difficult to excavate. The thickest accumulations of ground moraine in upland tributary valleys and hollows are the result of several glacial processes: (1) the dropout of subglacial debris as glacial ice moved over lee side depressions, (2) the meltout of basal debris from active ice, and (3) the meltout of debris from beneath stagnant, basal ice (Ozvath, 1985, p. 54). Ground moraine is absent where bedrock is exposed, such as in cols, notches, and ridges.

Colluvium

Colluvium constitutes one of the largest surficial geologic units in the Beaver Kill basin and covers about 7.4 percent of the basin (fig. 2). Colluvium commonly overlies valley deposits at the base of steep hillsides. Ozvath (1985) lists three types of colluvium in the western Catskills: (1) remobilized till, (2) talus, and (3) landslides. Remobilized till is present at the base of steep hillsides and forms a hummocky deposit, derived from lodgment till, that has moved downslope under gravity during periglacial conditions. Talus consists of angular, boulder-sized slabs of local bedrock that dislodged from steep valley walls or cliffs and accumulated at the base of the slope. Landslides are associated with the mass downslope movement of earth material, and form convex mounds of colluvium at the base of steep slopes with a corresponding concave depression in the hillside, directly upslope, where the material was removed.

Ice-contact stratified drift

Geomorphic features within the Beaver Kill basin that are composed of ice-contact stratified drift include kames, kame terraces, kame deltas, and kame moraines. These units (fig. 2) are closely associated with, and commonly interfinger with, adjacent or nearby deposits of ablation till (valley diamicton). Most of these deposits are within the main Beaver Kill and Willowemoc Creek valleys.

Kames are small mounded hills that occupy the valley floor or lower hillslopes and range to 60 ft in height and 800 ft in width. They consist of englacial or supraglacial debris that accumulated during ice melting and typically exhibit a wide range in grain size, sorting, and roundness. The large variability in grain size and sorting reflects the rapid changes in the rates of meltwater flow and sediment release in the glacial environment (Ozvath, 1985).

Kames can be indicative of areas that are favorable for water-supply development where they are largely saturated and hydraulically connected to ice-contact stratified drift at depth or to adjacent or overlying saturated outwash. Surface exposures of kames, even if mostly unsaturated, can be recharge areas for saturated ice-contact deposits at depth.

Kame terraces are large deposits of fluvially deposited ice-contact sediments that once occupied the area between the bedrock valley wall and the ablating ice within the valley. Kame terraces within the Beaver Kill basin can have surface elevations as high as 100 ft above the valley floor and can be as much as 1,000 ft wide and up to a 1/2 mi long. Many kame terraces have been partly eroded by postdepositional slumping or floods. Kame-terrace sediments within the Beaver Kill basin range from silt to cobble-sized gravel and are cross-bedded locally. Ozvath (1985) identified four common sediment facies within kame terraces in the western Catskills, all of which indicate deposition in a braided glacial-stream environment.

Kame deltas are terracelike deposits of stratified sand, gravel, silt, and clay that were deposited by meltwater into a proglacial lake. Ozvath (1985) recognized two forms of kame deltas in the western Catskills--those that flank a valley wall (terraces), and those that extend across the valley. Kame deltas emplaced as flanking terraces were deposited in lakes that developed between the valley wall and the ablating ice tongue, whereas cross-valley kame deltas were deposited in proglacial lakes that developed between the toe of the ice tongue and older downvalley deposits. Kame deltas typically have flat-topped terrace surfaces that developed at some depth below a former lake level and consist of three units of sedimentation--topset beds, foreset beds, and bottomset beds. Topset beds were the result of the deposition of coarse sediment in a nearshore, shallow-water environment by meltwater streams; foreset beds were the result of meltwater stream deposition of sediment at the leading edge of a delta advancing into a proglacial lake; and bottomset beds were the result of the deposition of fine-grained sediment in deeper parts of the proglacial lake. Although both foreset and topset beds of kame deltas can contain considerable amounts of coarse sand and gravel, the elevations of these beds are typically above the modern stream grade and, therefore, these deposits are largely unsaturated, and generally do not represent areas of large ground-water potential. They may, however, represent potential ground-water recharge areas for saturated ice-contact deposits at depth.

Kame moraines are ice-contact landforms closely associated with a retreating ice front within a valley and also are known as "outwash heads." Kame moraines generally consist of extremely coarse grained (up to boulder size), well-sorted material which indicates deposition by fast-moving meltwater streams close to the ice. These deposits generally exhibit deformation features from ice shove and can contain inclusions of till. Kame moraines indicate the location of a former ice-margin position within the valley, and their downvalley ends generally grade into outwash deposits. Kame moraines may represent potential areas for ground-water development because they are typically buried beneath later outwash and alluvium and, thus, are mostly saturated.

Outwash and Alluvium

Outwash consists of well-sorted, coarse-grained sediments deposited by meltwater streams issuing from the ice front. The relatively steep stream gradients within the Beaver Kill basin, coupled with variable meltwater flows and an abundance of coarse-grained sediments, resulted in high-energy braided streams that deposited tens of feet of coarse sand and gravel outwash. This outwash accumulated on the valley floor as the ice receded and formed what is known as a "valley train." Floods commonly reworked and redistributed the outwash and other material during postglacial time, to form a veneer of alluvium over the outwash. Sheets of outwash and alluvium in the major river valleys to the west of the Beaver Kill, such as the East and West Branch Delaware River valleys (fig. 2), are generally less than 2,000 ft wide but can be as much as 1/2 mi wide at major valley confluences. Outwash deposits on the valley floors of tributaries such as the Beaver Kill rarely exceed 1,000 ft in width, however, outwash blankets the main valley of the Beaver Kill and Willowemoc Creek but is absent in the upper reaches of the basin, especially in the small tributary valleys along the northern flank of the Beaver Kill.

The thickness and horizontal continuity of outwash within the Beaver Kill basin is highly variable, as a result of the various deglaciation processes that occurred in the basin. The retreat of stagnant ice, as mentioned earlier, resulted in the deposition of large amounts of ablation till during early stages of deglaciation; thus, most of the valley-fill sediments within the Beaver Kill and Willowemoc Creek valleys are ablation till or a combination of ablation till, ice-contact stratified drift, and fine-grained lacustrine sediments. Where outwash is present, it overlies these deposits as a veneer but is as much as 100 ft thick in some places. Test borings that were made in the late 1940's for the New York City Board of Water Supply in conjunction with the eventual construction of the East Branch Delaware Aqueduct revealed wide variability in outwash thickness. Geologic section D-D′ (fig. 6), at the East Branch Delaware aqueduct crossing under the Beaver Kill at Lewbeach, shows that the bulk of the valley fill here consists of till and lacustrine sand and silt, with only a 10-ft-thick veneer of outwash and alluvium on the surface. In contrast, geologic section E-E′ (fig. 7), at the East Branch Delaware aqueduct crossing under Willowemoc Creek, reveals a narrow deposit of outwash as much as 95 ft thick that fills a narrow valley incised into the till, although most of the valley fill consists of till and fine-grained lacustrine sediment.

Bedrock

The bedrock that underlies the Beaver Kill basin not only provides ground water to bedrock wells but is a major contributor of ground-water flow (base flow) to the Beaver Kill and Willowemoc Creek.

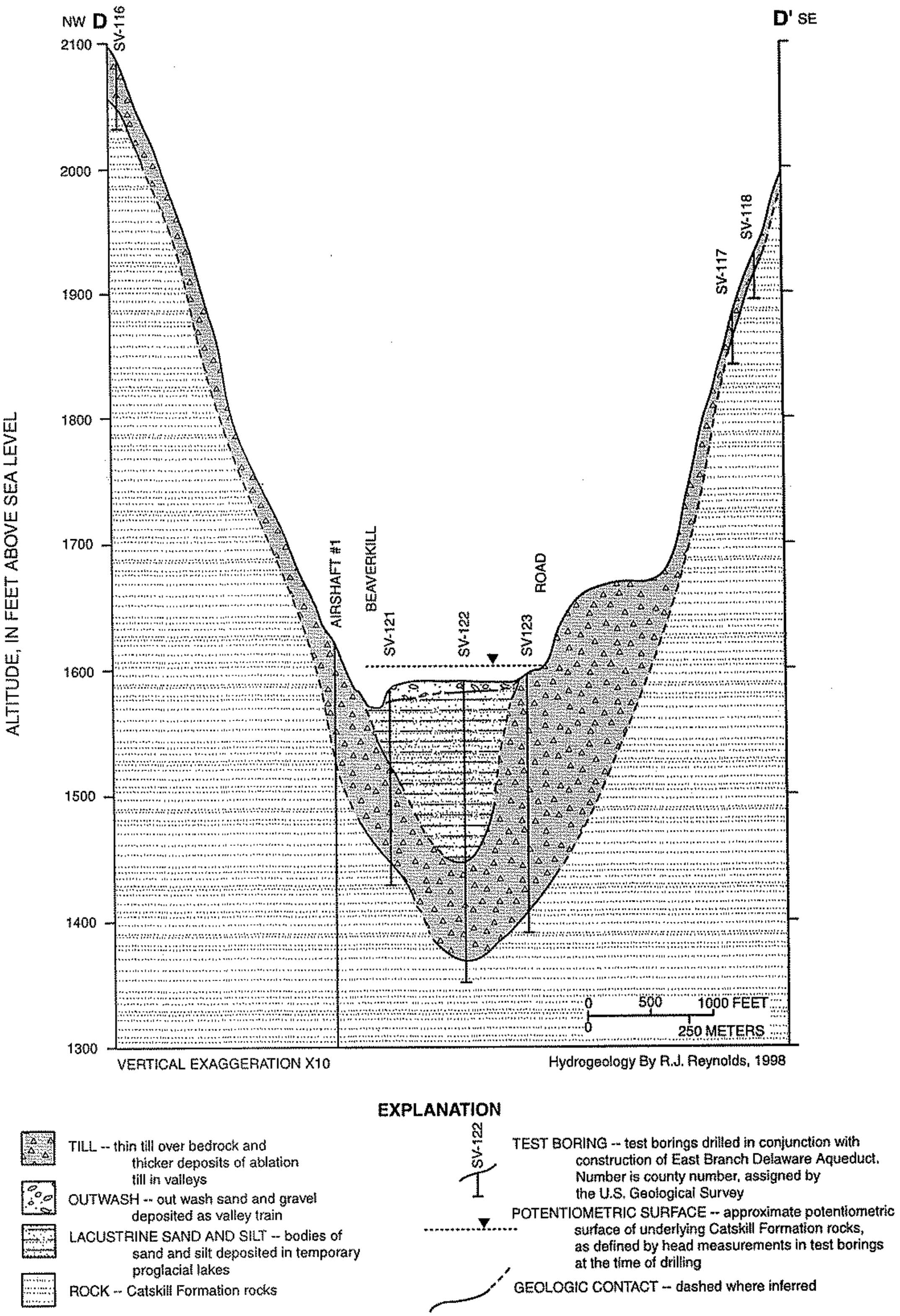
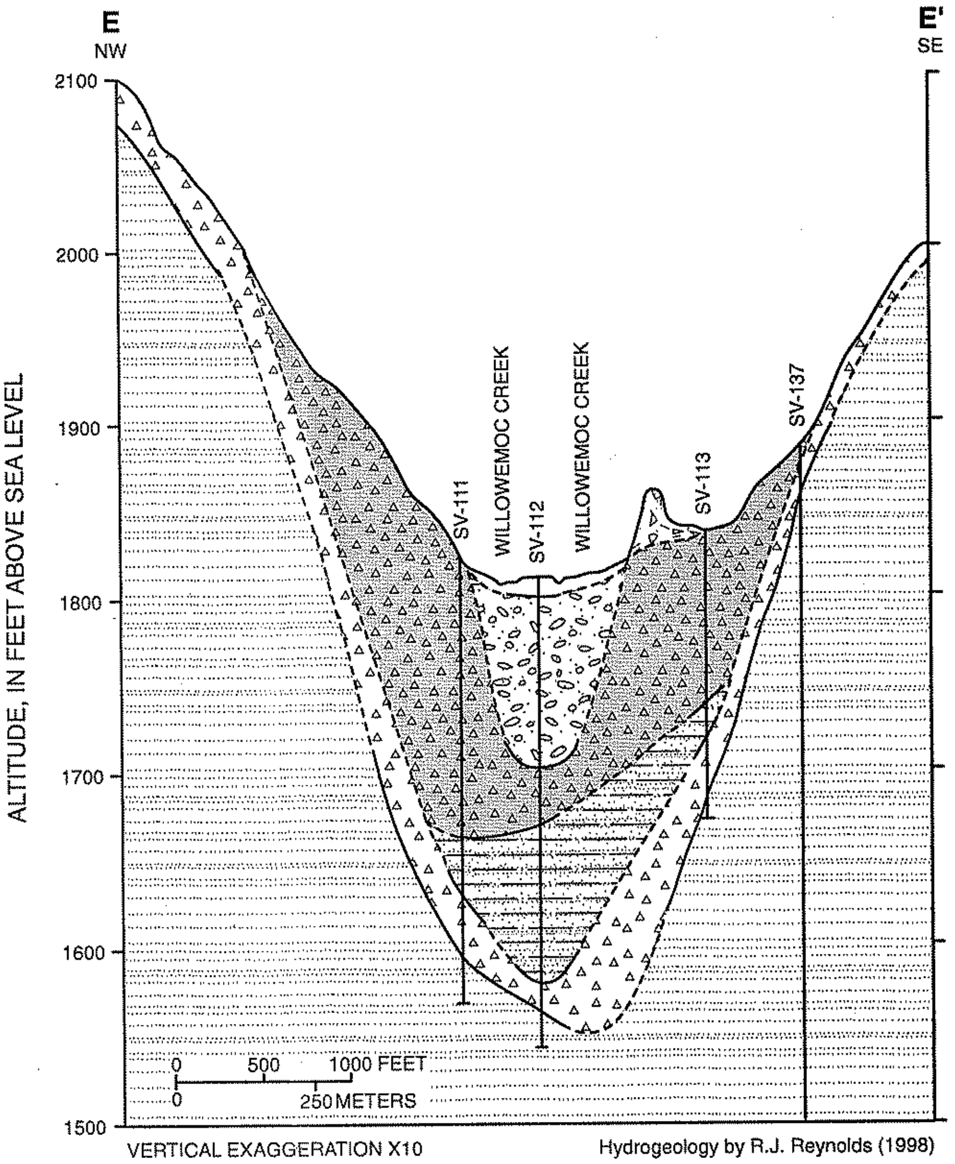


Figure 6. Geologic section D-D' along the East Branch Delaware aqueduct crossing of the Beaver Kill valley at Lewbeach, Sullivan County, N.Y. (Trace of section shown in figure 2.)



EXPLANATION

- ☐ ALLUVIUM -- modern and post-glacial flood plain alluvium of silt, clay, sand and gravel
- △ TILL -- thin till over bedrock; includes thicker deposits of ablation till within valleys
- ▨ TILL, THICK -- lateral embankment of ablation till
- ◁ TILL MORAINE -- till deposited as distinct morainal landforms
- ○ OUTWASH -- outwash of sand and gravel deposited as valley train
- ▤ LACUSTRINE SAND AND SILT -- bodies of lacustrine sand and silt deposited in temporary proglacial lakes
- ⋯ ROCK -- Catskill Formation rocks
- SV-113 TEST BORING -- test boring drilled in conjunction with the construction of the East Branch Delaware Aqueduct. Number is county number, assigned by USGS
- ╱ GEOLOGIC CONTACT -- dashed where inferred

Figure 7. Geologic section E-E' along the East Branch Delaware aqueduct crossing of Willowemoc Creek, Sullivan County, N.Y. (Trace of section shown in figure 2.)

Stratigraphy

The entire Catskill Region, including the Beaver Kill basin, is underlain by the Catskill Formation of Upper Devonian age, which is as much as 6,000 ft thick and consists primarily of a sequence of nonmarine sandstones, shales, and conglomerates. Beds within the formation are nearly flat lying and dip slightly to the northwest. The Catskill Mountains were formed by the dissection of a bedrock plateau by streams and glacial erosion. The highest hilltops and ridges, which form the principal drainage divides, are underlain by a siliceous conglomerate that is highly resistant to erosion, the lower hilltops and ridges are capped by sandstone units, which also are highly resistant. The valleys are developed along the strike of less competent siltstones and shales and along fracture zones (Soren, 1961, p. 8).

Fisher and others (1970) and Rickard (1975) have divided the Catskill Formation (or Catskill Facies) in the Beaver Kill basin into three major formations--the Honesdale, Slide Mountain, and Upper Walton Formations--all of which are part of the upper Devonian West Falls Group (Rickard, 1975, pl. 3). Within the Beaver Kill basin, the stratigraphically higher (and younger) Honesdale and Slide Mountain Formations occupy the hilltops and hillsides, and the upper Walton Formation generally underlies the lower slopes and valleys (Fisher and others, 1970). Most of the beds of the Catskill Formation are cut by three intersecting planes of fracture (joints), one of which is parallel to the bedding and two of which are vertical. The two vertical joint sets are roughly perpendicular, which facilitated the quarrying of bedrock from hillsides by glacial ice to produce horizontal surfaces and ledges bounded by nearly vertical cliffs, commonly tens of feet high (Parker and others, 1964). The joint sets also serve to increase the secondary permeability of the rock and, thus, can increase the yield of bedrock wells that intercept one or more joints that transmit ground water. Parker and others (1964) characterize the beds of the Catskill Formation as being poor to moderately good aquifers whose well yields can vary widely within short distances. In general, the sandstone beds are much more permeable than the shale or conglomerate beds, although some sandstone units are so massive and completely cemented (lacking in fractures) that they transmit little water (Parker and others, 1964, p. 82).

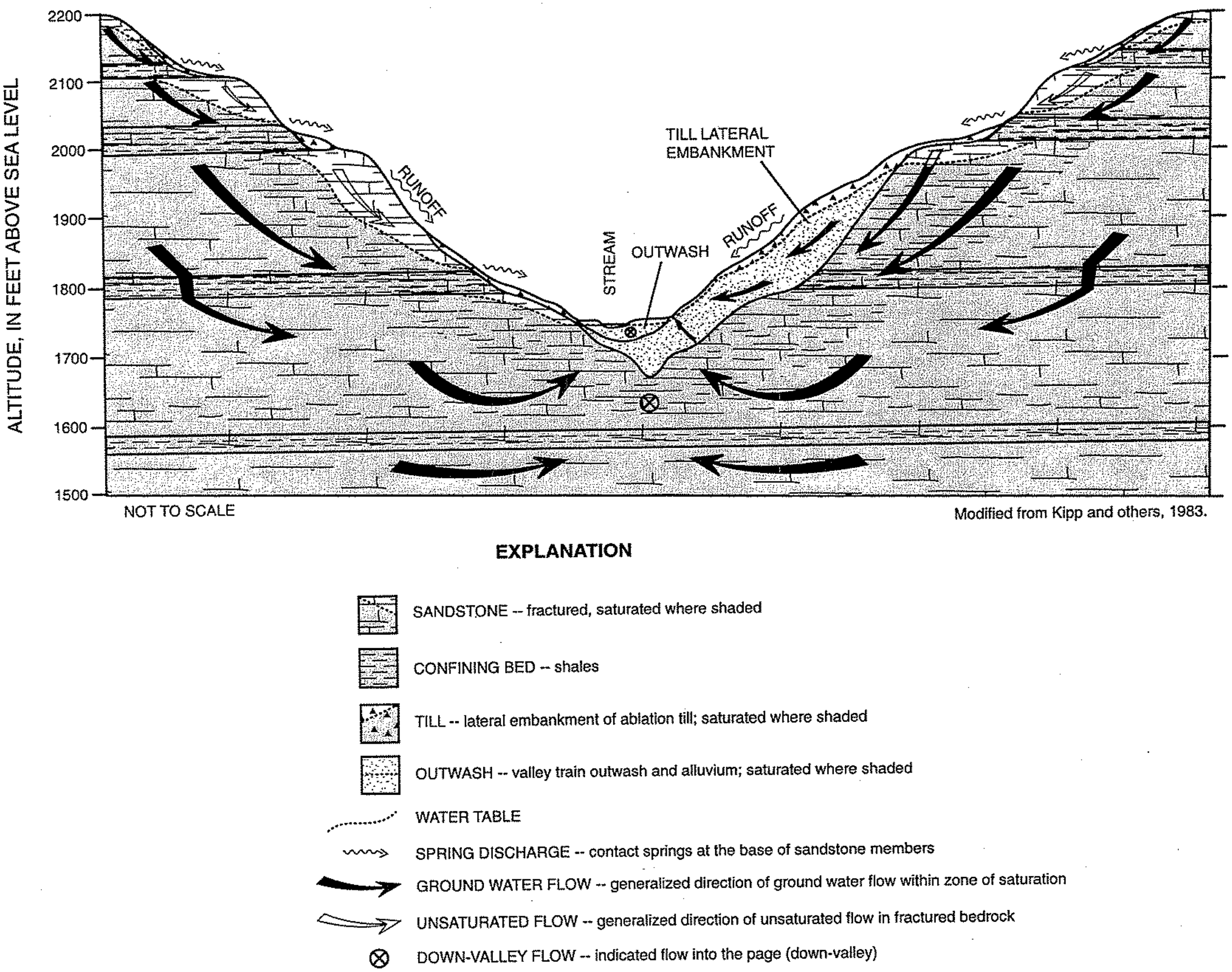
Ground Water

Records of 371 wells drilled into the Catskill Formation within the Appalachian Plateau physiographic province of the Delaware River basin indicate well depths ranging from 5 to 960 ft, and yields ranging from 0 to 600 gal/min, with an average yield of 25 gal/min (Parker and others, 1964). Wells that are completed in the Catskill Formation and are situated on valley floors typically exhibit artesian flow because potentiometric heads are above land surface. Data from exploratory borings made in the 1930's and 1940's along the routes of the East and West Delaware Aqueducts show that several borings in valley floor and lower hillside settings produced artesian flow because the potentiometric surface was more than 10 feet above land surface.

Ground water from the Catskill Formation generally is of excellent quality and is typically used for domestic, industrial, and municipal supplies without treatment. Hardness ranges from very soft to moderately hard, and dissolved solids concentrations are generally low. Iron concentrations are typically low, but can be elevated locally (Parker and others, 1964).

Ground-Water Flow System

The sequence of permeable sandstone units alternating with less permeable shale units within the Catskill Formation forms a series of stacked aquifers separated by confining units of varying thickness. Ground water within each of the sandstone units can be locally perched near the mountainsides, but is part of a larger saturated zone within each mountain or ridge. Weathering and glacial erosional processes such as scouring, plucking, and glacial unloading, have made exposed rock and rock nearest to the mountainsides typically more jointed and fractured than the unexposed rock type located deep within each mountain or ridge. This jointing increases the secondary permeability in these areas and, in turn, enhances the movement of ground water within these jointed zones, such that a water table is established. The water table within each saturated aquifer unit slopes downward toward its respective discharge point (spring) along the mountainside, as illustrated in figure 8. Thus, the jointed and weathered zone of each bedrock unit that lies immediately beneath the mountainside gives rise to a stepwise pattern of ground-water discharge from the ridgetop to the valley bottom (fig. 8). Horizontal joints and permeable bedding-plane fractures typically form at the contact



Modified from Kipp and others, 1983.

Figure 8. Conceptual ground-water flow within the Beaver Kill Basin, New York.

between lithologically dissimilar rock units; therefore, ground water within a saturated sandstone member typically discharges along the contact with the underlying shale unit as a contact spring. These springs can be ephemeral features that may flow only during the spring wet season (March and April), but, if the saturated zones above the springs are thick enough, they may flow all year long. These sandstone units also are saturated where they extend into the core of the mountain, but here they are less fractured or jointed, and ground water within them moves mainly as slow, diffuse flow through small intergranular spaces and small, discontinuous fractures and, therefore, probably contributes little to contact springs.

Ground water within saturated sandstone in valley segments that contain thick deposits of ablation till (lateral embankments) occurs generally under confined conditions, with heads typically above land surface. For example, records of two test holes drilled into sandstone and basal till along the proposed route of the East Branch Delaware aqueduct crossing of Beaver Kill at Lewbeach ((SV-122, 123) in section E-E′, fig. 6) indicate that artesian flow from a 3-in-diameter casing ranged to as much as 18 gal/min, and heads ranged from 12 to 13 ft above the valley floor. The large head difference between the water table in the valley and the potentiometric surface of the confined, fractured sandstone at depth may explain the relatively high base flows of streams in this basin.

HYDROLOGY

The hydrologic characteristics of 25 drainage basins within the Susquehanna and Delaware River basins were analyzed in a study by Coates (1971), in an effort to relate base-flow discharges to geomorphic, geologic, and hydrologic variables and to identify which variables (1) are most closely correlated with low-flow characteristics of streams and (2) yield the most reliable prediction of low-flow characteristics. Coates' study evaluated and compared 25 drainage basins, each with a drainage area smaller than 400 mi^2; 13 of which are in the western Catskill Mountains, and 12 of which are in the northern Susquehanna River Basin. Although the focus of Coates' 1971 study was to compare the predominantly shale Susquehanna basins with the predominantly sandstone Catskill basins, some of the statistics that Coates presented for the Catskill basins can be used to compare the three Beaver Kill subbasins with the other 10 Catskill basins in his study. Selected hydrogeologic data from the 13 western Catskill basins studied by Coates' (1971) are given in table 1, which treats the Beaver Kill and Willowemoc Creek (1) as two separate basins upstream from their confluence (fig. 1), and (2) as a combined basin downstream from their confluence. Stream-flow gages were historically maintained on the Beaver Kill at Craigie Claire (station 01418500) and on Willowemoc Creek near Livingston Manor (station 01419500) in addition to the currently maintained Beaver Kill at Cooks Falls gage (station 01420500). Station locations are shown in fig. 1.

In addition to Coates' 1971 study, Hely and Olmsted (1963) analyzed data from 123 basins within the Delaware River basin for the period 1921-1950; among these were 23 streams in the Catskill Mountain region, including the Beaver Kill and Willowemoc Creek.

Precipitation, Runoff, and Evapotranspiration

Of the 13 Catskill basins studied by Coates (1971), the Beaver Kill basin (at Cooks Falls) has the greatest relief--a maximum of 2,727 ft. The Willowemoc Creek and Beaver Kill (at Craigie Claire) subbasins receive the greatest average precipitation of the 13 basins--approximately 52 in/yr and have, correspondingly, the highest mean annual discharges--2.42 and 2.55 (ft^3/s)/mi^2 (table 1). These high discharges result from (1) the large amount of precipitation that falls in these two subbasins, and (2) the large amount of runoff, which is a result of the steep topography and the geology of each basin. A recently published map by Randall (1996) showing lines of equal precipitation, runoff, and evapotranspiration in the glaciated Northeast for 1951-80 indicates the wide range of values for these three hydrologic variables within the Beaver Kill basin (fig. 9).

Mean annual precipitation within the Beaver Kill basin ranges from 42 in. at the lowest elevations (downstream western end of the basin) to 55 in. at the highest elevations (eastern end of the basin). Coates (1971) used an average value of 50.1 in/yr for the entire Beaver Kill basin, and 52 and 51.8 in/yr for Willowemoc Creek and for Beaver Kill at Cragie Claire, respectively, based on data available in 1958. These average precipitation values are slightly higher

Table 1. Hydrogeologic characteristics of 13 Catskill drainage basins within the Delaware River Basin in southeastern New York

[mi^2, square mile; in., inches; ft, feet; (ft^3/s)/mi^2, cubic feet per second per square mile; Q_{90}, flow at 90 percent duration. Data from Coates, 1971. Locations are shown in fig. 2. Streams within the Beaver Kill basin shown in boldface.]

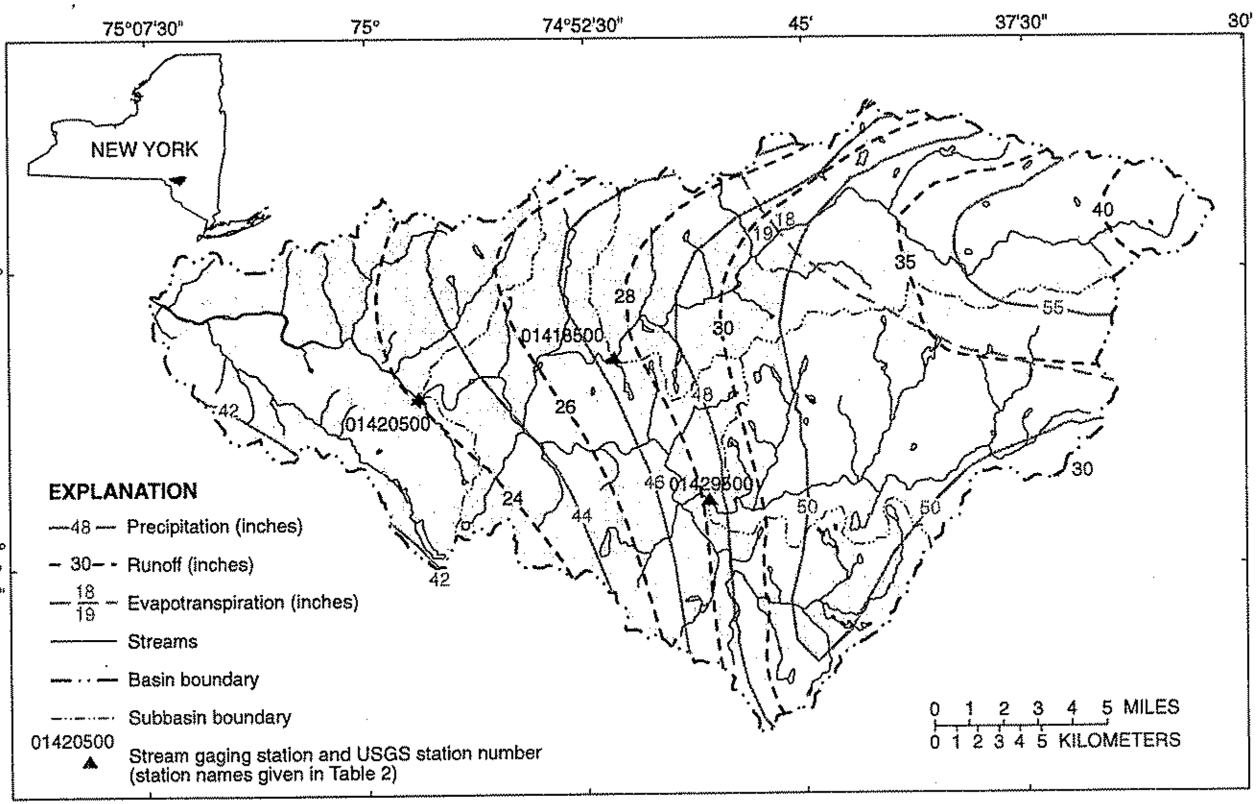
Basin	Basin area (mi^2)	Max. basin relief (ft)	Mean annual precip. (in.)	Mean annual discharge [(ft^3/s)/mi^2)]	Flow duration (Q_{90})†		Baseflow recession (days)		Area of stratified drift (percent of basin)	Sandstone index[a] (percent)	Massiveness index[b]
					Percent of mean annual discharge	Normalized to basin size [(ft^3/s)/mi^2)]	To 10 percent of mean annual discharge	Normalized to decline from 1.0 to 0.1 (ft^3/s)/mi^2			
Terry Clove	14.1	1290	44.0	1.88	10.0	.188	13.5	16.5	4.3	79	73
Mill Brook	25.0	2420	48.8	2.27	12.0	.272	26.5	36.1	2.9	91	88
Coles Cloves	28.0	1460	44.0	2.03	10.0	.203	17.7	21.0	5.7	79	73
Tremper Kill	33.0	2045	43.7	1.88	10.0	.188	13.2	25.2	5.5	88	79
Platte Kill	34.7	2055	43.0	1.82	9.0	.164	17.7	18.5	4.5	78	71
Trout Creek	49.5	1280	43.4	1.83	11.0	.201	22.5	29.7	7.6	78	68
Little Delaware River	49.8	1965	42.7	1.81	7.8	.141	22.7	28.0	3.6	64	51
***Willowemoc Creek near Livingston Manor**	**63**	**1960**	**52.0**	**2.42**	**16.0**	**.387**	**22.1**	**32.0**	**4.4**	**91**	**88**
Oquaga Creek	66	1040	43.0	1.78	8.5	.151	17.5	22.9	5.2	84	72
Beaver Kill at Craigie Claire	**82**	**2495**	**51.8**	**2.55**	**14.0**	**.357**	**30.3**	**37.6**	**5.0**	**98**	**96**
W. Branch Delaware River	142	1835	41.5	1.70	8.5	.145	27.5	33.0	12.2	64	53
E. Branch Delaware River	163	2595	44.0	1.89	10.0	.189	27.1	34.7	5.0	78	70
***Beaver Kill at Cooks Falls**	**241**	**2727**	**50.1**	**2.34**	**16.0**	**.374**	**31.5**	**36.7**	**6.0**	**89**	**82**
Mean	76.5	1930	45.5	2.01	11.0	.228	23.1	28.6	5.5	81	74

a) Sandstone index - the average percentage of sandstone found within measured stratigraphic sections with each basin (Coates, 1971).

b) Massiveness index - the percentage of rock units in observable outcrops that exhibit joint-free exposures of greater than 1-ft in thickness (Coates, 1971).

* Includes Willowemoc Creek drainage. Beaver Kill and Willowemoc Creek are treated as separate basins above their confluence at Roscoe and as a combined basin downstream from their confluence.

† Q_{90} - the stream discharge that is exceeded 90 percent of the time.



Base from New York State Department of Transportation
1:250,000 series, 1983

Figure 9. Precipitation, runoff, and zones of evapotranspiration within the Beaver Kill basin, New York (Modified from Randall, 1996).

than those indicated by Randall (1996), but are uniformly so and, thus, are suitable for purposes of basin comparison.

Runoff increases from less than 24 in/yr at the western end of the Beaver Kill basin to 40 in/yr at the extreme eastern end (Fig. 9). This increase corresponds to the general eastward increase in elevation and relief within the Beaver Kill basin. The maximum basin relief, for example, increases from 1,960 ft in the Willowemoc Creek basin (station 01419500) to 2,495 ft in the Beaver Kill subbasin to the north (station 01418500), and to 2,727 ft in the entire Beaver Kill basin (station 01420500).

Hely and Olmsted (1963) calculated average annual runoff for the 123 basins in the Delaware River Basin for the period 1921-1950; their results indicated that the Beaver Kill and Willowemoc Creek subbasins had two of the highest values of average annual runoff—33.7 and 32.9 in/yr, respectively. Evapotranspiration rates within the Beaver Kill basin were calculated by Randall (1996) to range from 19 in. over the western two-thirds of the basin to 18 in. in the eastern third.

Sources of Stream Base Flow

Several of the low-flow statistics listed in table 1 indicate that the Beaver Kill and Willowemoc Creek have, in proportion to their size, the highest base flows per square mile of the 13 Catskill basins studied by Coates (1971). The discharge that is exceeded 90 percent of the time (Q_{90}) is a commonly used measure of base flow. Values of Q_{90} for the 13 Catskill basins are shown in table 1 in two formats--first as a percentage of mean annual discharge, then as normalized to basin size and expressed as cubic feet per second per square mile. The Q_{90} for Willowemoc Creek is 16 percent of the mean annual discharge, and the Q_{90} for the Beaver Kill subbasin is 14 percent; similarly, the Q_{90} normalized to basin size is equivalent to 0.39 $(ft^3/s)/mi^2$ in the Willowemoc basin and 0.36 $(ft^3/s)/mi^2$ in the Beaver Kill subbasin. These relatively high base-flow values indicate that these basins contain a large amount of ground water in storage, presumably in saturated stratified drift along the valley floor. Another statistic that implies large ground water storage within a given basin is the duration of base-flow recession. The Beaver Kill at Cooks Falls (station 01420500) has an average baseflow recession period of 31.5 days (before declining to 10 percent of the mean annual discharge), which is the highest of all 13 basins studied by Coates (1971). A long base-flow recession generally indicates that ground water is supplying the base flow during long precipitation-free periods. Coates (1971) delineated the percentage of land area occupied by stratified drift within each basin and found that stratified drift comprises only 5 percent of the Beaver Kill subbasin above Roscoe, 4.4 percent of the Willowemoc basin, and 6 percent of the Beaver Kill basin above Cooks Falls. The other 10 Catskill basins listed in table 1 contain higher percentages of stratified drift, yet produce smaller sustained base flows than the Willowemoc and Beaver Kill subbasins. Therefore, other hydrogeologic units within the Beaver Kill and Willowemoc basins must be the source of the relatively large contribution of ground water, under base flow conditions, to these two streams.

A possible source may be the bedrock that underlies both basins. Bedrock in the Catskills consists of sandstone, shale, and siltstone, of which sandstone is the most permeable because it contains large, extensive joints. Coates (1971) developed two indices that describe the amount of sandstone present, and the degree of jointing within the sandstone, for each of the 13 Catskill basins he studied (table 1). His "sandstone index" is the average percentage of sandstone found within measured stratigraphic sections within each basin, while the "massiveness index" is a measure of sandstone competency and fabric and is used to quantify the percentage of rock units in observable outcrops with joint-free exposures greater than 1-ft in thickness. Coates observed that joints in the sandstone of the Catskill Mountains are larger and less numerous, but more continuous, than those in the shale bedrock of the Susquehanna River basin to the west (fig. 1) and that most of the sandstone within the 13 Catskill basins studied is massive and, therefore, would tend to have large, continuous joints that could serve to transmit ground water. Of the 13 Catskill basins studied by Coates, the Beaver Kill and Willowemoc Creek subbasins have the highest sandstone indices--98 percent for the Beaver Kill and 91 percent for the Willowemoc, and two of the highest massiveness indices--96 percent for the Beaver Kill subbasin and 88 percent for Willowemoc Creek (table 1).

Coates performed regression analysis of values for these two indices against 90-percent flow duration (Q_{90}), expressed (1) as a percentage of mean annual discharge, and (2) adjusted to 1 $(ft^3/s)/mi^2$, to test whether these two indices are related to certain low-flow statistics for each of the 13 Catskill basins. The results for all 13 Catskill basins indicated a moderately good correlation $(r^2 = 0.76)$ between the sandstone index and Q_{90}, and a similar correlation $(r^2 = 0.79)$ between the "massiveness index" and Q_{90} (Coates, 1971, table 6). Similarly, his regression analysis of precipitation against Q_{90} for the 13 Catskill basins shows a high correlation $(r^2 = 0.90)$ for Q_{90} expressed as a percentage of mean annual discharge, and a slightly higher correlation $(r^2 = 0.95)$ for Q_{90} adjusted to 1 $ft^3/s/mi^2$. Coates' regression analyses of Q_{90} against other geomorphologic factors for the 13 Catskill basins showed relatively poor correlation coefficients, however. For example, a regression of Q_{90} against maximum basin relief yielded an r^2 of only 0.49 for Q_{90} expressed as a percentage of mean annual discharge, and an r^2 of 0.53 for Q_{90} adjusted to 1 $(ft^3/s)/mi^2$. The results of Coates' study seem to indicate that the sustained high base flows in the Beaver Kill and Willowemoc subbasins are the result of considerable ground-water seepage, presumably from the jointed sandstone aquifer.

The thick till that covers most of the upland parts of the Beaver Kill and Willowemoc subbasins might seem to be a potential source of base flow, but recent studies in New York and New England have shown that ground-water flow from thick till deposits does not significantly increase the base flow of streams in glaciated basins. Randall and Johnson (1987) present four low-flow equations, each one developed from a separate low-flow study in the glaciated northeast, to estimate the average minimum 7-day low flow, known as the 7Q10. All four equations include independent variables that account for the area of stratified drift, the area of till, the mean runoff or the mean altitude, and the area occupied by wetlands (Randall and Johnson, 1988, table 1). In each of these studies, the regression coefficient for the area covered by stratified drift was from 9 to 25 times larger than that for the area covered by till. Regression coefficients for stratified drift ranged from 0.46 to 2.16, whereas those for till ranged from 0.05 to 0.10. These coefficients indicate that the area of till within a basin has only minor effect on the contribution of ground water to stream base flow.

A similar study by Wandle and Randall (1994) of the effects of surficial geology, lakes, swamps, and annual water availability on low flows of streams in central New England reached similar conclusions regarding the effect of till and stratified drift on stream base flow. The regression equations developed in that study to estimate 7Q10 for both high-relief and low-relief areas of central New England indicated that ground-water discharge from coarse stratified drift is 4 to 8 times greater than the discharge from till. These results provide additional evidence to suggest that the high sustained base flows within the Beaver Kill and Willowemoc Creek subbasins may be the result of ground-water discharge from the underlying fractured and jointed sandstone, not from the large areas of thick till that blanket the uplands of both basins.

Sub-basin runoff

A study of the entire Delaware River Basin by Hely and Olmsted (1963) presents runoff statistics for each of 23 Catskill Mountain streams under two separate summer low-flow conditions:

1. The amount of base flow from ground-water storage (R_a) for 30 days following a discharge equal to mean annual discharge (expressed in inches), and
2. The amount of base flow from ground-water storage ($R_{1.0}$) for 30 days following a discharge equal to (1.0 ft^3/s)/mi^2. This discharge, for any of the streams studied, would be the numerical equivalent of the drainage area as measured at the gaging station, in cubic feet per second and expressed in inches.

Hely and Olmsted plotted both values of base flow against the respective mean annual precipitation for each of the 23 Catskill streams (fig. 10). Best-fit regression lines through both sets of data indicate that base flow increases as mean annual precipitation increases, but at a much greater rate when calculated from R_a data than from $R_{1.0}$ data. The base-flow value R_a increases rapidly as mean annual precipitation increases because high mean precipitation produces high mean runoff; therefore, the 30-day segment of the recession curve used to calculate the value (R_a) will be located relatively high on the recession curve. Therefore, the R_a values for each basin are a weaker indication of ground-water contributions during dry conditions than are $R_{1.0}$ values. If the 23 basins have similar geologic characteristics, values of $R_{1.0}$ for these streams should not vary with precipitation because areal variations in mean annual precipitation are independent of the physical characteristics of a given basin. The $R_{1.0}$ data in figure 10 show a significant upward trend, however, which indicates that $R_{1.0}$ *does* increase with increasing mean annual precipitation. Hely and Olmsted (1963) attributed this upward slope to local variations in geology, topography, and(or) ground-water evapotranspiration, and plotted winter values of $R_{1.0}$ for these streams against mean annual precipitation. The resulting data showed essentially the same slope, suggesting that the relationship does not involve ground-water evapotranspiration, which is absent in winter, but only local differences in bedrock, surficial geology, and topography.

More importantly, figure 10 shows that values of both R_a and $R_{1.0}$ for the Beaver Kill at Cragie Claire (01418500) plot above both trend lines, while the same two runoff values for Willowemoc Creek near Livingston Manor (01419500) plot consistently below both trend lines. This discrepancy indicates a large difference in the amount of ground-water runoff produced from each of these subbasins from virtually the same mean annual precipitation (51.8 in. for the Beaver Kill and 52 in. for Willowemoc Creek). For example, the R_a and $R_{1.0}$ values for Beaver Kill at Craigie Claire (1.3 in. and 0.56 in., respectively), are significantly larger than the R_a and $R_{1.0}$ values Willowemoc Creek (0.80 and 0.44 in., respectively). These data suggests that some geologic difference between the two subbasins is producing a much greater amount of ground-water runoff (base flow) in the Beaver Kill than in Willowemoc Creek. Moreover, the larger numerical difference between the two R_a values (0.50 in.) than for $R_{1.0}$ values (0.12 inches) suggests that the greatest difference in base flow between these two subbasins occurs during periods of average precipitation and average flow (R_a data), as opposed to dry conditions, represented by the $R_{1.0}$ data. Although these data are not normalized to basin size, the two basins are of comparable in size--82 mi^2 for the Beaver Kill basin at Craigie Claire and 63 mi^2 for the Willowemoc Creek basin.

These data indicate that the Beaver Kill subbasin releases much more ground water than does

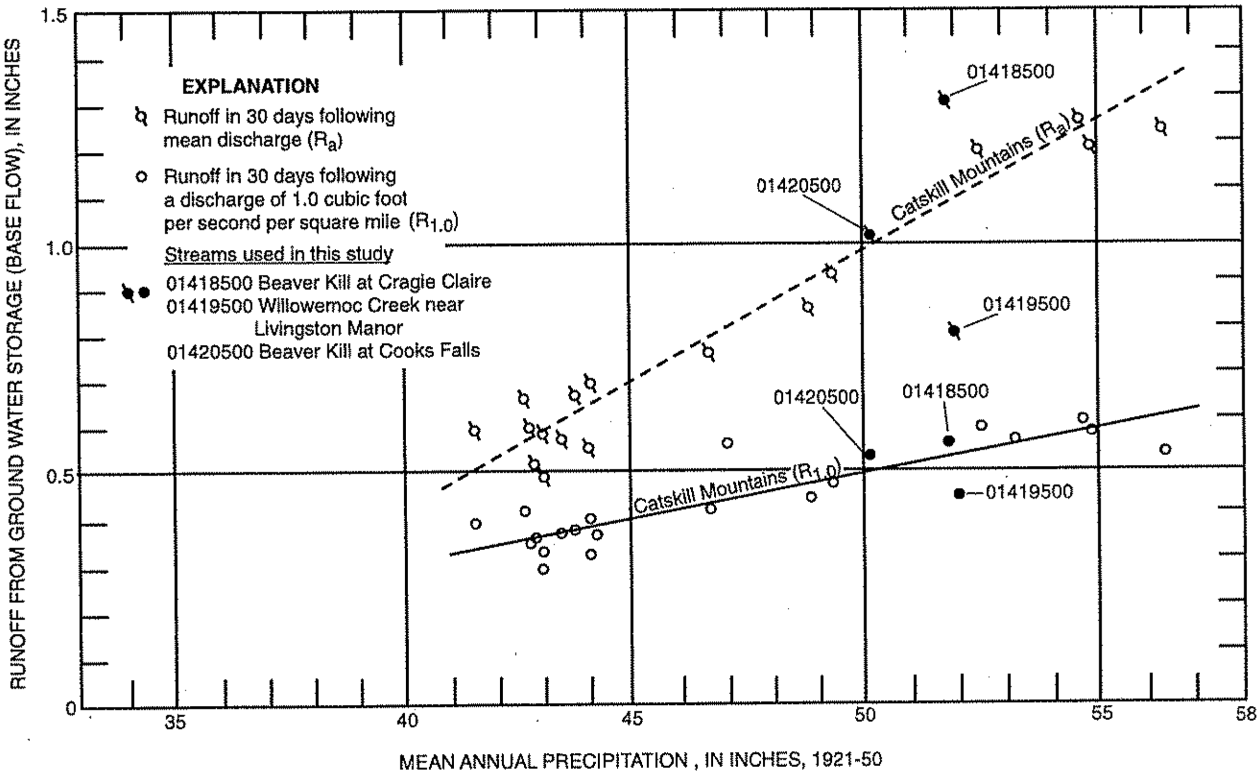


Figure 10. Relations between summer baseflow (ground-water runoff from storage) and mean annual precipitation for 23 Catskill Mountain streams, studied in Hely and Olmsted (1963).

the Willowemoc Creek subbasin during periods of average precipitation and flow, conditions, as well as during low-flow (dry) conditions, even though the Beaver Kill $R_{1.0}$ data is closer to the trend line in fig. 10 (i.e., normality with comparable basins) than that for the Willowemoc Creek subbasin.

Hydrogeologic differences between the two subbasins that might account for these differences in ground-water discharge may include:

1. *Surficial geology*--The Beaver Kill subbasin, which drains the northern rim of the Beaver Kill basin divide, contains much larger areas of thick upland ablation and lodgment till than does the Willowemoc Creek subbasin. An analysis of the digital data used to produce the surficial geologic map in figure 2 indicates that the Beaver Kill subbasin contains 14.3 mi^2 of thick-till units (17.5 percent of the subbasin area), whereas the Willowemoc Creek subbasin contains only 6.1 mi^2 of these units (9.8 percent of the subbasin area).
2. *Bedrock*--An analysis of published bedrock maps (Fisher and others, 1970) indicates that the three bedrock formations that underlie these two subbasins are present in similar proportions. For example, the upper Walton Formation underlies approximately 47 percent of the Beaver Kill subbasin and 53 percent of the Willowemoc subbasin, and similarly, the Slide Mountain Formation underlies 38 percent of the Beaver Kill and 37 percent of the Willowemoc subbasins. The percentage of sandstone in the Beaver Kill subbasin, as measured in exposed rock faces, is a slightly higher (98 percent) than in the Willowemoc creek subbasin (91 percent) (Coates, 1971), and the sandstone in the Beaver Kill subbasin is slightly more massive than that in the Willowemoc Creek subbasin (table 1). The more massive sandstone is characterized by longer, more continuous fractures and joints, which could allow for greater storage and more rapid release of ground water following recharge events. This greater storage and more rapid release is probably the main reason for the higher base flows in the Beaver Kill than in Willowemoc Creek.

SUMMARY

The Beaver Kill basin, which emcompasses the Beaver Kill and Willowemoc Creek subbasins, drains nearly 300 mi^2 of the southwestern Catskill Mountains. The most widespread surficial geologic unit, is till, being a direct result of ice-stagnation retreat. Large masses of ablation till occupy the main valleys of the Beaver Kill and Willowemoc Creek and locally reach thicknesses greater than 450 ft. These lateral embankments of till typically fill the bedrock valley such that the modern valley axis is laterally displaced as much as 1,000 ft from the preglacial (bedrock) valley axis. Ice-contact stratified drift in the form of kame moraines, kame deltas, and kame terraces are closely associated with, and interfinger with, deposits of ablation till. A veneer of coarse outwash sand and gravel overlies till on the floor of the Beaver Kill and Willowemoc Creek valleys. The outwash is of highly variable thickness; it is typically 10 feet thick but can reach thicknesses of as much as 100 ft locally. Saturated outwash and ice-contact stratified drift are the most productive ground-water source within the basin.

Mean annual precipitation within the Beaver Kill basin varies with elevation and ranges from 42 in/yr at the downstream (western) end of the basin to 55 in/yr at the upstream (eastern) end. Runoff also varies with basin elevation and ranges from 24 in/yr at the western end of the basin to 40 in/yr at the extreme eastern end.

A 1971 study of hydrogeologic factors that affect streamflow in the Susquehanna River basin and in Catskill (Delaware basin) streams indicates that the Beaver Kill and Willowemoc Creek have the highest mean annual discharges of 13 Catskill streams studied. The low flow that is exceeded 90 percent of the time, normalized to basin area, (Q_{90}) is 0.39 (ft^3/s)/mi^2 for the Willowemoc Creek subbasin and 0.36 (ft^3/s)/mi^2 for the Beaver Kill subbasin. These high values indicate that the dry-weather flow of both streams is sustained by ground water, discharged primarily from sandstone members of the underlying Catskill Formation, rather than from stratified drift (sand and gravel) which represents less than 5 percent of the area of both subbasins.

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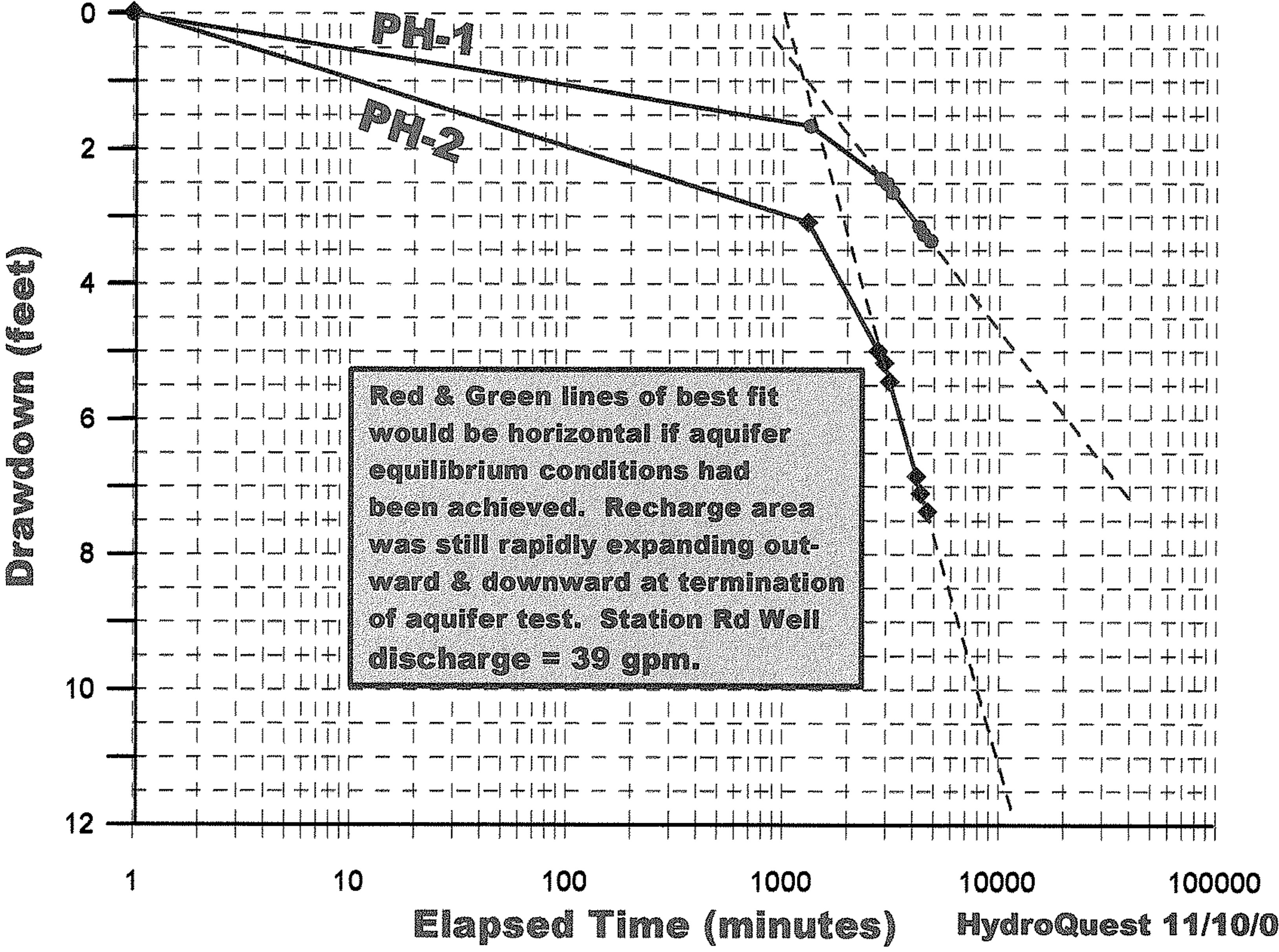
84

CPC # 84

Observation Well Drawdown
Associated With Station Road Well Aquifer Test



Red & Green lines of best fit would be horizontal if aquifer equilibrium conditions had been achieved. Recharge area was still rapidly expanding outward & downward at termination of aquifer test. Station Rd Well discharge = 39 gpm.

HydroQuest 11/10/02

Figure 2

85

CPC
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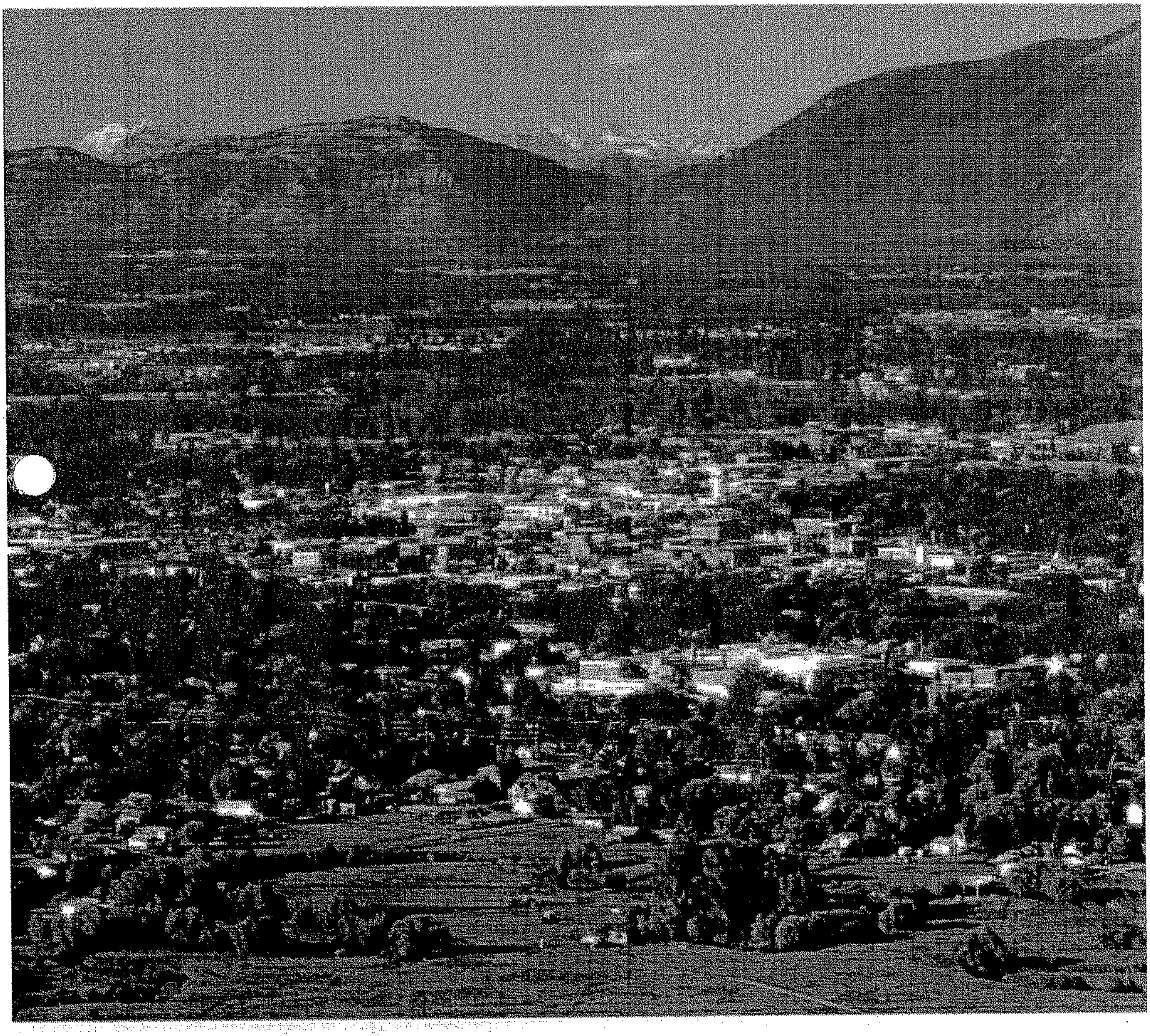
(already in binder)

Gateway to Glacier

The Emerging Economy of Flathead County



Healthy Parks,
Healthy Communities

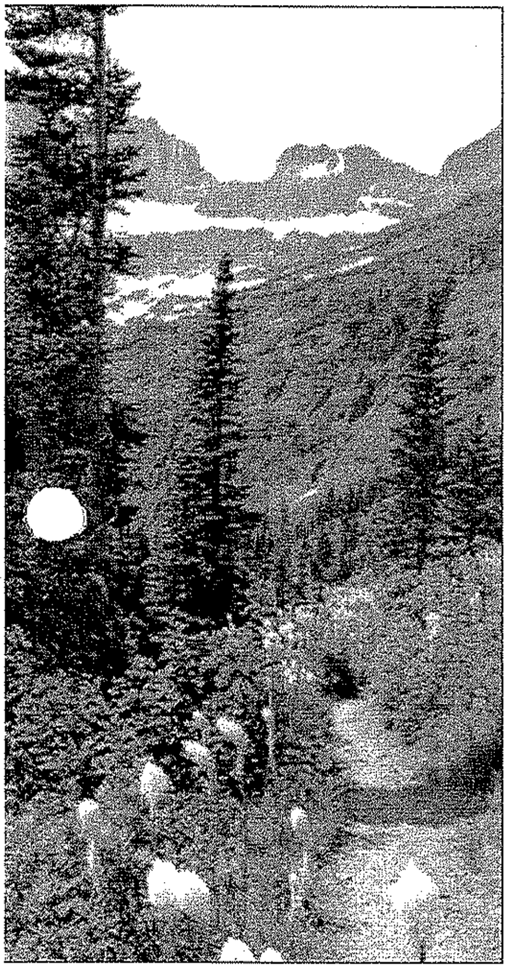
National Parks Conservation Association

Protecting Parks for Future Generations

MAY 2003

ABOUT THIS REPORT

Gateway to Glacier: The Emerging Economy of Flathead County is a synthesis of three technical studies on Flathead County's economy conducted by researchers at The University of Montana. Unless otherwise cited, the data and other information supporting this report's findings are found in those three studies. The detailed technical studies are available to interested individuals on the Internet at *www.npca.org/healthycommunities.* Or you may order copies of the three studies for the cost of reproduction by contacting the Northern Rockies office of the NPCA, P.O. Box 824, Helena, MT 59624, or call (406) 495-1560.
E-mail: northernrockies@npca.org.



Grinnell Trail

PHOTO: LARRY STOLTE

The three studies synthesized in this report are:

- *The Flathead's Changing Economy: Assessing the Role of National Parks in the Economies of High Amenity, Non-metropolitan Regions of the West*
  LARRY D. SWANSON, Ph.D., Associate Director and head of the Regional Economy Program, O'Connor Center for the Rocky Mountain West, The University of Montana, Missoula. (2002)

  Swanson undertook an extensive economic analysis of Flathead County to 1) identify and assess key trends and patterns of change, 2) evaluate the influence of Glacier National Park on the area economy, and 3) evaluate economic trends in other national park gateway communities around the western United States. This analysis is based on an evaluation of Flathead's economic characteristics and performance relative to "peer" counties throughout the West with similar economic and demographic profiles.

- *What the People Think - Glacier National Park and Vicinity*
  NORMA NICKERSON, Ph.D., Director, Institute for Tourism and Recreation Research, The University of Montana, Missoula. (2002)

  Nickerson surveyed opinion research focusing on Flathead Valley residents, and visitors to Glacier Park and the Flathead. Her report details specific characteristics that draw residents and visitors to the area, perceptions of change in the valley's natural environment, and concerns about the future.

- *Business Perspectives on the Flathead Economy, Conservation and Glacier National Park*
  JASON LATHROP, Graduate student, The University of Montana, Missoula. (2002)

  Lathrop interviewed 80 Flathead Valley business owners and managers from a broad spectrum of business sectors. His report explores business leaders' attitudes about the Flathead's changing economy, local communities, business environment, community leadership, Glacier National Park, and conservation.

Gateway to Glacier

The Emerging Economy of Flathead County

Healthy Parks,
Healthy Communities

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Protecting Parks
for Future Generations®

The National Parks Conservation Association, established in 1919, is America's only private, nonprofit advocacy organization dedicated solely to protecting, preserving, and enhancing the U.S. National Park System for present and future generations by identifying problems and generating support to resolve them.

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Family fun on Glacier's Going-to-the-Sun Road

PHOTO: KAREN NICHOLS

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FOREWORD

Kalispell Area Chamber of Commerce

A few years ago as a representative of the business community, I had a chance to share the same table with the National Parks Conservation Association (NPCA) on the Going-to-the-Sun Road Citizens Advisory Committee. At that table we blended diverse interests and developed a mutually acceptable solution for a difficult problem. The outcome was beneficial to the community and satisfying to participants.

Now it is time for community, conservation, and business interests to come to the table again to constructively contribute to the future of our beloved Flathead Valley. *Gateway to Glacier* provides an excellent place to start our discussions. This report makes the argument that we can maintain our small-town community character, grow a healthy economy, and conserve the natural treasures of our region. I believe these are goals we all share.

Let's not squander our resources. Our environment, our economy, and our community are treasures we can't afford to waste. Our time, our effort, and our good will are powerful resources we must use wisely. Cooperation is essential if we are to conserve the assets we treasure while accommodating the growth that these assets inevitably bring.

Gateway to Glacier points to the opportunity that comes with change. Those of us who live in the Flathead Valley have the chance to work cooperatively to harness change, to preserve both traditional values and achieve economic rewards. It will require mutual respect, a spirit of cooperation, hard work, and leadership.

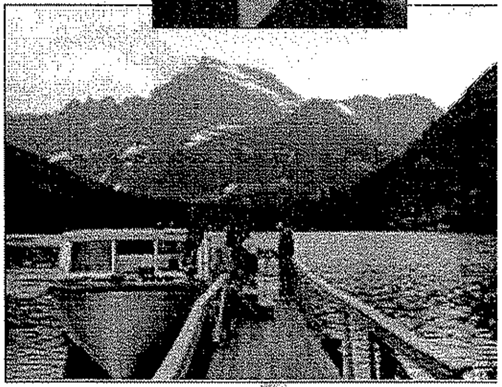

PHOTO: COURTESY
GLACIER PARK
BOAT COMPANY

I look forward to working with all of you.

Susan D. Burch

Susan D. Burch
CHAIRMAN, KALISPELL CHAMBER OF COMMERCE
OWNER, GLACIER PARK BOAT COMPANY

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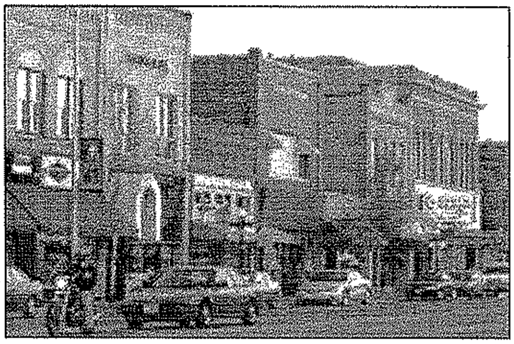
EXECUTIVE SUMMARY

While much of rural America struggles with economic decline, the economy in Montana's Flathead Valley is growing, vibrant, and diversifying. The reason is simple: Its superb quality of life pays off in tangible economic benefits. Glacier National Park and other scenic public lands, clean air and water, and a friendly, small-town character are cornerstones of this quality of life.



Main Street, Kalispell

PHOTO:KAREN NICHOLS

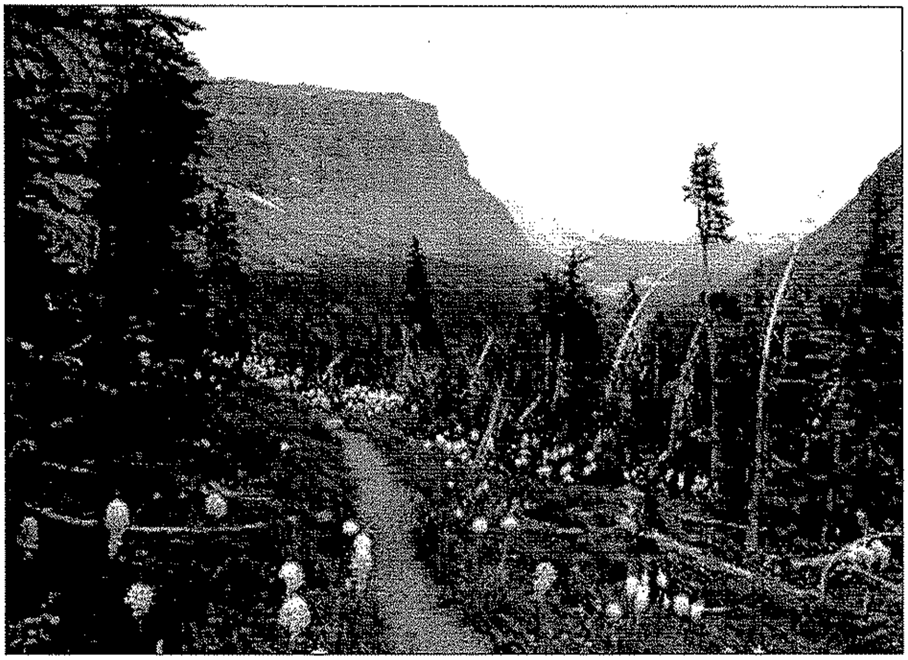
In 2002, the National Parks Conservation Association (NPCA)—through its Northern Rockies regional offices located in Whitefish and Helena—commissioned three separate studies to explore the roots of economic vitality in Flathead County, the primary "gateway" to Glacier National Park.

Gateway to Glacier: The Emerging Economy of Flathead County synthesizes the findings of these three studies to document how the Flathead's economic vitality is directly tied to Glacier Park and the region's natural environment and small-town character. It argues that many of the valley's most attractive qualities are at risk. And it points the way toward a collaborative approach to protect these valuable assets for the future.

Some say that the Flathead has been discovered, and this is probably the plainest way to explain the changes of the past decade. The attraction of Flathead County, its communities, and the surrounding landscape is obvious to long-time residents, newcomers, and first-time visitors alike.

Many valley residents fear that this "discovery" has brought rapid change that will erode what they value most about their home. Yet in this transition are opportunities to protect the qualities and characteristics that make this a uniquely wonderful place to live—and that are at the heart of the valley's economic vitality.

Gateway to Glacier explores the challenges and the opportunities within the county's economic transition. Its key findings about the Flathead's emerging economy are briefly described in this executive summary and explored greater in the six chapters that follow.



Two Medicine Pass trail

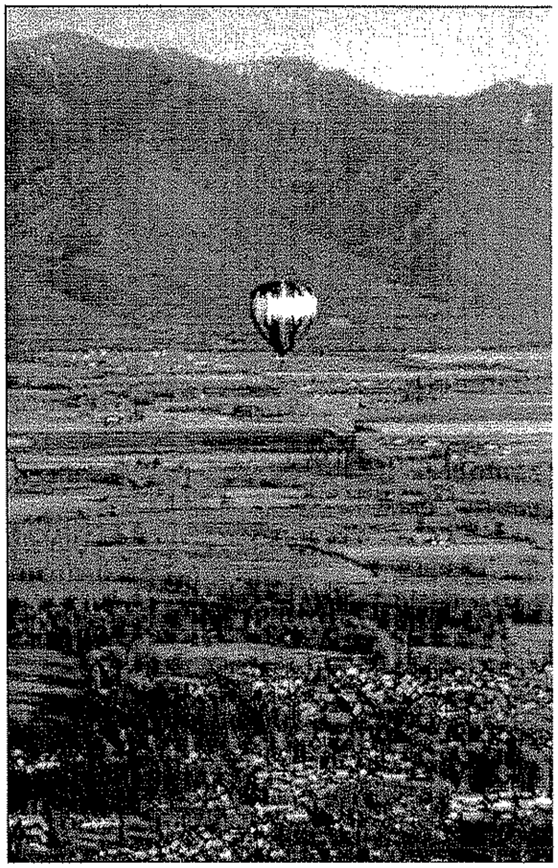
PHOTO:LARRY STOLTE

1. The Flathead County economy is vibrant, diverse, and growing.

By virtually any economic indicator, Flathead County is booming.

- In the last decade, 15,700 new jobs were created, an increase of nearly 50 percent. Dramatic increases occurred in relatively high-quality employment areas such as health care, business services, construction, and new areas of manufacturing.
- Population grew 26 percent between 1990 and 2000, led by an influx of new residents.
- Nearly 1,000 new businesses were established in the last decade, a 44 percent increase in local employers that marks a boom in entrepreneurial activity.
- Unemployment rates are the lowest in three decades.
- Per capita income rose by 13 percent in the last decade (up from nine percent in the '80s). Poverty has declined. And median income sharply increased, erasing losses in the previous decade.

The Flathead's economic vitality is largely fueled by an influx of new residents. But the numbers also tell a story of an economy in transition, more diverse and more stable than before, providing higher-paying jobs. Within this transition is the opportunity to direct economic development to sustain a vibrant economy, whether or not the population boom continues.



Soaring high over the Flathead Valley

PHOTO:KAREN NICHOLS

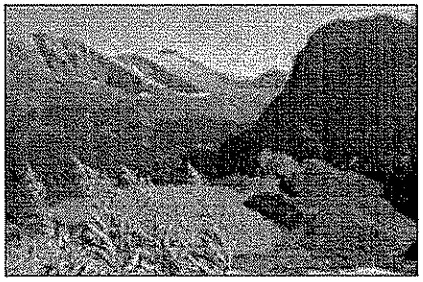
2. The quality of the Flathead Valley's spectacular natural environment is its chief economic asset.

Surveys and interviews with Flathead County residents, visitors, and business leaders confirm that the valley's chief appeal is the place itself: The small-town, friendly atmosphere, access to the outdoors and recreational opportunities, scenic beauty, clean water, wildlife, and the open, natural setting. These qualities are key economic assets because they draw people to visit, to live, and to stay in the area. Most business leaders interviewed believe they could make higher incomes elsewhere but choose to operate in Flathead County largely because of the quality of life.

Nationwide economic and technological trends have made it easier for people to live where they want. The Flathead's booming population is a sign of the area's undeniable attractiveness—and a confirmation that the quality of life is the area's chief economic asset. It is what draws people, income, jobs, and businesses here.

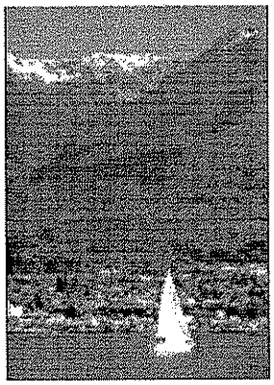
Grinnell Lake in the Many Glacier Valley

PHOTO:KAREN NICHOLS



3. Glacier National Park is an anchor for Flathead County's robust economy.

In a county blessed with a spectacular natural setting, Glacier National Park is the centerpiece. It is one of Montana's two most popular attractions for visitors, and tops the list of places local residents take out-of-town guests. The icon for nearly 200 business names and logos, Glacier also shows up on signboards for hundreds of millions of dollars of high-profile development, including a proposed mall, a performing arts center, and the redeveloped Big Mountain ski village. Glacier's appeal spans the globe, and it was voted America's best backcountry park by readers of *Backpacker* magazine. Meanwhile, Kalispell was selected in 1999 as America's "best mountain town" by *Mountain Sports & Living Magazine*, which cited its proximity to Glacier Park.

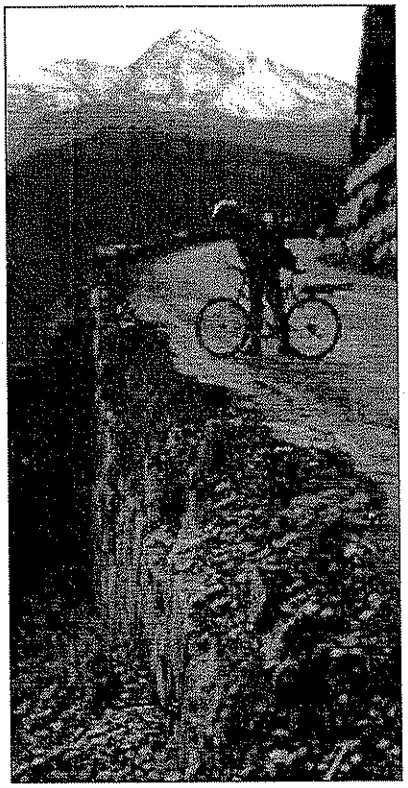


National Park gateways like Port Angeles, Washington, enjoy strong economic growth

PHOTO: VALERIE HENSCHEL

4. Proximity to national parks is an economic advantage for gateway communities such as Flathead County.

An assessment of national park gateway communities around the West shows that Flathead County's booming economy reflects a much larger pattern. Attracted by small, friendly communities and appealing landscapes, many Americans turned their attention from major metropolitan areas and traditional retirement havens during the 1990s. Rapidly growing populations in communities adjacent to national parks throughout the West suggest the special appeal of these places. This appeal has translated into economic vitality for gateway counties such as Flathead, which tend to have richer, more diverse, and more thriving economies than do similar counties that are not gateways. In these counties, tourism is but one piece of a rapidly expanding economic pie. Economic growth has been driven largely by the people who live in these gateway communities and by local businesses



Fixing Going-to-the-Sun Road and increasing funding for park operations will protect a major economic asset

PHOTO: KAREN NICHOLS

5. The Flathead Valley's most valued qualities and primary economic assets are at risk.

Many local residents believe that the valley is losing some of its special qualities, most notably its rural, small-town character, farmland, and open spaces. Returning visitors to Glacier National Park have noted declines in the condition of the natural environment, wildlife viewing opportunities, and the amount of open space. NPCA has listed Glacier as one of America's most endangered parks three times because of severe funding shortfalls, dilapidated infrastructure, and the encroachment of haphazard development on wildlife habitat outside the park.

6. Flathead communities must encourage high-quality economic growth and development.

The Flathead economy is in transition. Today's growth provides the opportunity to retool the economy so it remains strong and diverse, whether or not the population boom continues. Flathead County has enjoyed great success in creating jobs and attracting development and investment. The valley's communities must now create a clear strategy and focused initiatives to improve the well-being of Flathead residents and protect the area's most vital economic assets.

This focus will help Flathead County maintain the quality of life that old-timers, newcomers, and visitors find so appealing. High-quality economic development means maintaining water quality, wildlife habitat, an appealing landscape, and the valley's friendly small-town character. It means retaining working farms and forests, cultivating jobs with pay and benefits that can fully sustain workers and their families, and investing in a well-educated local workforce. Economic growth can be guided to support and protect the values that drive it, rather than leading inexorably to their erosion and loss.

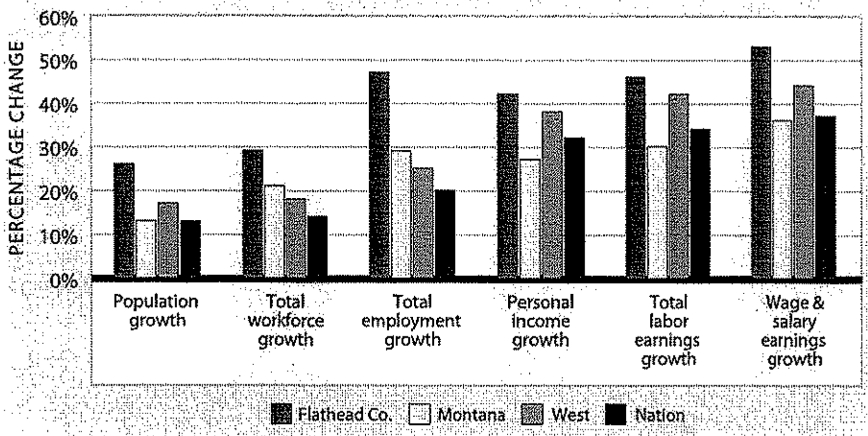


FIGURE 1.

Comparisons of Economic Growth in the '90s

Note: Total workforce refers to the total number of adults with jobs, while total employment refers to all jobs, both full- and part-time. Total labor earnings include both wage and salary earnings and self-employment income or proprietor earnings. The "West" includes the 22 contiguous states west of the Mississippi River. Dollar amounts are inflation-adjusted to 1996 dollars.
(Sources: U.S. Bureau of Labor Statistics, U.S. Department of Commerce)

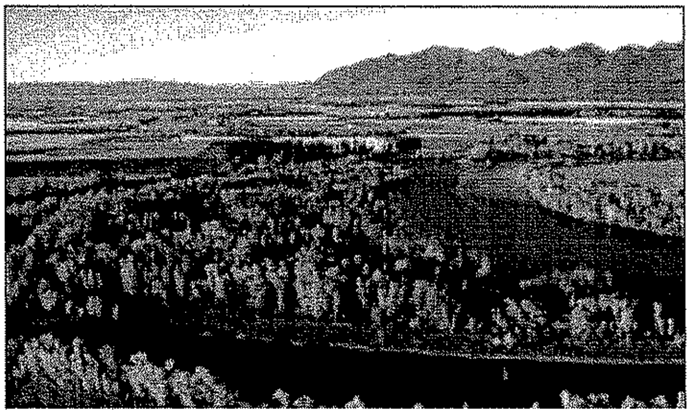
Investing in the Future

The families, businesses, and communities of Flathead County have been blessed with one of the most spectacular natural environments in North America. These natural amenities have become the area's chief economic asset. Flathead residents recognize that, along with small, friendly communities, these characteristics are largely responsible for the quality of life and economic vitality they enjoy.

This recognition can form a solid foundation for community dialogue and cooperative action to protect and enhance these fundamental assets. Partnerships of many kinds will be indispensable if Flathead residents are to guide growth to protect the values they cherish. With Glacier National Park and other public lands so directly linked to the valley's economic health, collaboration between public lands managers and communities is essential to sustain the appeal at the heart of the Flathead's economic vitality.

Glacier is a lure for outdoor enthusiasts

PHOTO: COURTESY BIG MOUNTAIN RESORT, WHITEFISH, MONTANA



Glacier National Park forms the headwaters of the Flathead River

PHOTO: KAREN NICHOLS

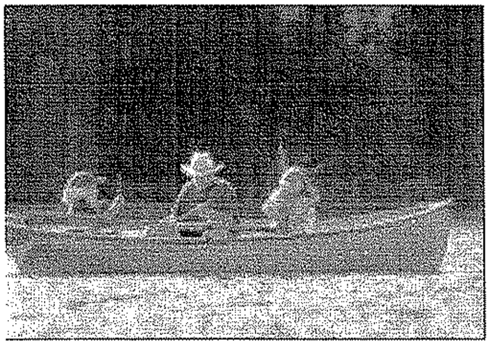
INTRODUCTION

Around the turn of the 19th century, proposals to create Glacier National Park met with considerable resistance in the Flathead Valley. Opposition was deep and broad, including several Flathead County newspapers that cited lost opportunities for mining, logging, new railroad routes, oil exploration, hunting, and homesteading.

"There may be some local people who favor the park plan," wrote the *Kalispell Daily Inter Lake* in 1907, "but we know of only two." The *Inter Lake* and other local papers voiced the concerns of many Flathead residents who feared that establishing the park would take the wind out of the area's economic sails.[1]

Floating and fishing at Glacier's Lake McDonald

PHOTO: KAREN NICHOLS



Nearly 100 years later, it is clear that these fears were unfounded. In an October 2002 editorial, the *Daily Inter Lake* called Waterton-Glacier International Peace Park "our region's biggest economic engine."[2] As in the past, the editorial staff voiced the convictions of residents, many of whom believe that the valley's economic vitality depends in large measure upon its spectacular natural surroundings.

> "You can't measure the mark Glacier Park has made on this community. The whole economy is tied to the park."
>
> **Carol Edgar**
> Executive Director,
> Flathead Convention
> & Visitor Bureau

In a region replete with extensive wilderness areas, national forests, lakes, streams, and mountains, Glacier National Park holds a special place. It is a landscape of exceptional beauty, known around the world and easily accessible by car, foot, and horseback. Carol Edgar, executive director of the Flathead Convention and Visitor Bureau, expressed a view common among local business leaders: "You can't measure the mark Glacier Park has made on this community. The whole economy is tied to the park."

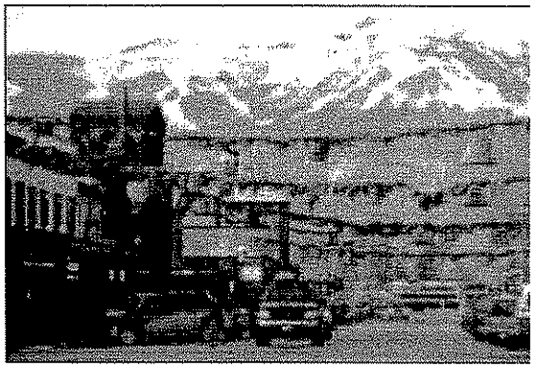
Across the United States, there is growing recognition of the link between attractive public lands such as national parks, and the well-being of the communities that provide access to them. These "gateway communities" generally provide food, lodging, and other services for visitors. But the parks are more than simple magnets for visitors. Many gateway communities, including Flathead County, have thriving, diverse economies that are not primarily dependent upon tourism and recreation. Yet the natural appeal of these areas is at the heart of their economic success.

In 2002, NPCA—through its Northern Rockies regional offices located in Whitefish and Helena—commissioned three studies (see About This Report). These studies explore the roots of economic vitality in Flathead County, the primary gateway to Glacier. From three different angles, the studies help to illuminate important relationships among economic vitality, the natural environment, and the quality of life that is valued by both residents and visitors. These studies overwhelmingly support the assertion that the Flathead Valley's chief economic assets are its friendly communities and the natural environment, which provides recreational opportunities, a wide-open feel, clean water, wildlife, and scenic beauty. Further, the studies support the conclusion that degrading those qualities will, in the long run, slow economic progress and dampen vitality in the Flathead. They point the way toward protecting these valuable assets for the future.

This report synthesizes findings of these three studies into a wide-ranging discussion of economic transition that will help residents and leaders navigate fast-paced changes in the emerging Flathead economy.

FINDING 1

The Flathead County economy is vibrant, diverse, and growing



Whitefish enjoys a vibrant economy and a strong community identity

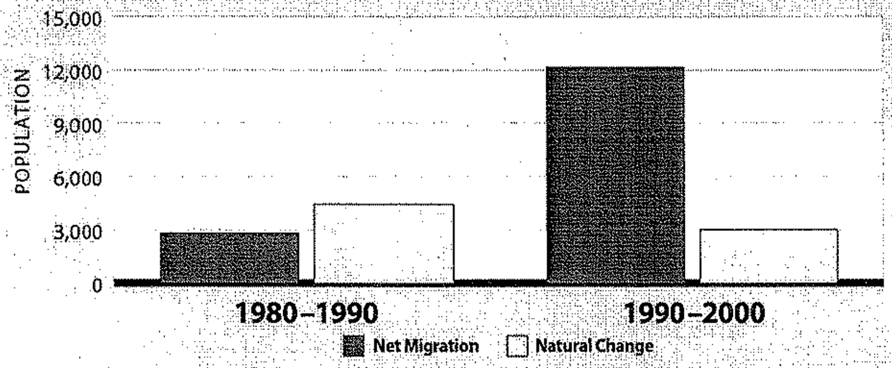
PHOTO: KAREN NICHOLS

Over the last 30 years, the Flathead County economy has changed tremendously. Industries that were once economic staples have declined in importance, and this economic restructuring has been sometimes painful and divisive. A nationwide recession in the early 1980s compounded the effects of contractions in natural resource industries such as lumber and wood products, and the valley felt the pinch.

Unlike many other rural areas still struggling with economic declines, Flathead County experienced a remarkable turnaround beginning in the late 1980s. Employment and income growth accelerated, driven in large measure by a rising tide of new residents. During the 1990s, dramatic growth occurred primarily in health care, specialized services, retail trade, and construction, more than filling the gaps left by the setbacks of the 1980s. Overall, manufacturing grew at a marginal pace, and now accounts for a much smaller share of the fast-growing economy.

The Flathead County economy is vibrant, diverse, and growing. In many ways, the valley's economic expansion is linked to its increasing population. These new realities call for a new understanding of the roots of prosperity in the Flathead.

FIGURE 2. **Flathead County Population Change by Major Component: 1980s vs. 1990s**



Note: *Net migration* is the difference between the number of persons moving to an area and the number moving away, and considers only persons changing their permanent residence. *Natural change* is the difference between the number of births and the number of deaths.
(Source: U.S. Census Bureau, "Components of Change")

A Growing Population

In the 1990s, Flathead County's population shot up by 26 percent, nearly double the rate of growth in the '80s. The 2000 census counted 74,471 residents. A more recent July 2001 estimate places the county's population at more than 76,000.

Population growth comes in spurts in the Flathead. Growth spiked in the late 1970s and again in the mid-1980s. The early and mid-1990s brought a more sustained growth trend, and now it seems that population growth may be on the increase again. In the '70s and '80s, the "natural change" of births and deaths was the biggest influence on the rate of population growth. In contrast, population growth in the'90s was driven largely by people moving into the valley.

Flathead County Courthouse, 101 years old

PHOTO: KAREN NICHOLS

Joe Unterreiner, Kalispell

"Unlike Las Vegas, people don't move here primarily for the job opportunities. We see people attracted to this area for its outstanding natural amenities, good schools, and small-town environment. It's a beautiful place to live. Many explore starting or acquiring a business as a way of making the transition to the Flathead. Or, maybe they bring an existing business with them. We're also seeing displaced workers return to school for retraining, then decide to start a business.

So I'd say the Flathead is enjoying a high level of entrepreneurial activity right now. A lot of people are taking a risk, putting capital on the line and making an investment, because they want to live here. And these are some very creative, enterprising people who often invent a market for their products or services.

Fortunately, the Flathead is a good place to do business, especially when you look at other places around the country. We enjoy a strong business environment. And that's why you see a tremendous amount of capital at risk in the valley right now."

Joe Unterreiner
President, Kalispell
Chamber of Commerce

Who is Moving to the Flathead?

By the end of the 1990s Flathead County's population had ballooned, with the greatest growth among persons between their early 40s and mid-60s. This pattern reflects the aging population nationwide. The large and economically influential segment of "baby boomers" is now between the ages of 40 and 60. Financially established, boomers make up the bulk of the people moving to places like the Flathead Valley.

In addition to this rapidly growing population of older, working adults, the Flathead experienced a significant increase in the number of teenagers during the '90s, reflecting an influx of established families. The Flathead seems to have attracted many people who feel comfortable enough financially to live where they want, and who bring with them jobs, income, or the capital to start new businesses.

"Transportable" sources of income such as investments and transfer payments are increasingly important here. Unlike most wage earnings, these income sources move with people when they relocate. In 1977, wage income was 70 percent of all income received by individuals and households in Flathead County. Now, although labor earnings continue to grow, they account for only 60 percent of the total. Income from investments (24 percent) and transfer payments (15 percent) make up the rest. Investment income is received primarily as rent, dividends, capital gains, and interest earnings. Transfer payments are mostly from Social Security, Medicare, and Medicaid, which tend to rise with an aging population.

Business is Booming

Flathead County's rapidly growing population is an important driver of the area's economic vitality. More people and more income have translated into more business activity and continuing job growth.

At the end of the 1990s, 980 more firms—not including sole proprietorships—were doing business in the valley than at the beginning of the decade, a 44 percent increase.[3] Employers created 15,700 new jobs during the '90s, a 47 percent increase. Per capita income and total personal income (all income received by individuals and households) grew significantly. Wage and salary labor earnings also increased at a faster rate than they did across the country and throughout the West.

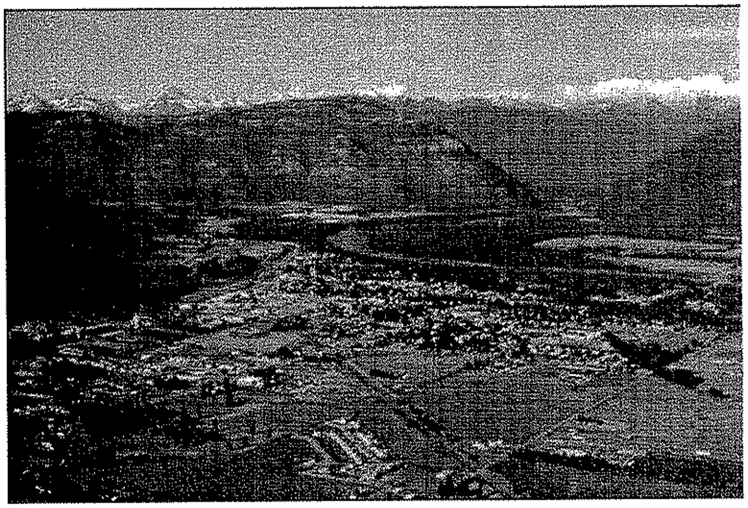
Business leaders interviewed for this report generally agreed that the area's growing population has been good for the economy. A majority said that growth has brought increased prosperity to their businesses, while others described business as stable. Not a single respondent reported a decline.

Another sign of vitality in the Flathead economy is the amount of capital being invested in residential, commercial, recreational, and industrial construction projects. "All enterprise starts with risk, and right now there's a tremendous amount of capital at risk in the valley," observed Kalispell Chamber of Commerce President Joe Unterreiner. As 2003 began, the chamber calculated that more than $1 billion was being invested in major construction projects across the county.

The Flathead Valley also is becoming known for its thriving arts community. Whitefish, Kalispell, and Bigfork are three of the country's top 100 small art towns according to a 1998 book, *The 100 Best Small Art Towns in America.* Artists, musicians, and crafters directly contribute to the economy and are an indispensable element in the unique appeal of the Flathead's communities.

An Economy in Transition

The Flathead economy is changing. Manufacturing—including lumber and wood products, metals, and high-tech—has become less important overall. Labor earnings and the number of manufacturing jobs rose slightly during the 1990s, but manufacturing's share of total labor earnings in the county fell from 32 percent to 18 percent between 1980 and 2000, signaling a major shift away from the area's long-standing dependence on this industry. Another mark of change is that different types of manufacturing are becoming more important in the valley. In the last decade, labor income gains in equipment manufacturing exceeded losses in wood products manufacturing by more than double.



With Glacier as a backdrop, Columbia Falls remains an industrial hub of Flathead County PHOTO: JACK ARCHIBALD

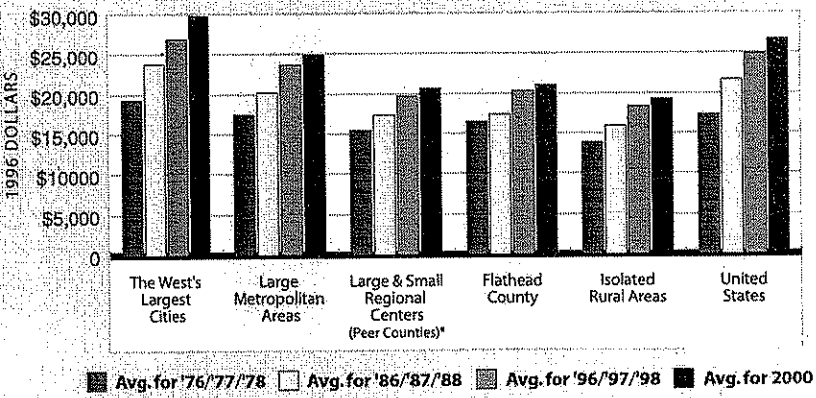
FIGURE 3. Per Capita Income: How is Flathead County Faring?

In 2000, Flathead County's per capita income was $23,142. The national average was $29,469. Does this mean that Flathead County is a "poor" area? Not necessarily.

As the chart demonstrates, per capita income levels tend to be considerably—and consistently—higher in large cities and urban areas than in rural ones. Since most people in the United States live in large cities and their surrounding areas, national per capita income is much higher than in less-populated places like Flathead County and in states, like Montana, that have no large cities.

But areas like the Flathead are starting to gain ground. Across the United States, per capita income grew most quickly in the largest cities during the 1970s and 1980s. During the 1990s, that pattern began to shift, with some of the greatest gains in per capita income happening in smaller cities.

Compared with its peers, Flathead County's per capita income is slightly above average (see chart). As per capita income growth slowed down across the United States during the late '80s and early '90s, Flathead County's economy was on the upswing. Per capita income grew more quickly here than in the rest of the country, and more quickly than the average among its peer areas. This is a sign that the current economic transition is boosting prosperity in the Flathead Valley.



Note: All figures are adjusted for inflation and translated into 1996 dollars to provide true comparisons over time. Data for the West's largest cities include the region's 28 largest cities including Los Angeles, San Francisco, Dallas-Ft. Worth, and Seattle.

Large metropolitan areas include 28 cities the next tier down in size, including Albuquerque, Spokane, Eugene, Boise, and Yakima. Large and small regional centers are the next tier smaller in size and include larger regional centers like Sioux City, Flagstaff, Grand Junction, and Missoula, and smaller regional centers like Port Angeles, Mankato, Bozeman, and Kalispell. *Isolated rural areas* are counties having no cities greater than 10,000 population that are not near larger regional centers and cities.

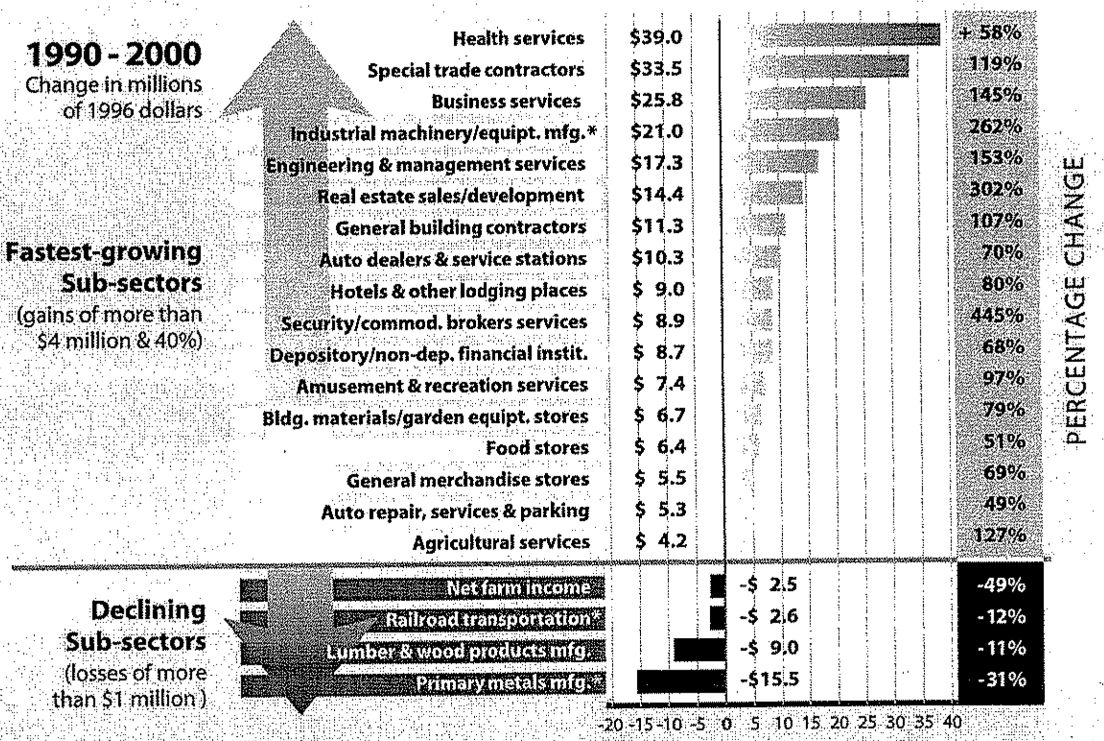
	PERCENT CHANGE	
Per Capita Income Change	77-'87	'87-'97
The West's Largest Cities	+23%	+13%
Large Metropolitan Areas	+16%	+17%
Large and Small Regional Centers (Peer Counties*)	+13%	+13%
Flathead County	+ 6%	+17%
Isolated Rural Areas	+15%	+16%
United States	+25%	+15%

(Source: Swanson, *The Flathead's Changing Economy,* October 2002)

* *Peer counties* are 67 counties in the western United States with similar characteristics to Flathead County, including population size and proximity to major urban centers. All of these counties have no cities exceeding 50,000 population ('90 Census).

FIGURE 4.

Rapidly Growing and Declining Sub-sectors in Flathead County



Note:
- Change in these sub-sectors is measured in terms of labor earnings received by sub-sector workers, in inflation-adjusted 1996 dollars.
- Estimates for 1990 are 3-year averages for '89, '90, and '91, while estimates for 2000 are 2-year averages using '99 and '00 data from the U.S. Department of Commerce.

(Source: Swanson, *The Flathead's Changing Economy*)

* Sub-sector change estimated because some data were suppressed or not available.

Swimmers enjoy the sparkling waters of Flathead Lake

PHOTO:KAREN NICHOLS

The primary source of new jobs and labor income has been a rapid expansion in the services, retail trade, construction, and F.I.R.E. (finance, insurance, and real estate) sectors, particularly in areas directly influenced by the expanding population. During the 1990s, these sectors accounted for more than 70 percent of the labor earnings growth in the valley.

During the 1980s, services and retail trade alone accounted for 85 percent of the new jobs created in Flathead County, causing many to be concerned about quality jobs and the area's future. The '90s, however, were marked by strong growth in other sectors, which held job growth in services and retail trade to around 57 percent of all employment growth. These other growing sectors provide balance and diversity in the overall economy, lending stability and resilience.

In the service sector, growth during the '90s has been particularly strong in sub-sectors that typically offer many high-quality jobs: Health care, engineering and management services, and business services such as computer programming, data processing, advertising, credit reporting, and printing.

The Flathead's popularity among visitors and part-time residents also adds vitality. In terms of labor earnings, two of the fastest-growing sub-sectors in the '90s are strongly related to tourism: Hotels and lodging places (#9 fastest-growing sub-sector) and amusement and recreation services (#12). In many trade and service sectors, labor earnings have grown faster than area population and income, suggesting the growing influence of part-time residents who spend time and money in the area. In the construction sector, for example, disproportionate growth in labor earnings indicates a boom in second-home building, a trend that is otherwise difficult to document.

Tourism continues to be a stable and growing industry in Flathead County, but some measures of tourism activity suggest it may make up a shrinking piece of the rapidly growing economic pie. While part-time residents play an expanding role in the economy, non-resident tourist spending seems to have declined in relative importance in the 1990s. For example, while labor earnings in the Flathead economy grew nearly 50 percent in the past decade, lodging revenue for Flathead establishments grew by only 29 percent, as reflected in bed tax receipts. This difference suggests that much of the Flathead's economic expansion is taking place outside what is commonly thought of as tourism.

Signs of Qualitative Growth

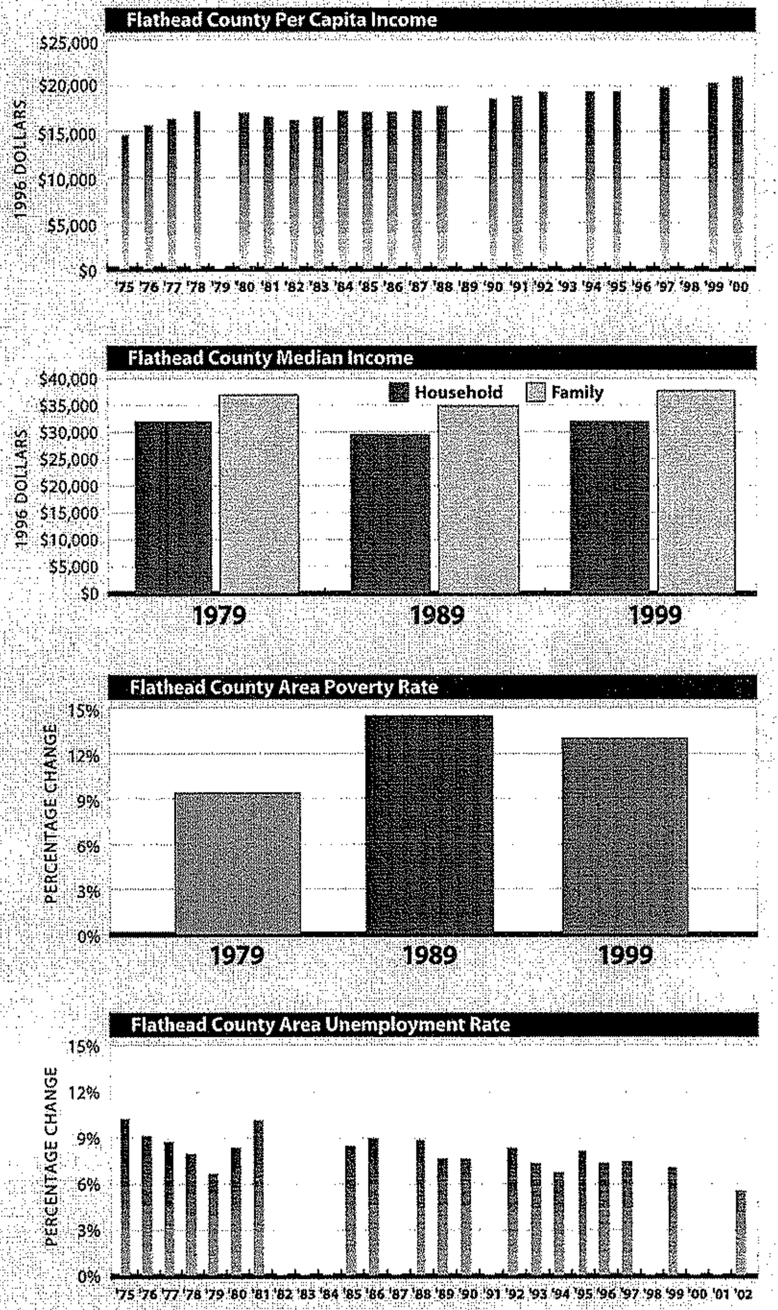
Flathead County has been experiencing rapid "quantitative" growth. More people, more jobs, and more income have helped ease the valley's economic transition. Growth has provided alternatives to extractive industries and traditional manufacturing, which are also declining in economic importance throughout the United States.

However, quantitative growth does not automatically translate into improvements that enhance prosperity and well-being for area residents. In the valley, fortunately, evidence exists of "qualitative" growth. While the 1980s brought economic setbacks in Flathead County, these declines reversed in the 1990s, with gains in per capita income and median income and declining rates of poverty and unemployment.

FIGURE 5.

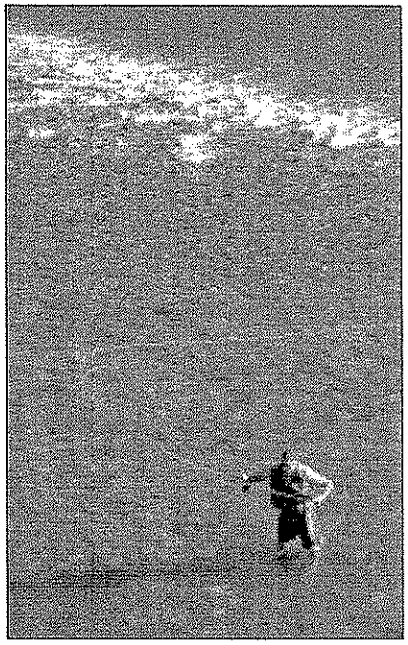
Recent Improvements in Economic Well-being in Flathead County

By nearly all measures, the quality of economic life in the Flathead is improving. Per capita income is steadily rising, median income is recovering after losses in the '80s, poverty is falling after rising in the previous decade, and unemployment is at a 30-year low.



(Source: U.S. Bureau of Economic Analysis, Census Bureau, and Bureau of Labor Statistics)

FINDING 2



Flyfishing on the North Fork of the Flathead River

PHOTO: KAREN NICHOLS

The quality of the Flathead Valley's spectacular environment is its chief economic asset

Changes in Flathead County's economy, driven by the area's growing popularity with new residents and visitors, invite a new interpretation of the valley's most important economic assets. The qualities that attract newcomers and visitors are the same ones that long-time residents most value about the Flathead Valley.

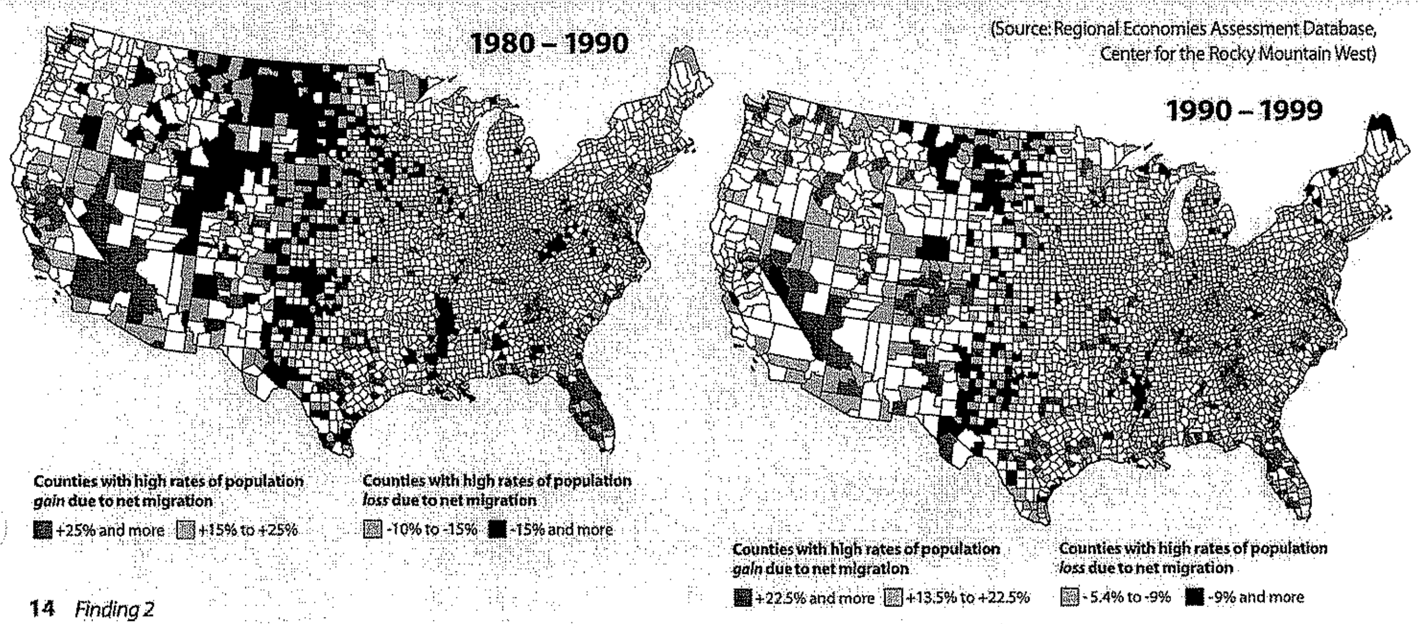
Changing Migration Patterns

Increasingly free to choose where they want to live, many people pursue the quality of life found outside of major metropolitan areas and traditional retirement havens. During the 1990s, patterns of migration shifted nationwide, reflecting this trend.

During the 1980s, the Plains region and parts of the Rocky Mountain West lost population as many people moved away. By contrast, in the West, California, Nevada, Arizona, and a handful of major metropolitan areas attracted new residents. In the East, Florida was the main magnet for people moving to a new area. In the '90s however, this pattern of concentrated population growth shifted. Population gains through migration are now much more dispersed.

During the 1990s in the Rocky Mountain West, a dramatic increase in new residents marked a sea change in migration patterns. Like the Flathead, many of the high-growth areas in the West are non-metropolitan, with relatively small population centers. Throughout the region, national park gateway communities like Flathead County are focal points for growth. More and more, people make decisions about where to live based in large part on the presence of natural "amenities"—appealing qualities or characteristics that add value—such as spectacular scenery, accessible public lands, and clean air and water.

FIGURE 6. **Population Change Through Migration in the U.S.: 1980s vs. 1990s**



(Source: Regional Economies Assessment Database, Center for the Rocky Mountain West)

The Flathead's Key Assets

In surveys and interviews, visitors, new residents, and lifelong community members identify a common core of qualities that attract them to the Flathead Valley. For these people, the valley's unique appeal lies in the small-town character of the communities and the quality of the natural environment. Visitors and residents alike are drawn by the friendly atmosphere, rural feel, clean water, wide-open spaces, wildlife, scenic beauty, and outdoor recreation opportunities.[4]

While visitors are important to the economy, valley residents are at the heart of the Flathead's economic vitality. The valley's natural and recreational amenities play a large part in attracting new residents and businesses while maintaining the loyalty of long-time residents. In a recent survey of Montanans, Kalispell residents expressed a higher degree of attachment to their hometown than do most Montanans.[5]

Most business people in the Flathead Valley say they are drawn here primarily by the quality of the community and surrounding landscape. Most of the business owners and managers interviewed for this report believe they could make more money elsewhere. They see themselves trading greater income opportunities for the quality of life they value so highly.

Of the 80 business leaders interviewed for this report, 13 were native to the Flathead. Most of the others had moved to the Flathead Valley for reasons that centered on lifestyle, outdoor recreation, scenic beauty, and family.

The Flathead Valley's natural and recreational amenities are well appreciated across the country. A 2001 study asked Internet users to identify the images that come to mind when describing a Montana vacation. The top three vote getters—natural beauty and scenery, mountains, and national parks—describe the Flathead Valley perfectly.[6] In 1999, *Mountain Sports & Living Magazine* selected Kalispell as America's "best mountain town," citing its proximity to Glacier Park and its "quaint, laid-back business district."

In today's economy, jobs and income tend to follow people, rather than the other way around. Flathead County's ability to attract and maintain the loyalty of full-time residents, as well as visitors, is critical. The character of the local communities and beauty of surrounding landscapes are the county's most important assets.

The New Economy: Where Jobs and Income Follow People

Behind the growing number of new Flathead residents and businesses are some nationwide trends that make it easier for people to choose where they live.

- The U.S. economy overall is less dependent on jobs in manufacturing and other large industries tied to a particular location. The shift to a more service-oriented economy has made business more mobile. Nationwide, job growth has been focused over the past decade in small firms, which have greater flexibility in location.
- Investment income is a larger share of overall personal income. Thirty years ago, 80 percent of the U.S. income base was labor earnings. Now, in many places, less than 60 percent of personal income comes from wages and salaries. The rest comes from investments and transfer payments, which are more transportable than wage income, giving people more freedom to live where they want.
- Improvements in information technology have fundamentally changed how business is conducted. These advances make it possible to work from home offices or run global businesses from remote locations.

Tom Krustangel Whitefish

"I don't know that anyone can adequately explain what led them to Montana. There is a magic here. I know the first time I set eyes on Glacier Park, I was absolutely awestruck. I had never seen anything so magnificent in all my life. I vowed right then and there to come back and sure enough. It took a few years, but now I have a successful business and I'm right where I want to be.

I love this valley. I love the people in it. I'd hate for us to look like Anytown, USA, with garbled, jumbled zoning. There is a character to this area that I hope we're smart enough to preserve. We as Americans have a bias to look at short-term profit rather than long-term growth, but I think there's a will here to keep our valley special."

Tom Krustangel
Owner, Montana Tom's Chocolate

The Wildest Assets

Visitors and residents share a deep appreciation of the wildlife inhabiting the valley and surrounding mountains. The majority of residents believe that large predators such as grizzly bears, mountain lions, and wolves play an important role in the natural systems they occupy.[7]

Hunting, fishing, and wildlife watching are popular pastimes among people who live in the valley. According to John Fraley at the Montana Department of Fish, Wildlife and Parks, "Northwest Montana has the highest rate of hunting and fishing by both men and women in the entire United States outside of Alaska." Some 40 percent of Northwest Montanans hunt, nearly six times the national average. Sixty percent fish, which is more than triple the national average. And nearly half of those surveyed say they go out to view or photograph wildlife.[8]

Among visitors who spend at least one night in Flathead County, wildlife watching ranks as the most popular activity Fifty-three percent of overnight visitors surveyed noted this as something they did during their stay. Other popular activities included nature photography (44 percent), day hiking (43 percent), and camping (29 percent).[9]

> "In Colorado a lot of the natural areas have been kind of taken over by sort of a trendiness. It's like Rocky Disneyland or something. And Montana is like Montana. It's a real deal place. There's still a sense of a real daily life, not a kind of a recreation tourist daily life."
>
> **–Minnesota man vacationing in Montana**
>
> (The Montana Vacation Experience, Institute for Tourism and Recreation Research, 2002)

Biologist Chuck Jonkel leads another bear watching field trip

PHOTO: KAREN NICHOLS

Figure 7.

Bears in the Backcountry: User Attitude Survey

In the summer of 2001, researchers surveyed nearly 1,600 Glacier Park backcountry users about their attitudes toward grizzly bears.[10] The survey included day hikers and overnight backpackers, all of whom had walked at least a half mile from the trailhead. Their responses suggest that Glacier visitors place a high value on grizzly bears—and understand the vital role these animals play in maintaining ecological balance, both within and outside the park.

	Strongly Agree	Agree	Neutral / No Opinion	Disagree	Strongly Disagree
To me, the grizzly bear symbolizes the beauty and wonder of nature.		🐾			
In my opinion, the grizzly bear is essential for keeping other plants and animal species in proper balance with nature.		🐾			
I would very much like to see a grizzly bear in the wild.		🐾			
Grizzly bears should be eliminated in areas outside of national parks.				🐾	
If oil, natural gas, or minerals were discovered in grizzly bear habitat, the resource should be extracted even if it harms bears.				🐾	

Glacier's Grizzlies

Joan Grote, who directs the Mars-Stout call center for the Flathead Convention and Visitor Bureau, knows what people are looking for when they visit this area. Running through the top attractions for visitors, Grote ended her list by noting, "And of course, everyone wants to see a bear."

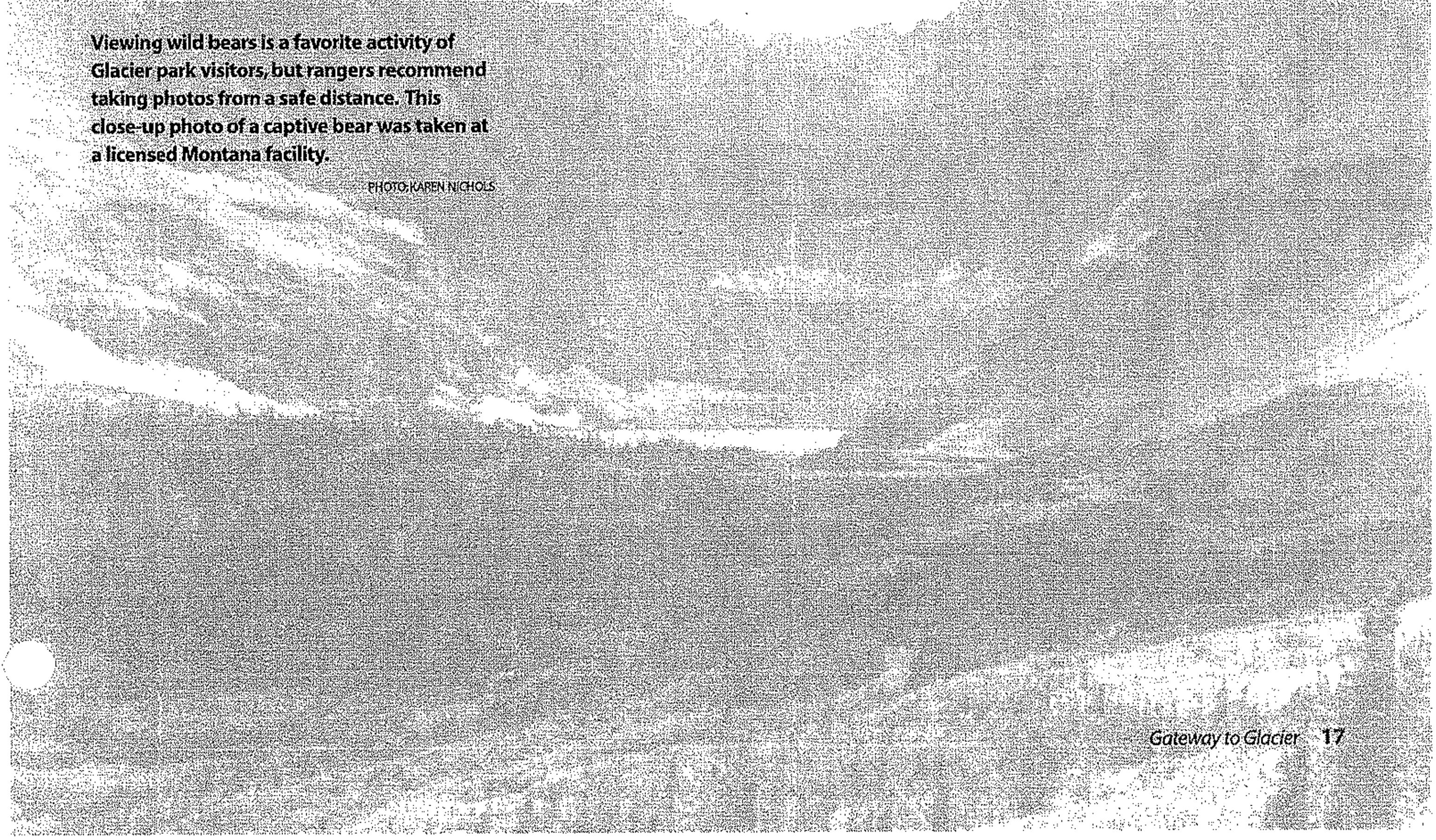
In reality, Flathead residents and visitors alike seem to have a healthy respect for the great bear. Some believe that seeing a grizzly in the wild would be a peak outdoor experience for them. On the other hand, many people are glad to know the great bear is around, but would rather not encounter one in the woods. Among both camps, however, there is widespread agreement that grizzlies are a key element of the natural systems they occupy. Seen or unseen, grizzlies are an important part of the Glacier experience—a sign of wildness and ecological integrity.

Viewing wild bears is a favorite activity of Glacier park visitors, but rangers recommend taking photos from a safe distance. This close-up photo of a captive bear was taken at a licensed Montana facility.

PHOTO: KAREN NICHOLS

Iceberg Lake cirque

PHOTO: NPCA



FINDING 3

Glacier National Park is an anchor for Flathead County's robust economy

In the late 1800s and early 1900s, prospectors searched for everything from gold to copper to oil in what we know today as Glacier National Park. Countless prospectors and speculators believed they would make their fortunes there. Hundreds of mining and oil claims were staked out, but the hoped-for booms turned to bust.

The real "gold" in Glacier was protected on April 11, 1910, when President Taft signed the bill creating Glacier National Park. The mountains, forests, wildlife, and clean waters were protected for posterity. With an initial appropriation of $15,000, crews prepared a few roadways and trails for the first season of visitors, and the park rapidly became a popular destination for travelers.[11]

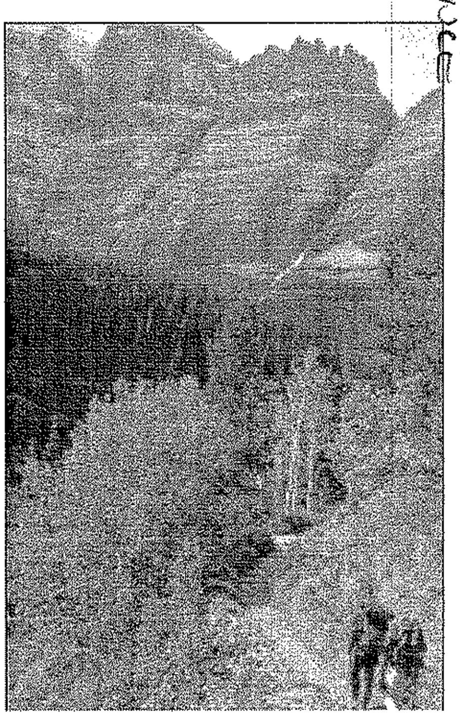
Glacier Park has become Flathead County's most pervasive icon, a widely recognized anchor for the region's many natural amenities, and a primary attraction for residents, visitors, and business leaders alike.

This is Glacier Country

Glacier National Park runs neck-and-neck with Yellowstone as Montana's number one attraction for vacationers. More than 80 percent of vacationers in Flathead County say Glacier was one of the attractions that drew them here.[12] Every year, Glacier is visited by people from every U.S. state and territory, from every Canadian province, and from nations around the globe.

Glacier's single most popular attraction is Going-to-the-Sun Road, with more than three-quarters of park visitors enjoying the spectacular scenery, wildlife viewing, and fresh alpine air at Logan Pass.[13] The park is just as well known as a premier hiking destination. Two-thirds of prospective park visitors surveyed planned to hike on some of the park's many trails.[14] In 2000, readers of *Backpacker* magazine selected Glacier as America's best backcountry park.

The park is beloved by Flathead residents, as well. Glacier National Park is the most popular place for Kalispell residents to take people who come to visit. Glacier is twice as popular as magnificent Flathead Lake, and outranks Big Mountain by a factor of three.[15]



Glacier hikers on the trail to Iceberg Lake

PHOTO: KAREN NICHOLS

Velinda Stevens, Kalispell

"Conservation affects the attractiveness of the area and the kinds of people we recruit to the Flathead Valley. We have been able to attract and retain an outstanding medical staff because this is such a nice place to live. And you know those things that make it a nice place to live—clean air, water quality, Glacier National Park, the wildlife—all the reasons that people live here, they want to keep.

Glacier is a big part of why I choose to live here. The hiking is spectacular. I like that there's nothing ostentatious about the park. I like the wildlife, how accessible it is. There isn't anything I don't like about the park. It's a huge part of our valley's quality of life, and the quality of life is why our economy is growing. Our challenge is to make sure we protect these qualities for the long term."

Velinda Stevens
Chief Executive Officer
Kalispell Regional
Medical Center

BIRCH CREEK STREAM DAMAGE – COORESPONDANCE

Overwhelmingly, Flathead business leaders treasure Glacier Park, expressing a deep personal fondness. Across various business sectors, managers and owners believe Glacier is good for local business and the overall economy. Nearly 200 Flathead businesses make that link directly, adopting Glacier as part of their name and identity. And several of the valley's largest developments, either under way or proposed, have adopted Glacier as their icon. These include a proposed mall, a performing arts center, and a redeveloped ski village.

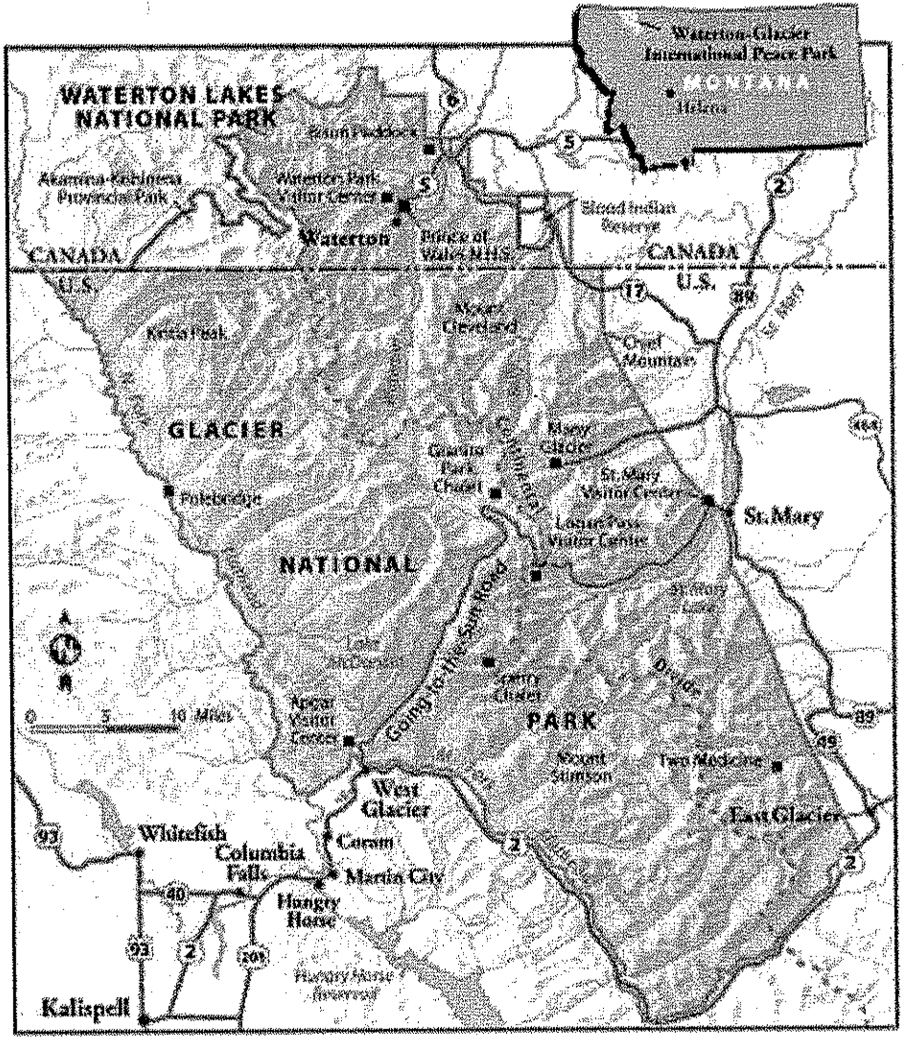
Glacier's Ecological Importance

The landscapes protected within Glacier National Park are essential to the natural amenities that Flathead residents and visitors enjoy, even many miles outside park boundaries. Substantial reaches of the North Fork and Middle Fork of the Flathead River are fed by clean waters that originate in the park. These rivers provide much of the volume in Flathead Lake.

Glacier Park is at the core of an extensive system of U.S. and Canadian public lands that provides important habitat for native species from elk to bull trout, from bear grass to mountain goats, and from lichens to peregrine falcons. The North Fork Flathead drainage provides unique habitat for carnivores such as lynx, grizzly bear, wolf, mountain lion, and marten. Spanning the U.S.-Canada border, this relatively intact and varied natural system hosts in abundance species that are now rare elsewhere in North America. A large part of this critical habitat is protected within Glacier National Park.[16]

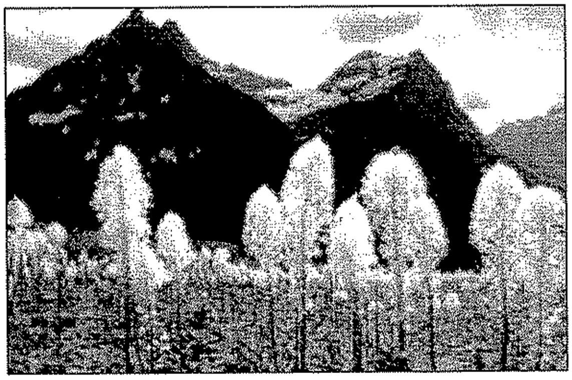
FIGURE 8.

Waterton-Glacier International Peace Park



Waterton-Glacier was designated the world's first international peace park in 1932 by Congress and the Canadian Parliament

MAP: MATT KANIA AND ROGER PARCHEN



Bear grass blossoms enchant Glacier's visitors

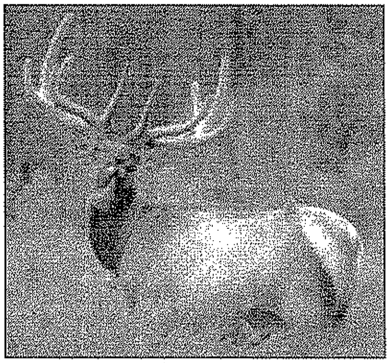
PHOTO: KAREN NICHOLS

FINDING 4

Proximity to national parks is an economic advantage for gateway communities such as Flathead County

Glacier is home to a full theater of large wild mammals

PHOTO: KAREN NICHOLS



The close relationship between Glacier National Park and Flathead County's economic growth and vitality reflects a larger pattern among national park gateway communities across the western United States. These gateway communities—which provide access to and visitor services for national parks— are experiencing similar changes in population, income, and employment. In the West, national parks often anchor a larger complex of public lands that provide desirable natural amenities. Like Glacier, these parks are key economic assets for the surrounding communities.

Magnets for Migrants

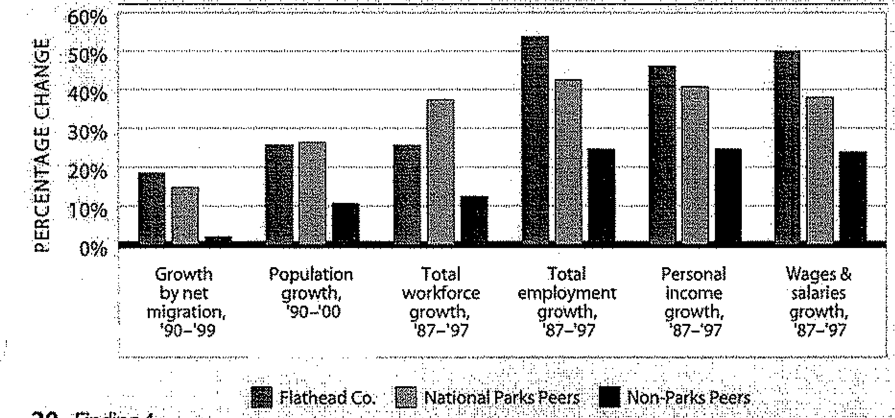
Throughout the western United States, national park gateway communities are among the most attractive to new residents. Fifty-one counties in the West, including Flathead, are next to large, attractive national parks and not part of a large metropolitan area. During the 1990s, 196,000 more people moved into all of these counties put together than moved away—triple the rate of net migration during the '80s.

National parks are magnets for new residents, and not because the parks are generating new jobs for government employees or contractors. In fact, park employment overall has declined. Similarly, population growth and business growth in these communities is not explained by booming numbers of park visitors. National parks play a different role in today's economy.

Attracted in large part by a clean and beautiful natural environment and access to outdoor recreation—as well as small, friendly towns—people are choosing to live in communities near national parks. Gateway counties that, like Flathead, serve as small regional trade centers, are attracting much of that growth. During the 1990s, such counties bordering national parks saw their populations increase by more than 26

The economic advantage of these park gateway communities can be gauged by comparing the performance of counties that differ primarily in their proximity to national parks. Throughout the West, Flathead County has 64 "peer counties" of similar size and character. Nine of these, including Flathead, are national parks gateway communities (or "national park peers"). The remaining 55 peer counties are not park gateways (or "non-park peers").

FIGURE 9. **Trends in Peer Counties of Flathead County**



Note: National park "peer counties" are nine counties near large national parks in the 22 contiguous states of the West that: 1) had 1990 populations between 30,000 and 100,000, 2) contained small regional trade centers under 50,000 population, and 3) had less than 10 percent American Indian population.

Of the ten national park counties listed in Figure 10 on page 22, Cococino County, AZ, was eliminated as a peer because of its high American Indian population.

The non-park peer counties are 64 other counties in the West with similar populations and small regional centers that are not near a major national park.

(Source: Swanson, 2002)

percent. Population growth in similar types of trade center counties that are not park gateways was less than half as strong, at 10 percent.

New residents from outside the county are responsible for most population growth in park gateway communities. By contrast, in their non-park peer counties, more people left than moved in during the 1980s. The 1990s were not much better, with very small net in-migration during the decade. While these non-park counties experienced population growth in the 1990s, it was largely because the number of births exceeded deaths.

Fueling Economic Growth

Across the western United States, national parks fuel strong economic growth in nearby communities. Like Flathead County, these areas enjoy a level of vitality not shared by most of their "non-park" peers. The attractiveness of these park areas drives economic growth.

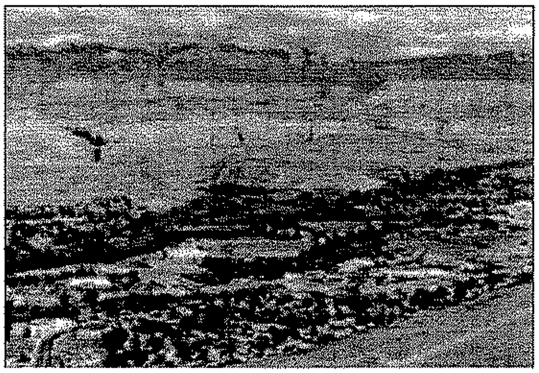
From 1987 to 1997, gateway counties like Flathead enjoyed a 40 percent growth in total personal income (all income received by individual and households). Income in non-park counties grew at less than two-thirds that rate. During the same time, total employment (all full- and part-time jobs) in park gateway counties grew almost twice as fast as in counties not adjacent to national parks.

National parks and the other public lands that often surround them are critical anchors for an array of natural amenities. Clean air and water, scenic beauty, recreation opportunities, and wildlife attract visitors and new residents and support economic growth.

Patterns of Economic Transition

National park gateway counties are going through similar economic changes, including a shift away from reliance on resource extraction. Lumber and wood products manufacturing declined sharply in regional center counties near parks. In these park gateway counties all together, income in the wood products industry fell by 23 percent between 1987 and 1997. Flathead County fared better than many of its peers in this respect—its lumber and wood products earnings declined by only 13 percent during that time.

Flathead County's gateway peers (see Figure 10) have also grown rapidly in income and employment, particularly in service and trade sectors linked to a growing population. Further, these areas also show evidence of an increasing influence of visitors and part-time residents. As in the Flathead, activity in construction and certain service and trade sectors appears to be expanding more quickly than the local population and income base.



Located between Arches and Canyonlands national parks, Moab, Utah, has seen 20 percent growth in the last 10 years. PHOTO: BRAD WEIS

Morrie Schechtman, Kalispell

"The Flathead valley is an extraordinary place in two respects: It is one of the most beautiful and inspiring natural environments in the world. And it is an ideal environment for creative people and virtual businesses. Both of these guarantee economic and population growth in the valley—and also in similarly beautiful places—to meet the increasing demand for quality of personal life, as well as the ability to conduct global businesses from a low-stress, people-friendly environment.

But these qualities also guarantee change, and even a certain anger and grief over the speed with which change has been occurring. The ability of all constituencies to identify and grieve their losses will determine how well these changes are integrated into future life in the Flathead.

By acknowledging our losses and embracing change, it should be possible for all parties to engage in an ongoing planning process that maintains many of the values we all share. Planning is absolutely essential to growth. On the surface, people think planning is antithetical to property rights. Actually, planning preserves the sanctity of property."

Morrie Schechtman
Business Management
Consultant

Paul Wachholz, Kalispell

"People in the Flathead Valley are waking up to the fact that we can determine the fate of our area. We can either sit back and watch what happens or step forward and direct what happens. Maybe people didn't think they could make much difference before, but now they do. If we don't get a plan in position, basically, the whole valley will look hodgepodge. It's to all of our advantage to have clusters where people live and clusters of farming and country landscape.

Same thing with the park. I think it's very important to keep it in its natural state because that's the essence and the beauty of it. We need to provide adequate funding for the parks, and we need to restore and maintain the Sun Road and the old buildings.

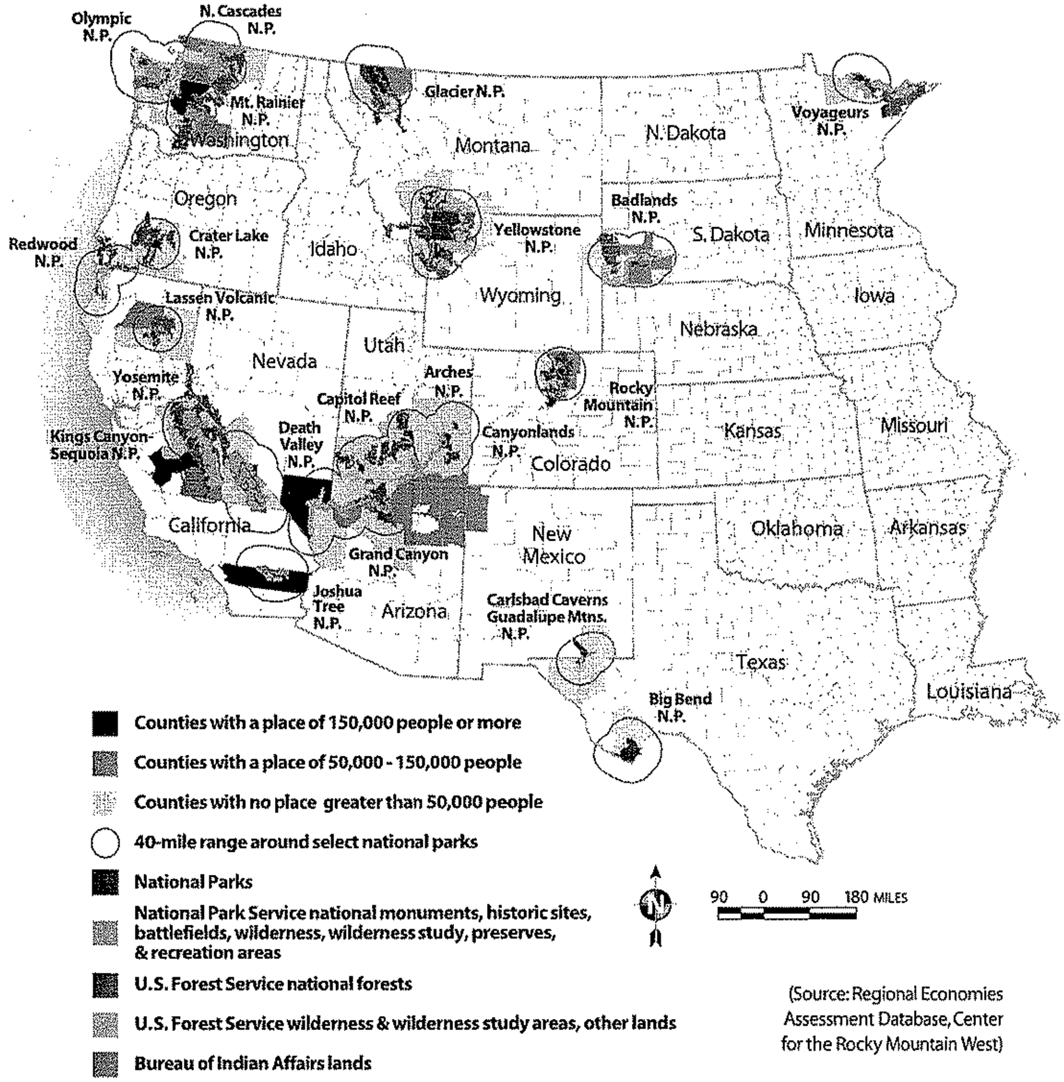
We can have a beautiful Glacier Park. We can have a beautiful Flathead Lake. We can have beautiful communities. But if we don't clean up our act where we live, we're not going to end up with what we want."

Paul Wachholz
Wachholz and Company
Real Estate

By some measures, Flathead County seems to be doing better than its park gateway peers in linking rapid population and economic growth with qualitative improvements in the well-being of its residents. In 1997, for example, the Flathead poverty rate was 14.2 percent, almost a full percentage point lower than the average for its peer group. And between 1987 and 1997, per capita income in Flathead County grew by 17 percent, more than double the rate of growth in peer counties. Flathead's per capita income in 2000 exceeded the peer average by more than $1,200. Like the Flathead, gateway communities across the West are getting an economic lift from an influx of new residents, part-timers, and visitors. But they find this growing popularity threatens the very qualities that make their communities so attractive.

FIGURE 10. **National Park Areas in Western United States**

This map shows areas near major national parks in the 22 contiguous states west of the Mississippi River. Other federal lands adjacent to these parks are also shown. There are 80 western counties whose geographic center is within 40 miles of these parks, the majority of which (51 counties) are non-metropolitan in character. Recent shifts in migration patterns are channeling more and more new residents into many of these non-metropolitan areas that serve as national park gateways.



(Source: Regional Economies Assessment Database, Center for the Rocky Mountain West)

FINDING 5

The Flathead Valley's most valued qualities and primary economic assets are at risk

Among this region's most important economic assets are those that give the Flathead Valley its unique appeal: The small-town community atmosphere, uncrowded spaces, easy access to outdoor recreation, scenic landscapes, clean water, and wildlife. These are the qualities that area residents are most attached to—and that attract new people to the area.

In the face of rapid population growth and commercial, recreational, and residential development, there are signs that stewardship of these valuable assets has been lacking.

Perceptions of Change

Overall, valley business leaders agree that the Flathead's unique characteristics have already been degraded, and that these losses continue. They most lament the loss of open space, farmland, and the valley's rural character. Many of them believe that small-town friendliness is being challenged by impatient drivers and demanding customers. Some point to commercial sprawl, the decline in traditional jobs, and the influx of national chain stores as further evidence of the valley's changing character.

Kalispell residents surveyed expressed concerns about open space in their community. Most believe that there is already too little undeveloped open area, and are concerned that what is there will disappear. Survey results suggest that Kalispell residents are more concerned about the loss of open space than are Montanans in general.[17]

A survey of Whitefish residents found that their biggest concerns for the future of their community are maintaining their town's character and protecting environmental qualities. They identified traffic congestion and growth issues, such as strip development, as significant concerns.[18]

Flathead visitors are beginning to echo residents' concerns. In a 2001 survey, returning Montana visitors were asked to indicate how they saw the state changing over time. For each of the 12 characteristics included in the survey, people indicated whether they thought the condition was better, the same, or worse than on previous visits. Survey responses from Glacier Park visitors raise a red flag, suggesting that the very qualities that attract visitors to the area in the first place are being eroded.

Development in the Flathead Valley, 1980

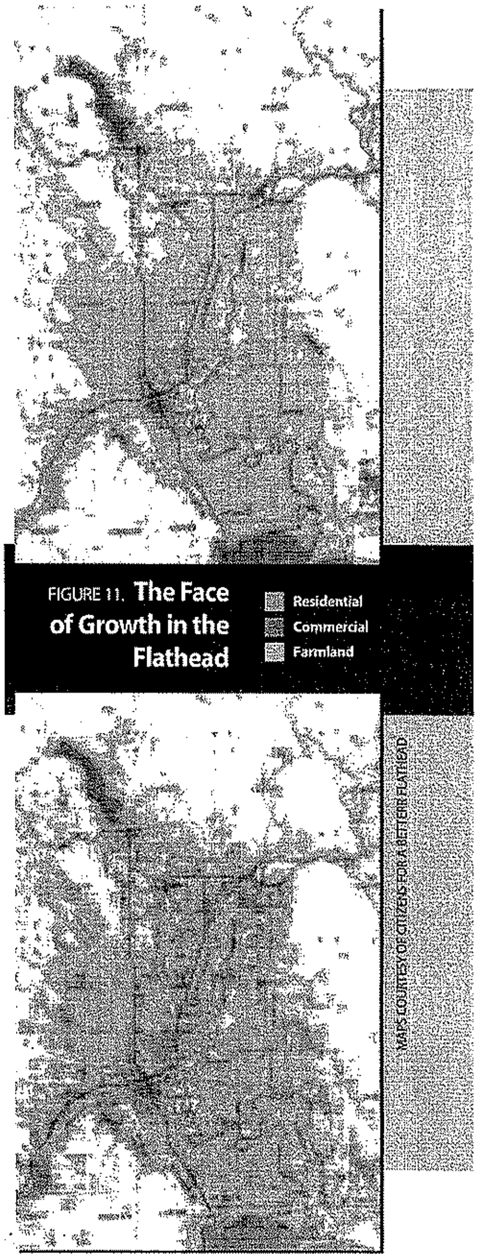


FIGURE 11. **The Face of Growth in the Flathead**

Development in the Flathead Valley, 1998

Most of Flathead County's growth is occurring in rural areas, converting wildlife habitat, farms, and forestlands into development. Land-use planning lags behind development pressure in the Valley.

FIGURE 12. **Open Space Concerns in Kalispell**

	KALISPELL		MONTANA	
	Agree	**Disagree**	**Agree**	**Disagree**
There is adequate undeveloped space in my community	42%	58%	59%	41%
I am concerned with the potential disappearance of open space in my community	76%	24%	60%	40%

(Source: Institute for Tourism and Recreation Research, The University of Montana)

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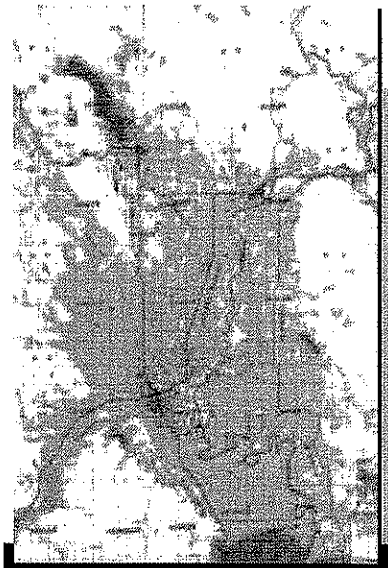
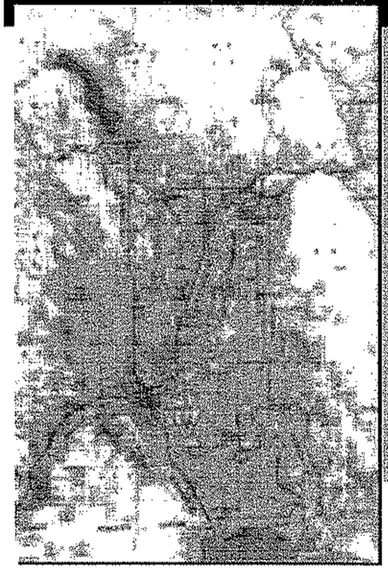


FIGURE 11. **The Face of Growth in the Flathead**

▨ Residential
▨ Commercial
▨ Farmland



Development in the Flathead Valley, 1998

MAPS COURTESY OF CITIZENS FOR A BETTER FLATHEAD

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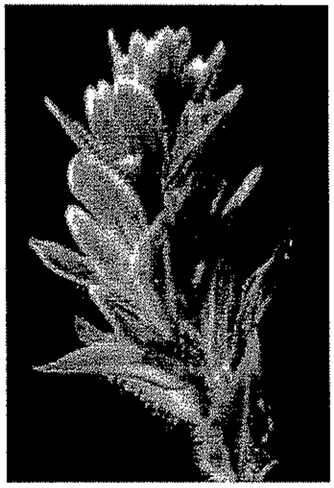
(Source: Institute for Tourism and Recreation Research, The University of Montana)

Among Glacier Park visitors, three features received "worse" ratings from more than 10 percent of respondents: the condition of the natural environment, amount of open space, and wildlife viewing opportunities. One of every five respondents perceived a decline in the amount of open space.[19]

The park visitors surveyed did not go to Yellowstone and were likely to have spent almost three-quarters of their Montana stay in and around Glacier Park. Their perceptions reinforce Flathead residents' concerns about changes in the local landscape. A clear picture is emerging in which the pace and nature of growth and development are bringing about changes that residents and visitors alike find unappealing.



Indian Paintbrush in Glacier PHOTO: NATIONAL PARK SERVICE

FIGURE 13. **Threats to Park Resources**

Ⓐ Proposed expansion of Highways 2 (U.S.) and 3 (Canada), paving of the North Fork Road, and associated development may impede the travel routes of grizzlies, elk, mountain goats, and other wildlife species. Several grizzlies, attracted to grain spills along the Burlington Northern-Santa Fe railroad, have been killed.

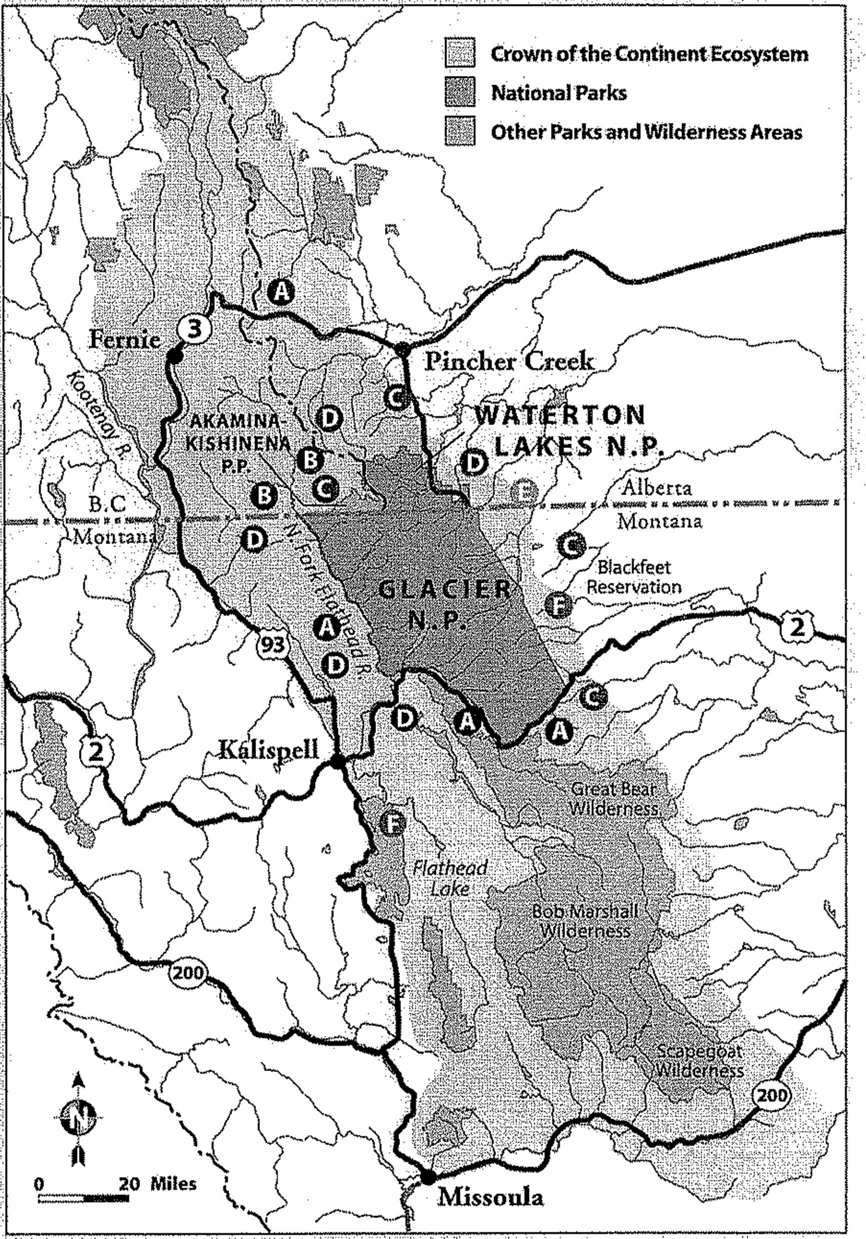
Ⓑ In the currently unsettled Canadian Flathead region, potential hard rock mining, long-term plans to construct an open-pit coal mine, and associated development would adversely affect water quality and transboundary populations of bull trout and other wildlife populations.

Ⓒ High-density road systems and other infrastructure associated with proposed logging, recreational and rural development, and extraction of oil and gas along the Rocky Mountain Front on both sides of the border would displace grizzlies and big game wildlife species that are known to avoid roads and drilling sites. Extensive gas-field development already has degraded habitat and displaced wildlife north of Waterton.

Ⓓ Residential, commercial, and resort developments on ranch, farm, and forest lands have encroached on important seasonal range for elk, mule deer, bears, mountain lions, and other wildlife species. Rapid population growth and poorly planned development may result in even more adverse impacts on wildlife.

Ⓔ In Alberta, the gray wolf can be legally hunted about nine months of every year. Ranchers are allowed to kill wolves within five miles of their land, and there is no limit on the number of gray wolves that can be trapped in a year.

Ⓕ Invasive non-native fish species have migrated from Flathead Lake into the park, and numerous non-native weed species have been introduced into the park through unauthorized grazing by cattle and horses along the borders of the park.



Examples of landscape alterations abound on land surrounding Waterton-Glacier International Peace Park. Most such changes have negative impacts on the native species that find refuge in the park.

MAP: MATT KANIA AND ROGER PARCHEN

Losing Farm and Forest Land

When business leaders talk about losing open space, farmlands, and the rural feel of the valley, it is easy to substantiate their concerns with facts. Periodic Agricultural Censuses report that, between 1978 and 1997, the amount of land in agricultural use decreased by a third, from 327,000 acres to 216,000 acres. Although similar statistics are not available for forested acreage, development patterns in the foothills and at the valley edges suggest a dramatic conversion of historic timberland.

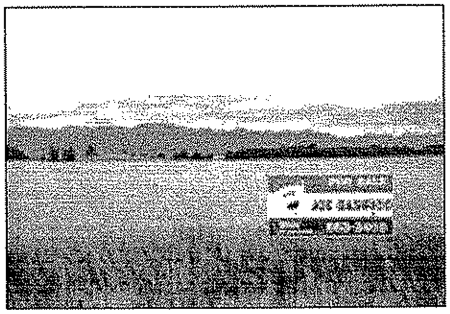
Development is not the only force influencing the amount of farmland in the valley, but it is an important one. During the rapid-growth years from 1992 to 1997, Flathead County lost 1.4 acres of farmland per hour, according to the U.S. Agricultural Census. More than a quarter of all homes in Flathead County were built after 1990. County data show 6,194 new lots and tracts created by subdivision between 1990 and 2000, and 8,225 housing starts in the same period. More than 70 percent of these housing starts went up in rural Flathead County, outside municipal sewer districts.[20]

A long-term decline in agricultural income contributes to the conversion of farmland to yards and parking lots. From a high of $45 million in 1980, farm income in the county has steadily declined to $30-$35 million a year during the last half of the 1990s. Annual production expenses also total between $30 and $35 million a year, indicating that Flathead farmers are either losing money or not making very much. As real estate values climb because of development potential, the valley's farmlands and private forest lands are more likely than ever to be sold and developed. The conversion of these lands affects the area's open, rural feel; access for outdoor recreation such as hunting, fishing, and walking in the woods; and habitat for wildlife—especially seasonal range for bears, deer and elk, and mountain lions.

Threats to Waterton-Glacier International Peace Park

In 2002, the National Parks Conservation Association released its State of the Parks® report for Waterton-Glacier International Peace Park.[21] This assessment finds that haphazard development of nearby landscapes and inadequate funding for basic park operations threaten the natural and cultural resources that make the park so extraordinary. Key points include:

- The Peace Park is one of the few protected places in the lower 48 states and southern Canada where a complete set of large predators, including grizzlies and gray wolves, still plays a prominent role in a largely natural ecosystem. The health of these wildlife populations is tied to their current ability to range freely across governmental boundaries.



According to the U.S. Agricultural Census, Flathead County lost 1.4 acres of farmland per hour in the mid-1990s

PHOTO: KAREN NICHOLS

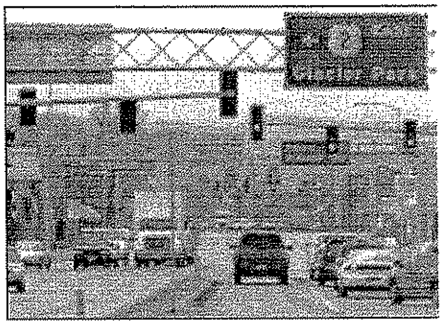


PHOTO: KAREN NICHOLS

"I wouldn't drive up the Flathead Valley again.... There's a lot more sprawl than I expected. Really, I mean Missoula basically to Whitefish looks a lot like Oregon. It looks a lot like California. Where little towns stop being little towns and there's kind of sprawl. I haven't been here since '61, so it's been a long time. I think my expectation was that it was going to be a little wilder than it was. And that was a ... disappointment."

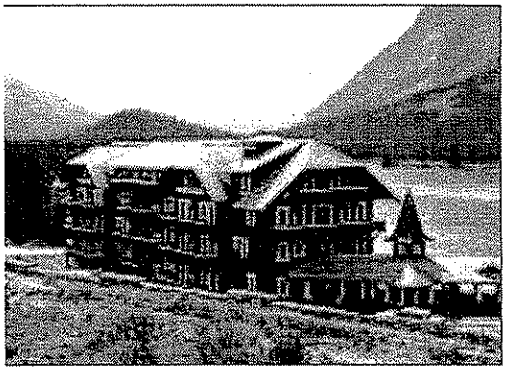
Couple from California, describing their trip through the Flathead Valley

(The Montana Vacation Experience, Institute for Tourism and Recreation Research, 2002)

Proposed highway expansion and North Fork road paving could impede the travel routes of grizzlies, elk, mountain goats, and other wildlife. Intensified development on ranch, farm, and forest lands has encroached on important seasonal range. Rapid population growth and poorly planned development may result in even more adverse impacts on wildlife.

The historic Many Glacier Hotel is in need of extensive repairs

PHOTO:NPCA



- Waterton-Glacier protects six National Historic Landmarks and more than 350 structures listed on the National Register of Historic Places. Many Glacier Hotel and Going-to-the-Sun Road are two of the best known of these attractions.

  Park staff estimate that Glacier's backlog of deferred maintenance and construction needs exceeds $400 million. The total includes funds needed to construct a new west-side visitor center, stabilize historic hotels, and rehabilitate Going-to-the-Sun Road.

- Glacier Park was designated to protect the area's natural and cultural resources.

  The park has neither the staff nor the money to monitor wildlife populations adequately, complete needed archaeological research, maintain historic structures and museum collections, and provide high-quality visitor services that people have come to expect at national parks.

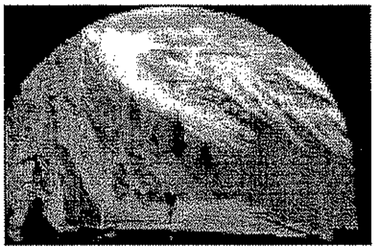
Overall, the State of the Parks® assessment suggests that a long history of protection has not spared the park from serious threats. These threats are worthy of Flathead residents' attention and action, as an investment in the valley's continued economic success.

Bighorn sheep graze in Glacier's alpine meadows

PHOTO: LARRY STOLTE

In a tunnel on the Going-to-the-Sun Road

PHOTO: KAREN NICHOLS



FINDING 6

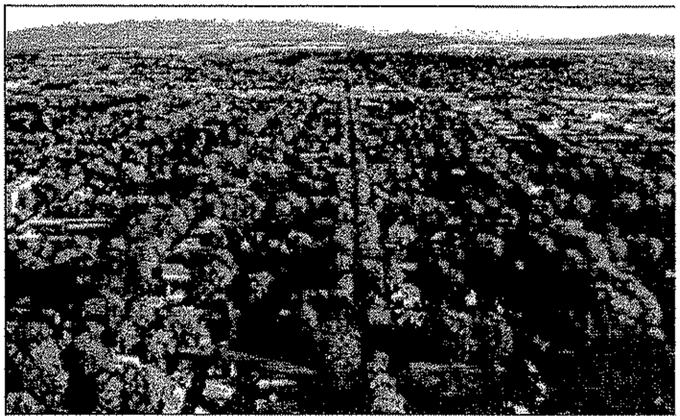
Flathead communities must encourage high-quality economic growth and development

The Flathead economy might best be thought of as a "transitional" economy. Across the country, resource industries such as wood products and metals processing are playing a smaller economic role. In the Flathead, troubles caused in part by declines in these long-standing pillars of the local economy have been offset in the 1990s by economic expansion closely linked to an influx of new valley residents.

The valley's growing popularity has been such a strong force that the local economy has become largely driven by, and dependent on, that growth. To ensure long-term prosperity, the Flathead must use its current strength to retool the valley's economy so it remains strong and resilient, even when population growth subsides.

For now, the Flathead's popularity remains high. Over the longer term, however, growth may degrade the very assets that make the area an attractive place to live.

Quantitative growth—more people, more jobs, and more income—is a given for now. The valley's communities must focus their attention on promoting "qualitative" growth—change that improves the well-being of Flathead residents and protects the area's most vital economic assets. The influx of new full-time and part-time residents has brought more jobs and income, volunteer energy, tax revenues, ideas, and other resources to valley communities. This puts the Flathead in a position to better guide growth and development to support local values.



Downtown Kalispell maintains its small-town feel

PHOTO: KAREN NICHOLS

Quality Economic Development

The economic setbacks of the 1980s have been more than offset by a resurgence in per capita income and median family income, and a drop in the area poverty and unemployment rates. Flathead County is on par with its peers in these indicators of economic well-being. Still, the community could do much to improve its residents' quality of life, and to ensure that economic growth leads to higher levels of qualitative growth and genuine economic improvement.

FIGURE 14. **Business Leaders' Views on Land Use Planning**

	More	Less	OK Now	Don't Know
Do you feel there should be more land use planning or less land use planning?	55%	24%	9%	12%

(Source: A & A Research, Kalispell Chamber of Commerce Survey, October 2001)

Joel Bonda, Kalispell

"In my work I deal with entrepreneurial high-tech firms located throughout the country, and I've asked them what factors might attract them to expand or relocate in Flathead Valley. First, they say that they would move to Montana for its environment: open spaces, big sky, pure water, fresh air. Glacier National Park is a huge part of the attractiveness of this place.

But these entrepreneurs also say, without exception, that they would only move to a state that showed total commitment to public education. They want this for their children, yes, but they say they cannot operate in today's new economy without a highly educated workforce. Not just a workforce that is literate, but one that is technologically sophisticated and that has been taught to think analytically.

Our environment and quality of life are our strongest economic assets. As a community, we can best use this asset for economic development only if we also invest in a top-notch education system. That's how the Flathead can thrive in this new economy.

Joel Bonda
Software Developer

The Flathead's greatest economic development need is to cultivate growth in better paying jobs with benefits that can fully sustain workers and their families. Because job growth is already happening, creating higher quality jobs should be the focus rather than simply creating more jobs.

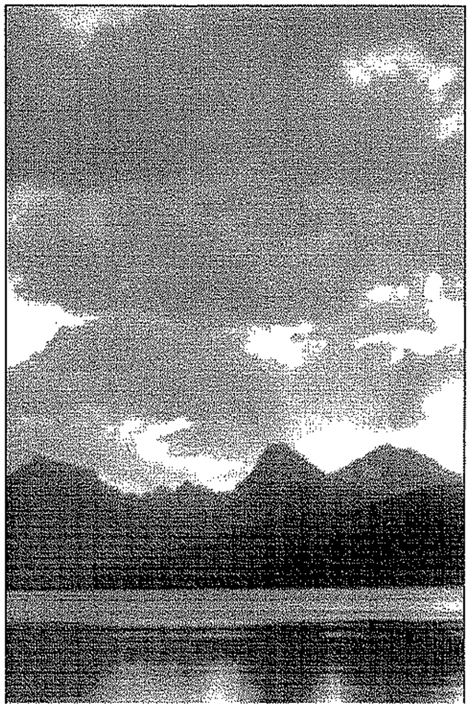
Flathead County should do all it can to foster a pool of high-quality, well-educated workers and entrepreneurs. Doing so requires a sustained public commitment to education and training. This serves to prepare future employees, and it attracts high-caliber workers and business owners with school-aged children to the area. Education and training also help workers adjust to economic transitions.

Planning for Growth

If population growth meets current forecasts, Flathead County will be home to between 87,000 and 100,000 people by 2010. As development continues, the character and appeal of the valley may be increasingly difficult to maintain. "...[N]o place will retain its special appeal by accident," writes Ed McMahon, co-author of *Balancing Nature and Commerce in Gateway Communities* (1997). He notes that gateway communities such as Flathead County are "ground zero" in the struggle between haphazard development and planned growth.[22] Haphazard development undermines the qualities that long-time community members, new residents, and visitors all find most attractive—the valley's most important economic assets.

Local business leaders interviewed for this report share a belief that unplanned growth could one day act as a drag on the region's economy and that city and county governments have not responded adequately to growth. In a survey of Kalispell residents, a solid majority of 80 percent agreed that they would support land use measures to help manage future growth in their community.[23]

In the Flathead Valley, no clear picture has yet emerged of what action would best help the valley get a handle on growth and encourage the kinds of recreational, residential, and commercial development that enhance the lives of area residents. Indeed, views diverge significantly on this question, and the local political climate may stand in the way of achieving consensus. More than half of the business leaders interviewed for this report believe that the tone of public debate in the Flathead Valley is harsh, dominated by parties with extreme viewpoints. Between the extremes is a vast middle ground and ample room for compromise and action.

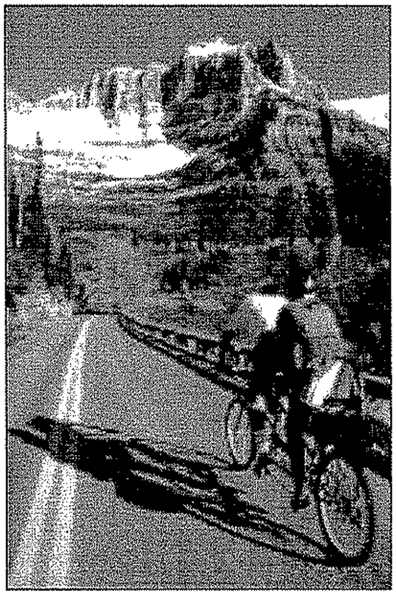


Sunset on McDonald Lake

PHOTO:KAREN NICHOLS

INVESTING IN THE FUTURE

In the face of these challenges, people in the Flathead share similar concerns about the future. In separate surveys, Kalispell and Whitefish residents identified the most important issues facing their communities. Maintaining existing community character, protecting the natural environment, diversifying the economy, and supporting local business growth topped the lists.[24] Flathead residents recognize the importance of their natural and community amenities to their own quality of life and to the economic health of the valley.



Working together in Glacier

PHOTO: KAREN NICHOLS

Collaborative Action

These common views can form a solid foundation for community dialogue and collaborative action. Flathead communities and their leaders need to begin sorting out "good growth" from "bad growth," and figuring out strategies to guide development.

Partnerships are critical to taking charge in the face of rapid change. In the Flathead, those partnerships must involve public land managers. The Flathead Valley's economic strength is closely linked to the health of the surrounding public lands. Similarly, the health of Glacier National Park, other public lands, and natural resources such as clean water depend on what happens within a broader context that includes the private lands and developed areas of the Flathead Valley. As the NPCA State of the Parks® assessment determined, most threats to Glacier originate outside park boundaries.

Given shortfalls in funding and staffing, Glacier National Park and other land management agencies cannot protect the valley's resources and assets without cooperation from Flathead community leaders. Broad support from its gateway communities will be essential as Glacier seeks massive congressional appropriations to fix its deteriorating infrastructure, particularly Going-to-the-Sun Road.

Dialogue and collaboration across all kinds of boundaries (including city/county, public/private, and U.S./Canada) must occur for the Flathead to create a unified effort to guide change, enhance residents' well-being, and protect the area's most important assets. If no place retains its special appeal by accident, as Ed McMahon suggests, then it is time for Flathead residents to craft clear plans and specific initiatives.

Forest glen in Glacier National Park

PHOTO: NATIONAL PARK SERVICE

> "Across America, dozens of communities are demonstrating that economic prosperity doesn't have to degrade natural surroundings, rob them of their character, or turn them into crowded tourist traps. Many of these initiatives resulted from partnerships involving both gateway communities and public land managers."
>
> —**Ed McMahon**, co-author of *Balancing Nature and Commerce in Gateway Communities*

Andy Feury, Whitefish

"We as decision makers must look to the future and recognize the changing face of our economies in the West. The quality of our environment and the character of our communities are fast becoming major contributors to that economy. They are our most important economic assets.

We have experienced a great deal of growth due to the beauty of the environment surrounding us and the easy recreational access to public lands. As a result of this growth, developers of all stripes want to move into our valley. We have the enviable opportunity to decide what kind of development we want, where we want it to go, and how we want it to look.

As a community, we can afford to steer development to meet our needs. We don't have to settle for whatever proposals walk in the door. In fact, we must direct development in a way that protects our core assets as an attractive, friendly place to live. To do otherwise would be unwise and unfair to future generations."

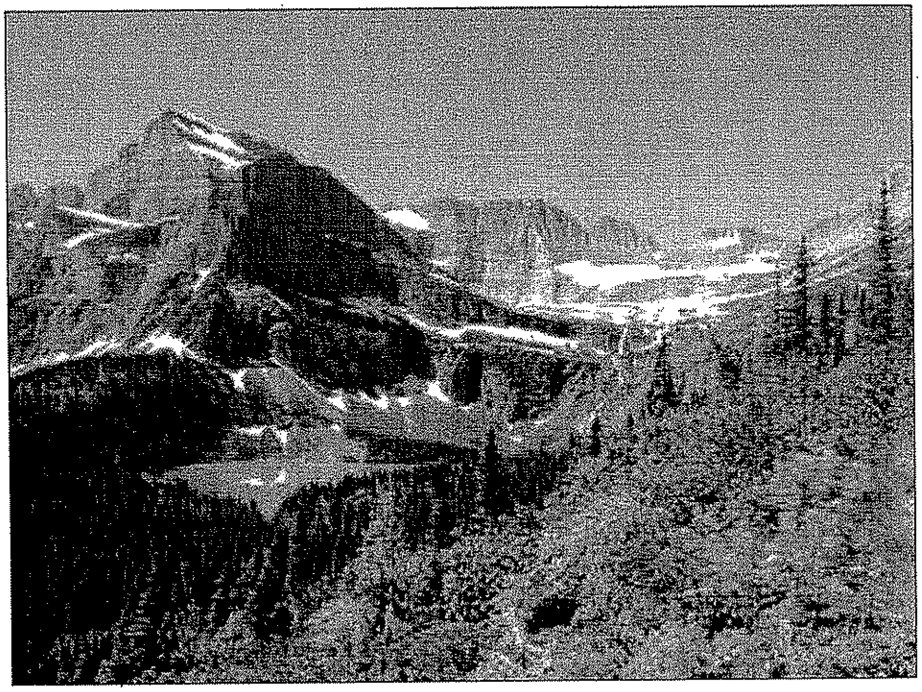
Andy Feury
Mayor of Whitefish, and
Independent lumber broker

Investing in Valley Assets

Recent trends suggest that the next decade will bring many more people to Flathead County. To sustain the appeal that is at the heart of the Flathead's economic vitality, the fundamental assets of community character and environmental quality need to be protected and enhanced.

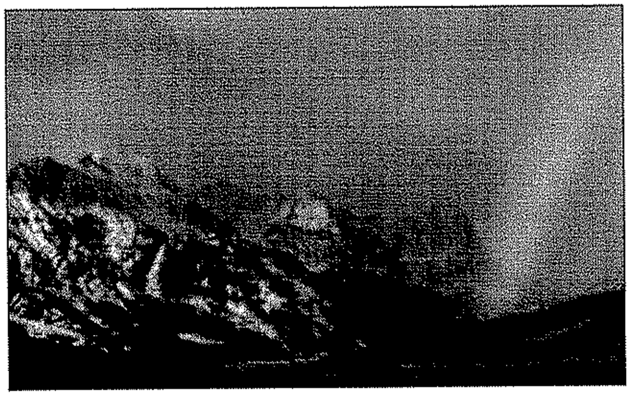
Recent trends suggest that Flathead County will see a continued influx of new residents, attracted by the area's outdoor amenities and quality of life. The economy will continue to grow, diversify, and add high-paying jobs. Yet many fear that a growing population may accelerate changes that erode the area's attractiveness.

The character of the Flathead's communities and its environmental qualities are at the heart of its appeal and economic vitality. Investing money, time, energy, and thought into protecting and enhancing these assets is an investment in the future.



Blackfeet Indians called Glacier's rugged spine the Backbone of the World. George Bird Grinnell, an early proponent of Glacier's park designation, called this region the Crown of the Continent.

PHOTO: KAREN NICHOLS



AN EXPLANATION OF TERMS

Amenity — A quality or feature that adds perceived economic value.

Gateway community — A town or group of towns that provides access to public lands such as national parks, as well as services for visitors to these natural areas.

Inflation-adjusted (real) dollars — Since the value of money changes over time due to inflation, economists account for these changes in their analyses. In this report, real dollar amounts are reported in "1996 dollars," which means that figures from years other than 1996 are adjusted to remove the effects of inflation, providing a true base of comparison.

Median income — This can be calculated for individuals, families, or households. To arrive at median family income for an area, imagine listing all of the families in that area according to the total amount of money they receive each year from all sources. The income figure in exactly the middle of that list is the median family income.

Net migration — The difference between the number of persons moving to an area and the number moving away, and considers only persons changing their permanent residence.

Natural change — The difference between the number of births and the number of deaths in a locality.

Per capita income — This is the average income per person in an area, calculated by adding all income received by all residents of an area, regardless of age, and dividing this total by the number of area residents.

Poverty rate — A U.S. Census Bureau calculation of the percentage of a population living at income levels below those deemed necessary for basic sustenance. No consideration is given to variations in the local cost of living in making poverty estimates.

Qualitative growth — Economic expansion and change that improves the well-being of area residents and protects valuable assets.

Quantitative growth — Expansion in the size of an area's economy, seen in indicators such as population growth and increasing numbers of jobs and total income.

Sector, Sub-sector — A "sector" is one of 14 major categories into which economic activity is divided. Sectors include manufacturing, construction, services, retail trade, local government, farm and ranch producers, and eight other categories. A "sub-sector" is a smaller economic division within a sector. For example, the "services" sector is comprised of activity in a number of areas including health care, business services, legal services, engineering and management services, auto repair, and so forth.

Total personal income — All money received from all sources by all individuals and households in an area.

Unemployment rate — The number of people who are not employed but who are actively seeking work, expressed as a percentage of the total adult population that is capable of working.

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We appreciate the guidance and valuable contributions of the following people:

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Independent Lumber Broker,
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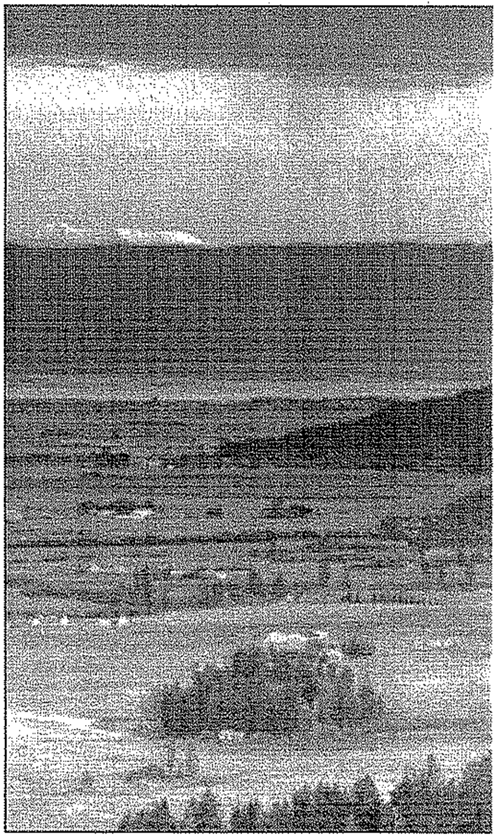
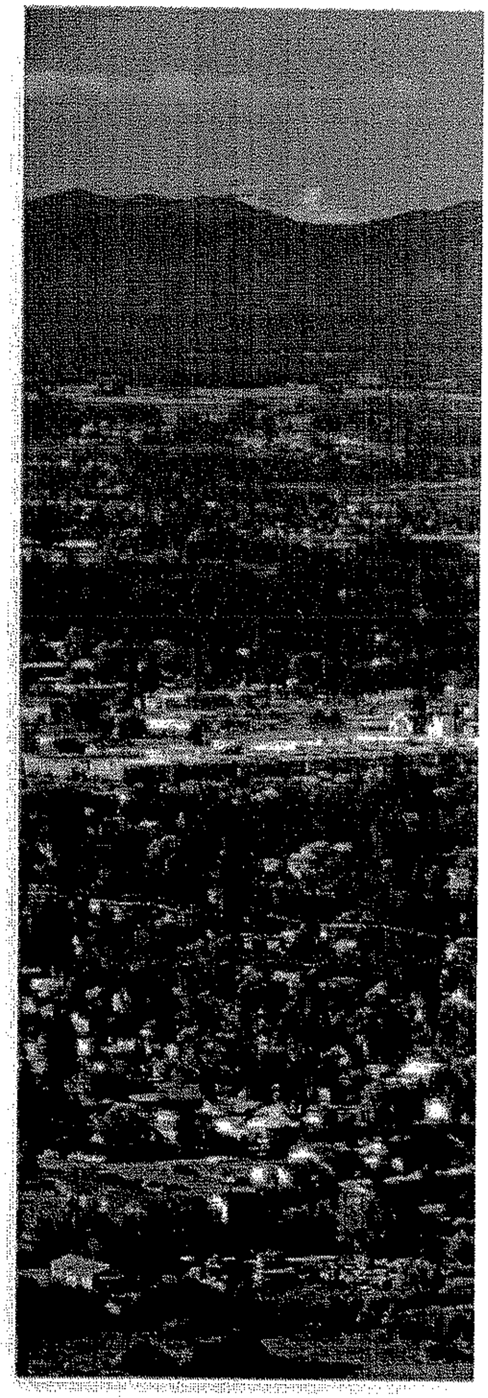


Flathead Lake near Somers

PHOTO: KAREN NICHOLS

Gateway to Glacier

The Emerging Economy of Flathead County



National parks exert a powerful pull on the American people. They rejuvenate us and they preserve our cultural and natural wonders. Every year, tens of millions of Americans visit our national parks.

But from an economic perspective, national parks do much more than draw visitors. Today, Americans in growing numbers choose to locate their families and businesses in gateway communities next to our national parks.

Growth brings change and change brings challenges. Fortunately, many gateway communities are forming creative partnerships to ensure that growth does not degrade the natural environment and community character that make these places so special.

—Tom Kiernan,
President, National Parks Conservation Association

National Parks Conservation Association

Protecting Parks for Future Generations®

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cpc #86

- Winter Use Plan EIS on Over-snow Vehicle Noise, Yellowstone and Grand Teton National Parks, WY
- Watercraft Noise Studies, Glen Canyon National Recreation Area, AZ & UT
- Overflight Noise Model Validation, Grand Canyon National Park, AZ
- Development of National Park Soundscape Management Plan, NPS, USDOI

Highway Projects

- Development and Implementation of the Traffic Noise Model (TNM) Acoustical Algorithms, Federal Highway Administration.
- I-495 Capitol Beltway Widening EIS Noise Analysis, Fairfax Co., VA
- I-95 / I-395 / I-495 Springfield Interchange Noise Barrier Designs, Springfield, VA
- U.S. 101 Traffic Noise/Absorptive Material/Pavement Evaluation, Marin Co., CA
- Woodrow Wilson Bridge (I-95) Replacement EIS Noise Analysis, VA, DC, & MD
- Dallas North Tollway System-wide Noise Abatement Study, Dallas, TX
- Massachusetts Turnpike System-wide Noise Barrier Priority Program, MA

Airport Ground Noise Projects

- Portland International Airport Engine Run-up Enclosure Design and Testing, OR
- Logan Airport Many Ground-operations Noise Studies, 1978-2003, MA
- Pease International Jetport Engine Run-up Enclosure Design, NH
- LaGuardia Airport Western Boundary Noise Barrier Design, NY

Representative Publications and Presentations

- “Noise Data from Snowmobile Pass-bys: The Significance of Frequency Content,” Society of Automotive Engineers paper no. 2002-01-2765, SAE International Publication SP-1726, 2002.
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CPC# 87

Nicholas P. Miller

President

Professional Experience

1989 to Present	Harris Miller Miller & Hanson Inc., President
1981 to 1989	Harris Miller Miller & Hanson Inc., Vice President
1973 to 1981	Bolt Beranek and Newman Inc., Consultant and member Senior Technical Staff
1969 to 1973	U. S. Air Force, ICBM Missile Launch Officer
Summer 1968	Atlantic Research Corp., VA, Machinery Design Engineer
Summer 1967	Westinghouse Research, Pittsburgh, Heat Transfer Design Engineer
Winter 1966	Massachusetts Institute of Technology, Research Assistant in Pulsatile Fluid Dynamics
Summer 1965	Sulzer Brothers, Switzerland, Machine Shop Apprentice
Summer 1964	The John Hopkins University, Laboratory Assistant in Experimental Acoustics

Education

M. S. (Mechanical Engineering), University of North Dakota, 1974
The School of Advanced International Studies, Washington, D.C., 1967-1969
Massachusetts Institute of Technology, 1966-1967
B. E. S. (Mechanics), The Johns Hopkins University, 1966

Affiliations

Member, Acoustical Society of America
Member, Institute of Noise Control Engineering
Member, Society of Automotive Engineers, Committee A-21, Aviation Noise
Member, Pi Tau Sigma, Tau Beta Pi, Delta Phi Alpha

Experience

A co-founder and the president of Harris Miller Miller &Hanson Inc., Mr. Miller is also responsible for project management and marketing of consulting services in aviation and other noise related studies.

Mr. Miller started his work in environmental acoustics in 1970 at the University of North Dakota, completing a Master's Thesis based on scale modeling of sound propagation in urban canyons. In 1973, he began working at Bolt Beranek and Newman Inc. in highway noise and regulatory acoustics. He worked with the U.S. EPA, the Federal Highway Administration and several state agencies analyzing, developing and implementing noise control laws and regulations. He also worked extensively on highway traffic noise problems, conducting measurements and analyses for state departments of transportation. He has assisted in providing litigation support for issues related to noise annoyance and noise takings related to highway, aircraft and racetrack noise.

He began aviation noise work by measuring, modeling and assessing the noise of aircraft ground operations, then moved into full analysis of flight operations for the State of Maryland, for other airports and for the Navy. Helping to found Harris Miller Miller & Hanson Inc. in 1981, he devoted full time to aviation noise. He has since worked on most aspects of aviation noise and vibration, from assessing the effects of aircraft noise on building vibration, to environmental studies of new or lengthened runways, to computer model validation and refinement, to quantifying the effects of aircraft overflights on national parks.

Representative Projects

- Comprehensive Acoustical Services, Baltimore Washington International Airport (MD) (1985 to Present)
- Evaluation of Effects of Noise Sources in National Parks, National Park Service (Multiple National Parks) (1991 to Present)
- Evaluation of INM Accuracy Using Radar and Noise Monitoring Data, NASA (1999)
- Analysis of Mitigation Measures for Military Aircraft Overflights at National Parks, USAF (1999)
- Evaluation of Low Frequency Aircraft Departure Noise, FAA, (MD) (1998)
- Naval Air Station Aircraft Noise Studies, U.S. Navy (~60 facilities) (1982 to 1996)
- Effectiveness of Noise Barriers on Departure Noise, Ft. Lauderdale (FL) (1994)
- Building Code Provisions, Memphis-Shelby County (TN) (1992)
- Health Effects of Noise, Transport Canada (1991)
- Management of Air Operations EIS, NAS Whidbey Island (WA) (1989)
- Noise Measurements, Noise Barrier Feasibility Study, William P. Hobby Airport (TX) (1987)
- Noise Analysis of Blue Route, I-476, for Township of Nether Providence (PA) (1986)
- Noise Analysis / Barrier Feasibility, Maryland Route 100 Environmental Analysis (MD) (1986)
- Part 150 Study, Noise Barrier Design, Portland International Jetport (ME) (1986)
- Noise Measurements and Analysis, Rickenbacker Airport (OH) (1985)

TECHNICAL SUPPORT AND TESTIMONY FOR LITIGATION

Case: Salamanca District Hospital v. State of New York (1980)

Analysis of New York Southern Tier Expressway traffic on Salamanca District Hospital
Client: New York State Department of Law
Attorney: Carl Rosenbloom, New York State Department of Law

Case: Gardner, et al. v. State of Maryland (1991)

Description of methods used to analyze aircraft noise and to develop Noise Abatement Plan. Qualified as expert in Circuit Court of Anne Arundel County, Maryland.
Client: Eccleston and Wolf for Baltimore/Washington International Airport
Attorney: Charles Martinez, Eccleston and Wolf. (410) 752-7474

EXAMPLES OF TESTIMONY IN OTHER MATTERS

Matter: Administrative Action against the Maryland Aviation Administration for alleged failure to follow administrative procedures in establishment of Airport Noise Zone and other matters (1992)
Provided expert testimony at formal hearing regarding details of development of noise zone, noise metrics and methods.
Client: Maryland Aviation Administration
Attorney: Louisa Goldstein, Assistant Attorney General, Council to Maryland Aviation Administration. (410) 859-7066

Matter: Public hearings for proposed runway extension at Baltimore/Washington International Airport (1988)
Testimony on noise effects of runway extension
Client: Maryland Aviation Administration

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July 9, 2004

Cheryl A. Roberts
The Law Office of Marc S. Gerstman
313 Hamilton Street
Albany, New York 12210

Subject: HMMH Review of Materials Related to Sound Impact Study, Proposed Belleayre Resort

Reference: HMMH Project Number 300350

Dear Cheryl:

We have reviewed pages 3-170 through 3-176 and Appendix 22 of the Draft Environmental Impact Statement for the Belleayre Resort at Catskill Park, dated September 2003. These documents describe the Sound Impact Study conducted for the proposed Belleayre Resort. The pages summarize the detailed study described in the appendix, which addresses sound measurements and the construction noise analysis. The pages also discuss possible noise impacts that could result from operation of the resort once it is completed. The methods used are well documented and appear to be in conformance with procedures contained in various New York State and Federal documents. We understand that Mr. Peter J. Smith offered his opinion on behalf of the Catskill Preservation Coalition ("CPC") concerning the applicant's compliance with the Department of Environmental Conservation's Policy concerning assessing noise impacts. We do not offer our opinion on those issues. In general, limited impacts were found during construction and none during operation of the resort.

After conducting this review, we believe there are some potentially significant impacts that have not been mentioned or addressed. Primarily, we understand that the proposed project is near on state lands that have been designated as wilderness or wild forest in which "solitude" is recognized as an important value. Our 14 years of work for the U.S. National Park Service have identified specific methods that can be employed in order to assess the effects intruding sounds can have on values of solitude, interpreted as freedom from sounds produced by human activities.[1] These methods have

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[1] Our methods have been developed, applied and described for several studies. Among these are:
•Menge, C.W., *et al*, "Technical Report on Noise: Personal Watercraft and Boating Activities at Glen Canyon National Recreation Area," HMMH Report No. 295860.370, October 2002. [The results of this study are summarized in: U.S. National Park Service, "Final Environmental Impact Statement, Personal Watercraft Rulemaking, Glen Canyon National Recreation Area."
•Harris Miller Miller & Hanson Inc., "Technical Report on Noise: Winter Use Plan Final Environmental Impact Statement for Yellowstone and Grand Teton National Parks and John D. Rockefeller, Jr. Memorial Parkway," HMMH Report No. 295860.18, June 2001.
•Menge, C.W., "Measurement and Modeling of Snowmobile Noise and Audibility at Yellowstone and Grand Teton National Parks," paper no. 2aNSa8, proceedings of Noise-Con 2000, Congress on Noise Control Engineering, Newport Beach, CA, Dec. 2000.

been developed through extensive measurements made in parks, both of sounds and of visitor reaction to intruding sounds.[2]

In general, in locations where solitude or freedom from human produced sounds is important, the analysis must be based on the concept of audibility of intruding sounds. There is a well-established method for computing when humans with normal hearing can "detect" an intruding sound in the presence of other sounds.[3] To conduct this audibility analysis, as was done for the studies listed in footnote 1, the frequency content or spectrum of both the background "ambient" sound and of the intruding sound must be known. This method for evaluating the audibility of sound in sensitive locations, like wilderness areas, goes beyond the traditional methodology for assessing noise impacts set forth in the methodology employed by the Department of Environmental Conservation. Audibility of an intruding sound occurs when there is sufficient sound energy in the intruding sound to approximately equal the sound energy of the ambient sound. The important point is that this relationship need take place at only a single or few frequencies for a human to hear and recognize the intruding sound. (Use of a single metric, such as A-weighted sound levels does not permit this analysis.) The DEIS does not assess these potential impacts.

We expect that ambient sound levels in the wilderness areas would be quite low. Hence both construction activities and any operations at the resort, such as powered cutting of greens, tees and fairways, aeration, powered application of herbicides, fungicides and insecticides on golf course turf, etc., could be audible at considerable distances into the wilderness areas.[4] This concept of hearing one intruding sound in the presence of background sound is illustrated in Figure 1. This figure shows the frequency content of background sounds in Yellowstone National Park, of a snowmobile at 3000 feet distance, and of the human "auditory system noise." The background sound plus the human hearing system make up the total "noise" that affects whether or not an intruding sound can be heard. In this example, the snowmobile produces sound in a narrow frequency range at about 200 Hz (Hertz or cycles per second). Under such conditions, a human can "detect" or hear the snowmobile even though it is over half a mile distant and relatively quiet.

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[2] •Anderson, G.S., *et al*, "Dose-Response Relationships Derived from Data Collected at Grand Canyon, Haleakala and Hawaii Volcanoes National Parks," NPOA Report No. 93-6, October 1993.
•Miller, N.P., "The effects of aircraft overflights on visitors to U.S. National Parks," Noise Control Eng. J. 47 (3), 1999 May-Jun.
•Miller, N.P., "Acoustic Data Collected at Hawaii Volcanoes National Park," HMMH Report No. 295860.341, September 2003.

[3] For a description of this concept, see:
•Miller, N.P., "Aircraft Noise Model Validation Study," Appendix C, HMMH Report No. 295860.29, January 2003. This study, in its entirety is available from NPS at
http://www.nps.gov/grca/overflights/documents/anmvs/index.htm

[4] It is possible that snowmobiles may be used for various recreational, administrative or operational functions at the resort. This use would introduce an additional dimension of potential noise impact in the winter months. It is also possible that the golf clubs / resort may occasionally, or even as a matter of course, provide the venue for outdoor dances, wedding receptions or other celebrations. These, if very occasional, may be of little concern, though they could be louder than any of the other regular club noise producing activities.

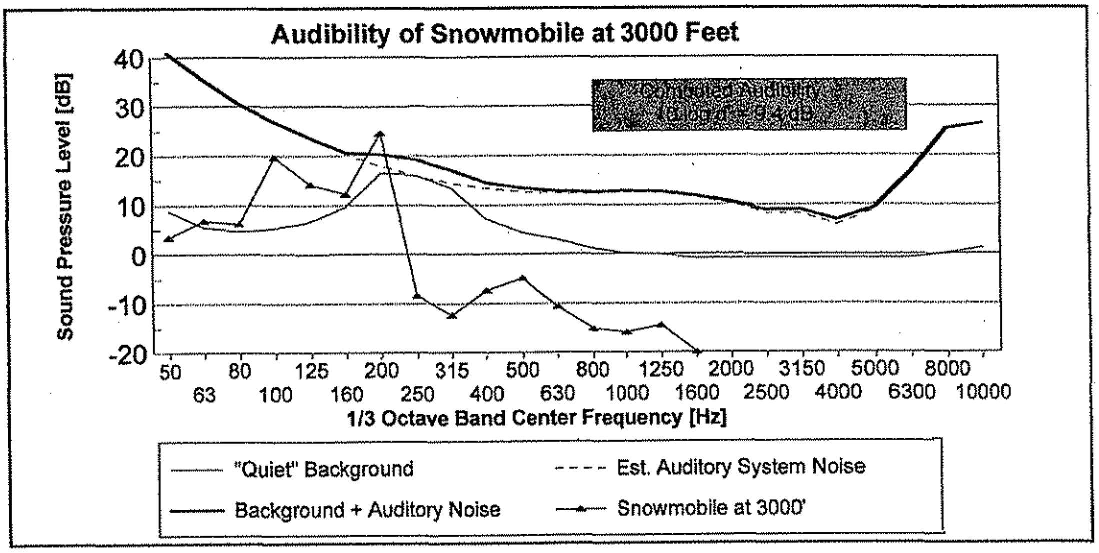

Figure 1 Graphic Example of Audibility

With knowledge of the general schedule of construction and grounds maintenance, of source levels (by frequency), and of ambient levels (by frequency), the methods developed for the U.S. NPS can be applied to provide information for judging the audibility of these activities in the forest and wilderness areas.

Be forewarned, however, that there are no established guidelines for when intruding sounds are acceptable or unacceptable. The only clear case of intrusion criteria has been established by NPS for the Grand Canyon and aircraft overflights. For this situation, Congress directed the Secretary of the Interior to develop actions for aircraft overflights that would "...provide for substantial restoration of the natural quiet and experience of the park...."[5] NPS responded by deciding that "...substantial restoration requires that 50% or more of the park achieve 'natural quiet' (i.e., no aircraft audible for 75-100 percent of the day."[6] The type of analysis we have developed, if applied to the proposed resort, would yield information about how much of the time intruding sounds might be audible and how far into the wilderness they might be audible. Judgments would then have to be made as to the acceptability of these anticipated intrusions.

We understand that New York State's Environmental Quality Review Act or SEQRA requires that significant adverse environmental impacts be evaluated in order to determine whether they can be mitigated or avoided to the maximum extent practicable consistent with social, economic and other essential considerations. Without suggesting the results of such a noise impact evaluation, it seems to us that the potential audibility impacts can and should be assessed in order to determine whether the wilderness experience provided by the Forest Preserve wilderness and wild forest lands will be adversely impacted.

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[5] Public Law 100-91, August 18, 1987.

[6] U.S. Department of the Interior, National Park Service, "Report on Effects of Aircraft Overflights on the National Park System," July 1995.

We hope this review and comment is of value. Please contact Chris Menge or me of our firm should you wish to discuss these concepts or have additional information.

Sincerely yours,

HARRIS MILLER MILLER & HANSON INC.

Nicholas P. Miller
Senior Vice President

cc: C.W. Menge
file

APPENDIX C. AUDIBILITY AND AMBIENT LEVELS

C.1 Introduction

This appendix provides background information about audibility and the associated detection theory as applied in this study. Congress tasked NPS and FAA with developing a plan for tour aircraft use of Grand Canyon airspace that will succeed in "substantially restoring the natural quiet in the park"[72] and NPS defined substantial restoration of natural quiet as occurring when "50% or more of the park achieve[s] 'natural quiet' (i.e., no aircraft audible) for 75 – 100 percent of the day."[73] Hence, determination of success in substantial restoration of natural quiet must address tour aircraft audibility.

C.2 Audibility and Detection Theory

C.2.1 Concept

In its simplest form, audibility occurs when an attentive person of normal hearing acuity listens and can hear a tour aircraft. Detection occurs because humans have the ability to distinguish changes in sound level in narrow frequency regions. These narrow regions correspond approximately to 1/3-octave bands, where an octave is a doubling of frequency. Hence, when the sound level in one or two 1/3-octave bands starts to increase above previous levels, human hearing is capable of identifying this increase and identifying the source, if it is a familiar one. This listening approach was used during the logging at the audibility sites.

However, in order to calculate when an aircraft is likely to be heard, algorithms that use measurable sound quantities are required. There exist well-developed mathematical relationships that reliably predict when human hearing can identify a "target" source in the presence of background "noise".[74] These relationships are based on the results of the testing of human subjects, and use frequency information of both the source to be detected and of the noise that covers or "masks" that source.

C.2.2 Calculation

These auditory signal detection calculations compare the *source sound levels* with the *background or ambient sound levels* and with the human threshold of hearing by frequency in 1/3-octave bands. The metric of audibility is called d' ("dee prime"), and the metric used in this study is the Detectability Level, abbreviated D'L computed as 10 log (d'). In essence, d' is the root-mean-square sum of the signal to noise ratios across all 1/3-octave bands, each adjusted for bandwidth and for frequency-specific human hearing characteristics, see Eq. 7 below. More generally, d' is a ratio of the sound intensity of the source to the sound intensity of the background, and 10 log (d') is a decibel representation of that ratio. Generally, sounds become audible in a laboratory setting when 10 log (d') is between 1 and 3 dB. In a park setting, early research showed that listeners were hearing tour

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[72] Public Law 100-91, August 18, 1987, § 3. (b) (3) (A).

[73] U.S. DOI, National Park Service, "Report on Effects of Aircraft Overflights on the National Park System," Report to Congress, July 1995, Section 9.2.1, p. 182.

[74] See for example, Green, David M. and J. A. Swets, "Signal Detection Theory and Psychophysics," Peninsula Publishing, 1988.

aircraft on average when 10 log (d') equaled approximately 7 dB,[75] and this value was used in the spectral models (spectral INM, NODSS and NMSIM) to compute when aircraft were audible.[76]

The basic d' equation for a single frequency band is:

$$d' = \eta \times \frac{S}{N} \sqrt{BW} \tag{7}$$

Where:

η is frequency dependent and is a measure of human hearing sensitivity with respect to an ideal detector, but is approximately 0.4 for most frequencies,
BW is the bandwidth at the 1/3-octave band frequency in question,
S is the signal energy in the 1/3-octave band, and
N is the noise energy in the 1/3-octave band.

C.2.3 Special Considerations Regarding Background Sound Levels

As part of the sound level analysis of the recorded data tapes, a detailed analysis of the sound levels measured when aircraft were not present revealed that, for some periods and locations in the Canyon, natural ambient sound levels are significantly below the threshold at which a human with normal hearing could detect a sound. Hence, to apply the detection calculations simply to the measured aircraft sound levels and the measured ambient sound levels would, in these quiet periods / locations, falsely indicate when the aircraft would be audible. In determining the measured ambient levels to be used for modeling, these quiet period ambients were therefore adjusted upward by adding to the measured levels an estimate of the human "auditory system noise" derived from an international standard threshold of hearing (ISO 389-7:1996). The next section describes this addition with an example, then tabulates the measured ambients as used in modeling.

C.3 Determining the Measured Ambient Sound Levels

C.3.1 Introduction

Tape recordings made during all audibility logging at 17 sites (1A, 2A, 2D, 3A, 3B, 3D, 4A, 5A, 5B, 6A, 7A, 7C, 8A, 8D, 9A, 9C, 9D, see Figure 22) were used to determine the ambient sound levels during measurements at these sites. One second, 1/3-octave band levels were used to develop the median values (L_{50}) by 1/3-octave band, during morning and afternoon measurement periods. These L_{50} values were adjusted, by frequency, for instrumentation noise and windscreen effects, and then added to the derived auditory system noise. The resulting spectra provided the "measured ambient" for each hour of data collected and modeled at each of the 17 sites.

C.3.2 Reduction of Taped Sound Levels

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[75] Fidell, Sanford, et al., "Evaluation of the effectiveness of SFAR 50-2 in restoring natural quiet to Grand Canyon National Park." NPOA Report No. 93-1, June 23, 1994, p. 55.

[76] In order to provide additional diagnostic information, the audibility logs and the tape recorded sound levels were used to estimate the Detectability Levels, 10 log (d') at which the measurement personnel were operating during data collection. Section C.4 describes the estimation process and presents the resulting empirical values.

Each tape of recorded data (about four hours in length) was processed using a Larson-Davis Model 2900 1/3-octave band analyzer. The frequency range analyzed was 0.8 to 10,000 Hz, and the sound level resolution of the LD-2900 is approximately 1/40th of a decibel. One-second linear averages were obtained every second for the duration of each DAT tape. Each tape's 1/3-octave band time history was stored in a separate file. Using the observer logs for sound source identification, the 1/3-octave band files were analyzed to produce sound level histograms with bin widths of 0.1 dB for each band for sound segments identified as "natural"; that is, for all periods when no human produced sounds were audible. These histograms provided L_{50} values for each 1/3-octave band, for each DAT tape. Note that these L_{50} values apply to the entire tape, so that the derived measured ambients apply to all hours of audibility data collected during that taped period.

C.3.3 Accounting for Instrumentation Noise

Resulting L_{50} sample sizes for "natural" sounds from the nominal 4-hour DAT tapes ranged from 6,000 to 10,000 spectra. The plots of spectral L_{50} values of these spectra are smooth and orderly. Figure 66 shows the relationships of a measured L_{50} spectra, the instrumentation noise floor, and the measured levels corrected for the noise floor. It also shows for reference the ISO threshold of hearing. At the higher frequencies the spectral content is dictated by instrumentation noise (more high-frequency bands are affected when using the 1/2-inch electret microphones than when using the 1-inch low-noise condenser microphones). In general, bands above 1,000 Hz are affected with the 1/2-inch system, and above 5,000 Hz with the 1-inch system. Using the constant-slope of the high-frequency sound levels *vs.* frequency band as a guide, the instrumentation noise curve was extrapolated to lower frequencies and used to correct the mid-frequency bands by energy subtracting the extrapolated L_{50} instrument noise from the measured L_{50} sound levels, as shown in Figure 14. This energy subtraction was not done when the difference between the measured and extrapolated instrument noise became less than 0.5 dB; in those cases, the adjusted ambient was set to a large negative number. In most cases, the sound levels adjusted for instrumentation noise were near the ISO threshold of hearing over some of the range of interest.

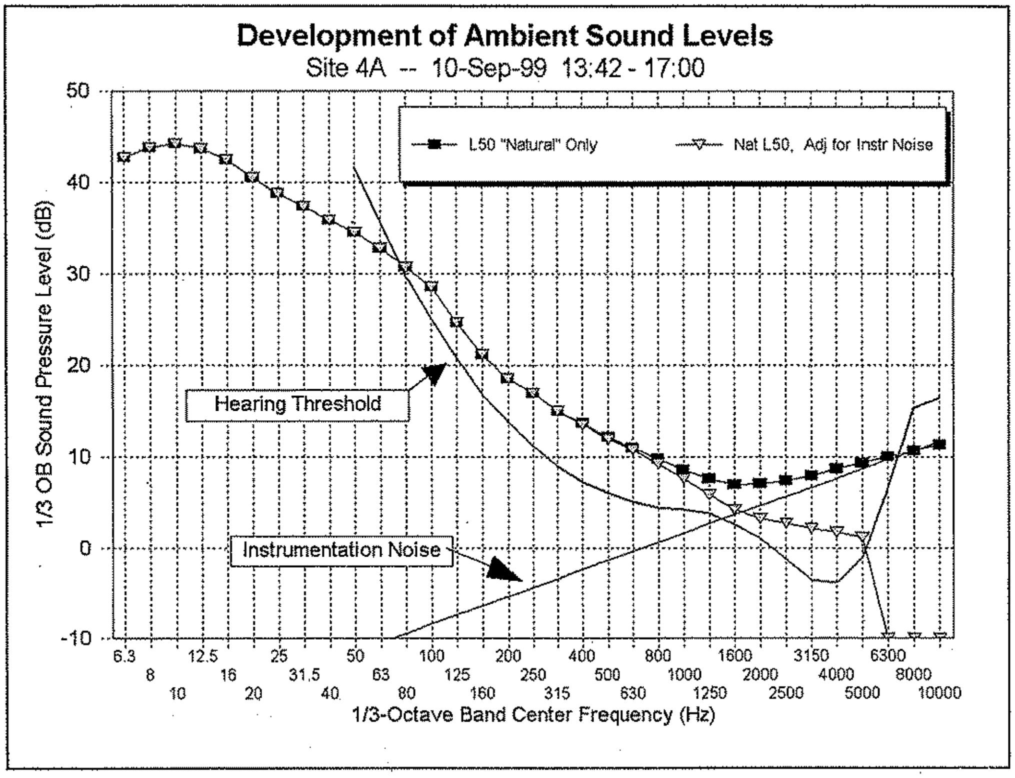

Figure 66. Effect of Instrument Noise Floor Adjustment to Ambient L50

C.3.4 Accounting for Auditory System Noise

Because the adjusted natural L_{50} spectra were often close to or below the ISO human threshold of hearing, an adjustment of the "natural" spectra was required. Without this adjustment, computations of signal to noise level (10 log (d')) could indicate aircraft audibility even when a person with normal hearing would not have detected the aircraft sound.

The assumption was made that the phenomenon controlling the human hearing threshold was a Gaussian masking noise spectrum internal to the human auditory system. This mathematical construct assumes that the reason people can not hear sound levels any lower in level than the threshold of hearing is because there is masking noise in the combined auditory system and brain. Whether this is in fact the case is not important. The important point is that this construct provides a way to mathematically combine the signal (aircraft sound), ambient noise, and hearing threshold, and it does so in a way that yields common sense results under a variety of conditions.

Equation 7 was solved for the 1/3-octave band equivalent auditory system noise, N, using the assumption that S is the ISO pure tone sound level at the threshold of hearing and that d' is about 1.5 in the laboratory conditions in which the ISO threshold was determined.

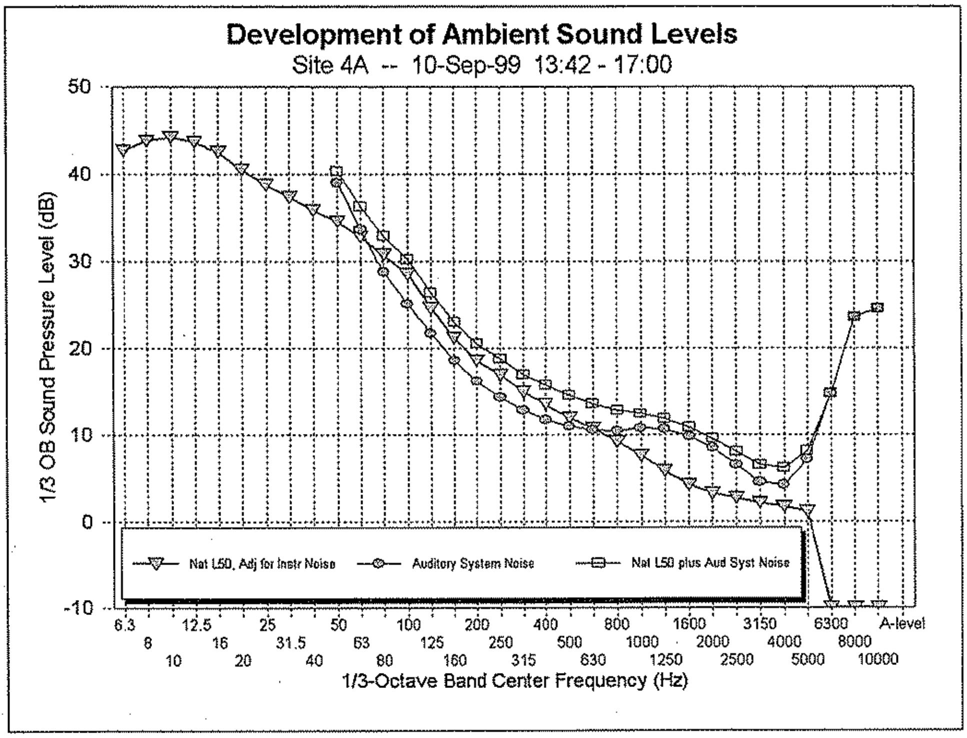

Figure 67. Adjustment of Natural L50 for Auditory System Noise

Figure 67 shows the effect of adding the instrumentation noise adjusted natural L_{50} spectrum energy to the derived auditory system noise energy spectrum. Additional small adjustments were made for microphone / windscreen frequency response. The resulting adjusted summations were used for the "measured ambient" in the modeling. In general, at the lower frequencies the total was controlled by the measured ambient, and at higher frequencies the total was controlled by the equivalent auditory system noise. It should be noted that, in detection of tour aircraft, the important energy generally lies somewhere between 100 Hz and 300 Hz, and hence, these are the frequency bands in which the ambient levels are most important; the exact levels in the higher bands are not significant in computing detectability of current rotor or propeller powered tour aircraft. (Section C.4, below, provides an example of the relationship between aircraft spectrum, ambient spectrum and 10 log (d').)

Additionally, a second set of spectra were provided for modeling, referred to as the "ambient plus 10 dB." These spectra were derived by increasing the auditory system noise 10 dB and then recalculating the energy sum again using the instrument noise adjusted natural L_{50} spectra. This second ambient was used to assess the sensitivity of the models to assumptions about background sound levels.

C.3.5 Resulting Ambient Levels for Modeling

The tables on the following pages give the measured ambient L_{50} spectra (adjusted for instrumentation noise and auditory system noise) for each of the audibility sites where DAT recordings were made. The columns identify the site, the date of the measurement, the time at which the measurement began, and the L_{50} sound pressure levels in each listed 1/3-octave band. The last two columns provide first the A-weighted value for the instrumentation noise (and microphone/ windscreen) adjusted spectrum, and second the A-weighted value for the instrumentation and auditory system noise adjusted spectrum. Because auditory system noise would likely control the A-weighted level due to the high levels above about 4,000 Hz, see Figure 67, these last A-weighted values are based on the 1/3-octave band levels up to 3,150 Hz only.

Site	Date	Start Time	1/3- Octave Band Center Frequency >>>>>>>>>>>>>>>>>>>														
			40 (dB)	50 (dB)	63 (dB)	80 (dB)	100 (dB)	125 (dB)	160 (dB)	200 (dB)	250 (dB)	315 (dB)	400 (dB)	500 (dB)	630 (dB)	800 (dB)	1000 (dB)
1A	9/12/1999	8:54:00 AM	44.9	39.2	34.3	30.7	27.4	24.6	21.8	19.9	17.5	16.1	14.7	14	14	13.4	13.1
1A	9/12/1999	12:57:00 PM	44.9	39.2	34.2	30	26.5	23.1	20.3	18.6	16.3	14.2	13.7	12.8	12.6	12.3	12.3
2A	9/10/1999	10:38:00 AM	45	39.4	34.9	31.7	28.5	25.7	23.2	21	19.2	17.8	16.7	15.6	15	14.5	13.8
2A	9/10/1999	3:20:05 PM	45.1	39.8	35.5	33	30.9	29	26.8	24.2	21.7	20.1	18.6	17.6	16.4	15.5	14.9
2D	9/13/1999	8:00:01 AM	44.9	39.1	34	29.6	26.2	23.3	19.6	17.6	15.6	14.5	13.9	12.9	12.1	11.7	11.7
2D	9/13/1999	1:00:00 PM	44.9	39.2	34.1	30	26.3	22.7	19.6	17.3	15.5	13.8	13.1	12.4	11.7	11.4	11.5
3A	9/10/1999	9:32:15 AM	45	39.7	35.7	32.7	30.9	30.8	30.8	29.9	29.6	29.6	29.2	28.6	27.8	27.2	26.4
3A	9/10/1999	12:58:15 PM	45	39.5	35.2	32.1	30.3	30.3	30.4	29.5	29.5	29.5	29.2	28.7	28	27.2	26.1
3B	9/12/1999	7:59:30 AM	44.9	39.2	34.3	30.5	27.7	25.5	23.6	22.2	21	20	18.5	17.5	16	15.2	14.7
3B	9/12/1999	1:01:15 PM	44.9	39.1	34.1	29.9	27	24.8	22.7	21.4	20.1	19	17.6	16.5	15.2	14.4	13.9
3D	9/13/1999	7:58:45 AM	44.9	39.1	33.9	29.2	25.8	22.6	19.6	17.7	16	14.8	14.3	14.2	14.6	15	15.4
3D	9/13/1999	1:00:00 PM	44.9	39.1	33.9	29.3	25.9	22.6	19.6	17.6	16	14.7	14.2	14	14.3	14.6	14.9
4A	9/10/1999	8:00:15 AM	45.6	41	37.4	34.3	31.4	27.5	23.9	21	18.9	16.6	14.7	12.2	10.5	10.4	10.7
4A	9/10/1999	1:42:10 PM	45.4	40.4	36.3	32.9	30.2	26.4	23	20.5	18.7	16.9	15.6	14.3	13.3	12.4	12
4A	9/12/1999	8:00:02 AM	45.9	41.2	37.5	34.9	32	28.3	25.3	23.4	22	20.7	19.8	18.3	17.1	16.1	14.9
4A	9/12/1999	1:00:30 PM	45.1	39.7	35.3	31.9	29	25.5	22.8	20.7	19.1	17.4	16.2	14.9	14	13.4	13.1
4A	9/13/1999	8:00:01 AM	45.5	40.3	35.8	32	28.9	25.8	22.2	20.2	18.6	16.9	15.7	14.1	13	12.4	12.1
4A	9/13/1999	1:00:00 PM	45	39.5	34.8	30.8	27.8	24.1	21.1	18.9	17	15.4	14.3	13.1	12.1	11.5	11.4
5A	9/12/1999	8:00:15 AM	44.9	39.2	34.2	30	27.1	23.7	20.2	17.7	15.7	13.7	12.6	11.6	10.9	10.8	11.1
5A	9/12/1999	1:01:40 PM	44.9	39.2	34.2	30	26.8	23.5	20.3	17.8	15.8	14.1	13	11.9	11.2	11.1	11.2
5A	9/13/1999	8:00:15 AM	44.9	39.1	34	29.5	26.1	23	20.1	18	16.2	14.8	13.8	12.8	11.9	11.5	11.6
5A	9/13/1999	1:00:15 PM	44.9	39.2	34.1	29.7	27	24.3	21.4	19.6	18.3	17.7	17.5	17	16.1	15	14.1
5B	9/10/1999	8:16:30 AM	44.9	39.3	34.5	30.3	26.8	23.8	21.7	22	23.7	25.6	26.8	27	26.1	24.3	21.2
5B	9/10/1999	1:00:20 PM	45	39.3	34.6	30.4	27.1	24	22.2	22.7	24.7	26.8	28.3	28.9	28.6	27.5	24.7
6A	9/10/1999	8:01:30 AM	45.1	40	36.3	32.5	31.3	26.9	26	24.8	22.1	21.2	21.2	20.4	19.9	19.4	17.5
6A	9/10/1999	1:00:15 PM	45.1	40	36.4	34.1	32.6	29.2	26	24.2	22.2	21.7	21.9	21.6	21.3	20.8	18.8
6A	9/12/1999	8:00:15 AM	45	39.3	34.5	30.7	27	23	20.1	17.9	15.7	14.3	14	13.4	13.6	14	13.4
6A	9/12/1999	1:00:15 PM	45	39.8	36.3	33.8	31.2	28.1	23.7	20.6	18.7	17.3	15.4	14.9	14.5	14.7	13.7
6A	9/13/1999	8:00:15 AM	44.9	39.1	34.1	29.8	26.4	22.9	20.6	18.5	16	15	15.2	13.5	13.2	13.1	13
6A	9/13/1999	1:00:15 PM	45	39.5	35.2	32.4	30.4	27.7	25.2	23.3	21.5	20.9	20.8	20.4	20.1	19.8	17.8
7A	9/10/1999	8:01:14 AM	45	39.3	34.3	30	27.3	24.1	21	19.1	17.4	15.8	14.7	13.9	13.3	12.6	12.5
7A	9/10/1999	1:00:00 PM	45.2	40	35.5	31.6	29.2	25.7	22.6	20.6	18.8	17.2	16	15.2	14.3	13.4	13
7B	9/12/1999	8:00:00 AM	45.1	39.6	34.9	31.1	27.9	24.2	21.4	18.8	16.9	14.7	13.1	12	11.2	10.8	10.7
7B	9/12/1999	12:59:00 PM	44.9	39.3	34.2	29.7	26.4	23	20.1	18	16.6	15.1	14.1	13.4	12.8	12.5	12.5
7C	9/13/1999	8:00:00 AM	45	39.3	34.3	29.8	26.5	23.3	20.5	18.4	16.7	15.5	14.5	13.5	13.3	12.9	12.7
7C	9/13/1999	1:00:30 PM	45	39.4	34.4	29.9	26.6	23.2	20.5	18.6	17.2	15.9	14.9	14.1	13.7	13.1	12.9
8A	9/10/1999	1:45:30 PM	45.2	40.3	36.7	34.1	31.9	29.4	27.1	25.6	24.9	24.4	24.5	25.4	25.6	25.1	24.6
8A	9/10/1999	1:45:30 PM	45.2	40.3	36.7	34.1	31.9	29.4	27.1	25.6	24.9	24.4	24.5	25.4	25.6	25.1	24.6
8A	9/12/1999	9:17:30 AM	45	39.5	35.2	32	28.8	24.7	21.2	19	17.4	15.7	14.5	14	12.7	12.3	12.1
8A	9/12/1999	1:22:00 PM	44.9	39.3	34.6	30.8	28.3	24.5	21.3	19.2	17.7	16.1	15.2	14.6	13.3	12.7	12.7
8D	9/13/1999	10:17:30 AM	44.9	39.3	34.5	30.4	27.5	24.4	21.3	18.8	17.8	15.5	14.4	14.8	13.1	12.8	12.8
8D	9/13/1999	10:17:30 AM	44.9	39.3	34.5	30.4	27.5	24.4	21.3	18.8	17.8	15.5	14.4	14.8	13.1	12.8	12.8
9A	9/10/1999	8:00:15 AM	44.9	39.2	34.2	29.8	26.4	23.1	19.8	17.7	15.9	14.4	13.4	12.9	12.2	11.8	11.8
9A	9/10/1999	1:00:15 PM	45	39.4	34.7	31.2	29.5	26.8	25.1	23	21.2	20.2	19.7	18.9	18.3	17.5	16.6
9C	9/12/1999	8:06:15 AM	44.9	39.5	35.3	31.5	29.7	28.2	26.1	25.1	24.2	22.4	20.6	19.2	17.3	16.5	15.4
9C	9/12/1999	1:02:15 PM	45	39.4	35	32.9	32.1	30.9	27.2	25.7	24.8	22.1	20.3	18.8	16.8	15.9	14.7
9D	9/13/1999	8:01:15 AM	44.9	39.3	34.5	31.1	28.9	25.9	22.5	19.5	17.2	15.6	14.3	13.1	12.4	11.4	11.2
9D	9/13/1999	12:59:45 PM	45.9	45.9	42.8	41.2	41.3	38.3	34.7	32.7	31.3	29.2	26.9	25.5	24.9	24	23

Site	Date	Start Time	1/3- Octave Band Center Frequency >>>>>>>>>>>>>>>>>>>>						5000 (dB)	6300 (dB)	8000 (dB)	10000 (dB)	A-lev (dB)	A2-lev (dB)
			1250 (dB)	1600 (dB)	2000 (dB)	2500 (dB)	3150 (dB)	4000 (dB)						
1A	9/12/1999	8:54:00 AM	12.2	10.9	9.2	7.2	5.2	4.9	7.4	14.8	23.6	24.6	19	23.2
1A	9/12/1999	12:57:00 PM	11.7	10.6	9.1	7.1	5	4.6	7.3	14.8	23.6	24.6	16.5	22.5
2A	9/10/1999	10:38:00 AM	12.8	11.4	9.4	7.2	5.1	4.6	7.2	14.8	23.6	24.6	21.1	24.2
2A	9/10/1999	3:20:05 PM	13.7	11.8	9.7	7.3	5.2	4.7	7.3	14.8	23.6	24.6	23.8	25.7
2D	9/13/1999	8:00:01 AM	11.3	10.2	8.8	6.9	5.1	4.9	7.3	14.8	23.6	24.6	15.2	22.2
2D	9/13/1999	1:00:00 PM	11.1	10.1	8.7	6.8	4.8	4.5	7.2	14.8	23.6	24.6	14	22
3A	9/10/1999	9:32:15 AM	24.6	21.9	19	14.5	9.9	8	7.2	14.8	23.6	24.6	34.7	34.9
3A	9/10/1999	12:58:15 PM	24	21	17.5	12.8	8.7	8	9.4	14.8	23.6	24.6	34.5	34.7
3B	9/12/1999	7:59:30 AM	13.6	12.3	10.6	8.5	6.7	7	7.2	14.8	23.6	24.6	22.8	25.1
3B	9/12/1999	1:01:15 PM	12.9	11.6	10	8.1	4.6	4.4	7.2	14.8	23.6	24.6	21.4	24.3
3D	9/13/1999	7:58:45 AM	14.9	14.1	12.6	10.1	7.4	4.4	7.2	14.8	23.6	24.6	21.5	24.4
3D	9/13/1999	1:00:00 PM	14.4	13.3	11.6	9.1	4.6	4.4	7.2	14.8	23.6	24.6	20.5	23.9
4A	9/10/1999	8:00:15 AM	10.6	9.8	8.5	6.6	4.6	4.4	7.2	14.8	23.6	24.6	19.3	23.3
4A	9/10/1999	1:42:10 PM	11.3	10.1	8.6	6.6	4.6	4.4	7.2	14.8	23.6	24.6	19.6	23.5
4A	9/12/1999	8:00:02 AM	13.8	12.5	11.2	9.7	8.5	8.3	9.8	15.3	23.6	24.6	24.9	26.3
4A	9/12/1999	1:00:30 PM	12.7	11.8	10.7	9.4	8.3	8.3	9.9	15.3	23.7	24.6	21.5	24.1
4A	9/13/1999	8:00:01 AM	11.5	10.4	9.1	7.4	5.9	6.1	8.5	15.1	23.6	24.6	19.7	23.4
4A	9/13/1999	1:00:00 PM	11.1	10.1	8.9	7.3	5.7	5.9	8.4	15.1	23.6	24.6	17.2	22.5
5A	9/12/1999	8:00:15 AM	11	10.1	8.7	7.1	6.8	5.2	7.3	14.8	23.6	24.6	14	21.9
5A	9/12/1999	1:01:40 PM	11	10.1	8.8	6.9	5	4.7	7.2	14.8	23.6	24.6	13.9	22
5A	9/13/1999	8:00:15 AM	11.4	10.3	8.8	7	5.7	5	7.3	14.8	23.6	24.6	15.3	22.2
5A	9/13/1999	1:00:15 PM	13	11	9.3	7.3	5.6	4.9	7.2	14.8	23.6	24.6	21.1	24.2
5B	9/10/1999	8:16:30 AM	17.5	14.4	12	10.5	9.3	9.4	9.8	15.1	23.6	24.6	30.9	31.3
5B	9/10/1999	1:00:20 PM	20.8	17	13.4	11	9	8.3	9	15	23.6	24.6	33.4	33.6
6A	9/10/1999	8:01:30 AM	14.5	12	10.1	8.3	6.7	6.6	7.2	14.8	23.6	24.6	26	27.3
6A	9/10/1999	1:00:15 PM	15.3	12.4	10.5	8.5	6.8	6.7	7.2	14.8	23.6	24.6	27.2	28.2
6A	9/12/1999	8:00:15 AM	12.1	10.8	9.4	7.7	6.1	6	7.2	14.8	23.6	24.6	18.3	23
6A	9/12/1999	1:00:15 PM	12.4	11	9.6	8	6.4	6.5	7.2	14.8	23.6	24.6	21.5	24.4
6A	9/13/1999	8:00:15 AM	12	10.9	9.5	7.8	6	6	7.2	14.8	23.6	24.6	18	22.9
6A	9/13/1999	1:00:15 PM	14.5	11.9	10	8.1	6.3	6.5	7.2	14.8	23.6	24.6	25.9	27.2
7A	9/10/1999	8:01:14 AM	12.2	11.2	10	8.4	6.7	6.4	7.2	14.8	23.6	24.6	18.7	23.1
7A	9/10/1999	1:00:00 PM	12.4	11.3	10	8.3	6.2	4.4	7.2	14.8	23.6	24.6	20.6	23.9
7B	9/12/1999	8:00:00 AM	10.6	9.8	8.5	6.6	4.6	4.4	7.2	14.8	23.6	24.6	14.9	22.1
7B	9/12/1999	12:59:00 PM	12.1	11.2	9.9	8.2	6.4	4.4	7.2	14.8	23.6	24.6	17.7	22.8
7C	9/13/1999	8:00:00 AM	12.4	11.6	10.4	8.8	7.4	7.1	8.7	14.8	23.6	24.6	19	23.1
7C	9/13/1999	1:00:30 PM	12.5	11.5	10.2	8.5	6.7	6.3	7.2	14.8	23.6	24.6	19.1	23.2
8A	9/10/1999	1:45:30 PM	22.2	19.7	16.4	13.4	9.9	7.4	8	14.8	23.6	24.6	32	32.3
8A	9/10/1999	1:45:30 PM	22.2	19.7	16.4	13.4	9.9	7.4	8	14.8	23.6	24.6	32	32.3
8A	9/12/1999	9:17:30 AM	11.6	10.5	8.9	6.8	4.8	4.3	7.2	14.8	23.6	24.6	18	22.9
8A	9/12/1999	1:22:00 PM	12.2	10.9	9.2	7.1	4.9	4.4	7.2	14.8	23.6	24.6	18.7	23.2
8D	9/13/1999	10:17:30 AM	12.5	11.4	9.6	7.4	5.3	4.7	7.2	14.8	23.6	24.6	18.8	23.2
8D	9/13/1999	10:17:30 AM	12.5	11.4	9.6	7.4	5.3	4.7	7.2	14.8	23.6	24.6	18.8	23.2
9A	9/10/1999	8:00:15 AM	11.4	10.4	8.9	7	5	4.6	7.2	14.8	23.6	24.6	15.4	22.2
9A	9/10/1999	1:00:15 PM	15	13	10.5	8	5.6	4.9	7.3	14.8	23.6	24.6	24.6	26.3
9C	9/12/1999	8:06:15 AM	13.7	11.5	9.2	6.8	4.6	4.3	7.1	14.8	23.6	24.6	24.8	26.4
9C	9/12/1999	1:02:15 PM	13.2	11.1	9.1	6.9	4.8	4.5	7.2	14.8	23.6	24.6	25	26.5
9D	9/13/1999	8:01:15 AM	10.8	9.9	8.5	6.7	4.8	4.7	7.3	14.8	23.6	24.6	17	22.6
9D	9/13/1999	12:59:45 PM	21.9	19	16.6	15.2	15.5	17.8	20.4	18.7	24.2	24.6	34.2	34

C.4 Empirically Determined Values of Detectability Level

C.4.1 Introduction

As part of the information provided here for diagnostic purposes, this section presents the Detectability Levels at which the measurement staff operated during data collection. The following sections describe the method used to calculate the Detectability Levels, 10 log (d'), for each tour aircraft event heard, and present the resulting distributions of 10 log (d').

C.4.2 Method

In order to compute 10 log (d'), two matched spectra are needed: the spectrum of the tour aircraft and the spectrum of the non-tour aircraft background at the times when the tour aircraft was first heard (onset) and last heard (offset). By matching the continuous one-second spectra obtained from the DAT recordings, see Section C.3.2, with periods when tour aircraft were logged by the observers, these spectra could be estimated.

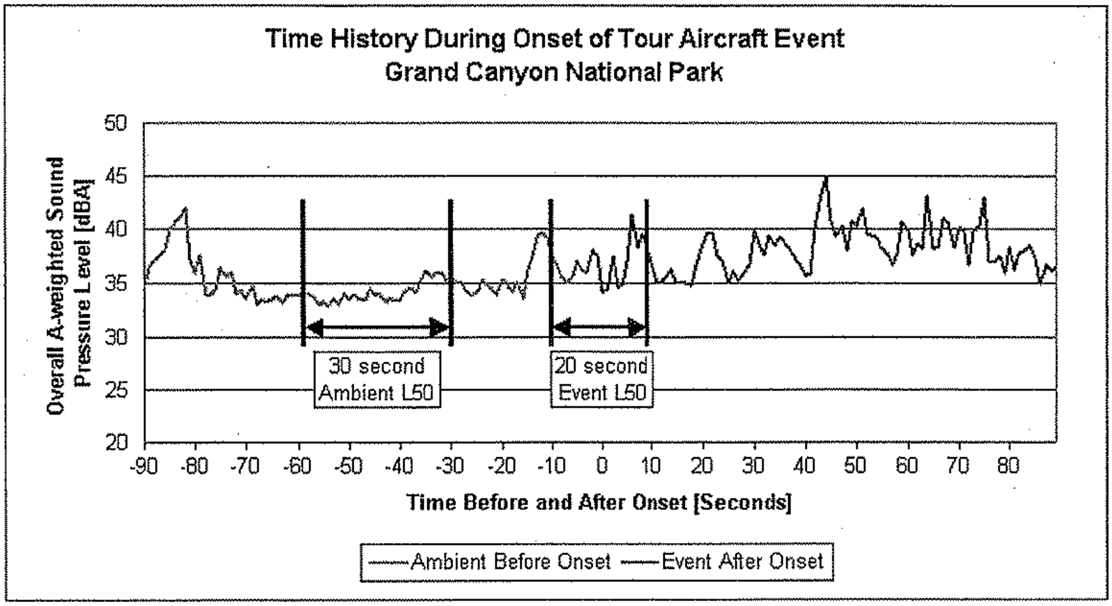

Figure 68. Example of Derivation of Aircraft and Non-Aircraft Spectra for 10 log (d') Calculations

Figure 68 shows how these spectra were obtained. To estimate the non-aircraft background spectrum, a 30 second sample of the 1/3-octave band time history was extracted from 60 seconds to 30 seconds before the event onset was logged. The background spectrum used was the median sound pressure level, L_{50}, in each 1/3-ocatve band during this 30-second sample. The aircraft spectrum was similarly obtained from the 20-second time history starting 10 seconds before the event onset and ending 10 seconds after onset. The ambient spectrum was then energy summed with the auditory system noise, as described in Section C.3.4, and 10 log (d') computed. Spectra for the offset (end of the event) were similarly determined by sampling 10 seconds before to 10 seconds after offset for the aircraft spectrum, and 30 seconds to 60 seconds after offset for the background spectrum.

Figure 69 provides an example of the relationship of the various spectra for an identified tour aircraft. The ambient spectrum is energy summed with the auditory system noise, and the result then compared with the aircraft spectrum to yield 10 log (d') of 9 dB. In this example, the frequency of maximum Detection is 100 Hz.

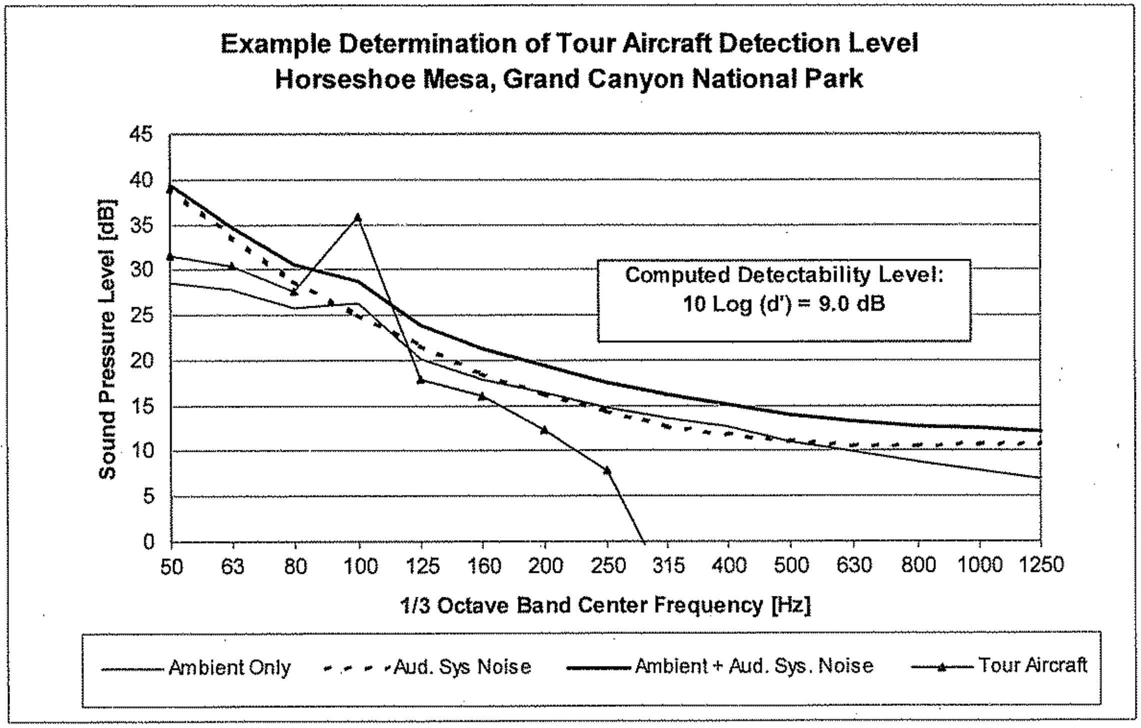

Figure 69. Example of Relationships Between Tour Aircraft and Adjusted Ambient Spectra and the Resultant Detectability Level, 10 log (d')

C.4.3 Results

Table 35 summarizes the numbers of events available for analysis by the frequency of maximum detection, as determined by the method described above. Because it is very unlikely that any tour aircraft detection frequencies exceeded about 300 Hz, events with maximum detection frequencies at or above 500 Hz were excluded from the 10 log (d') computations. It is possible that the method did not always capture the appropriate spectra, with the result that the frequency of maximum detection is unrealistic, and the 10 log (d') computations would be suspect.

Table 35. Number of Events by Frequency of Maximum Detction

Number of Observations of 1/3-Octave Band Center Frequencies of Maximum Detection														
1/3-Octave Band, Hz	63	80	100	125	160	200	250	315	400	500	630	800	1000	1250
Number of Observations	3	8	38	59	44	17	24	23	14	13	9	12	13	16

Table 36 summarizes the computed results, while the following figures present the specific results in various formats. Figure 70 shows how the results varied by day, and Figure 71 gives the computed detectability levels by audibility site, from sites closest to the tour aircraft corridor to the sites most distant from the corridor, see Table 15. Finally, Figure 72 shows the distribution of detectability levels by frequency of maximum detection, and Figure 73 presents the results by observer.

Table 36. Summary of Empirical 10 log (d') Results

	Event Onset	Event Offset
Number of Events	129	101
Average 10 log (d')	5.7	4.26
Standard Deviation	5.95	5.93

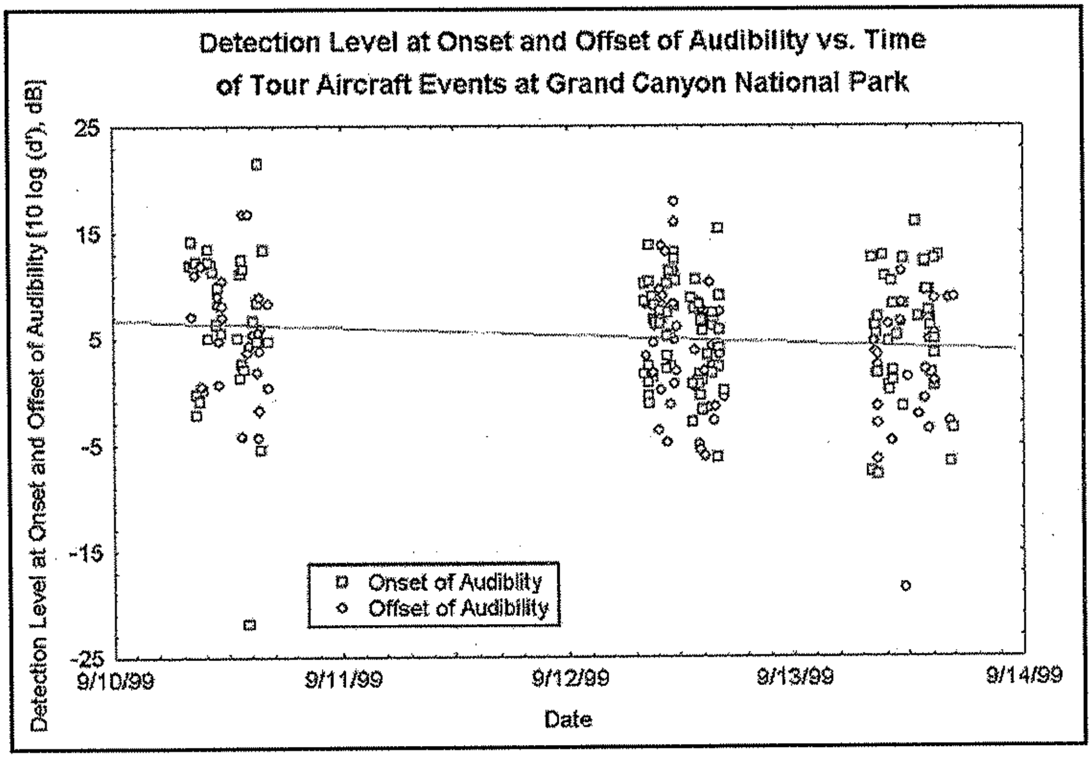

Figure 70. Computed Detectability Levels by Day

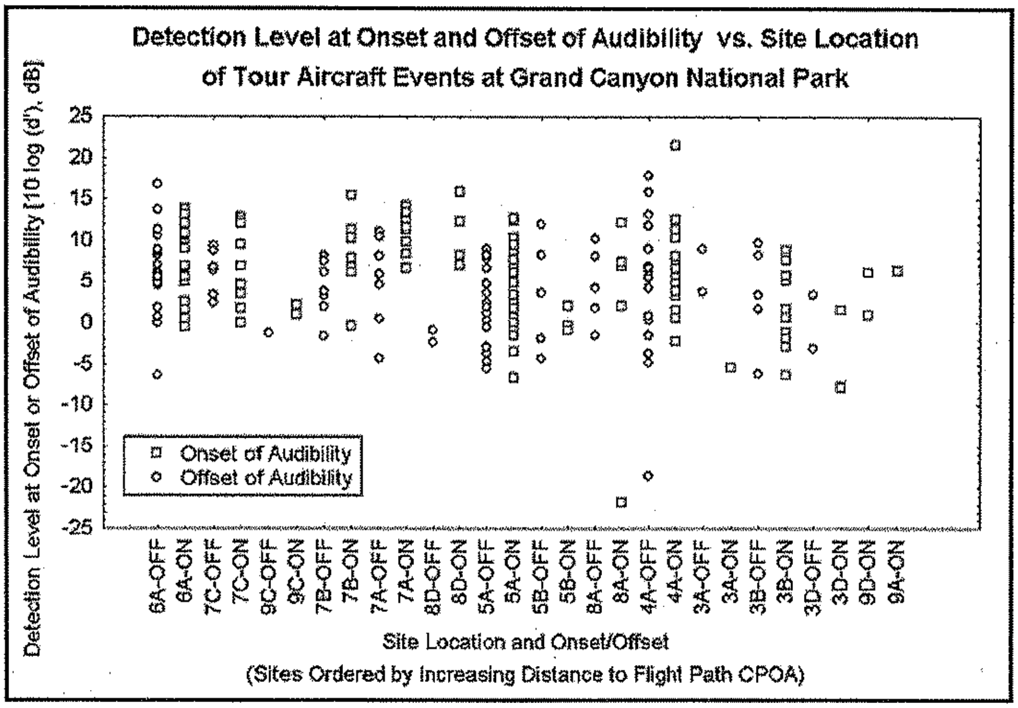

Figure 71. Computed Detectability Levels by Site, Nearest to Most Distant from Tour Corridor

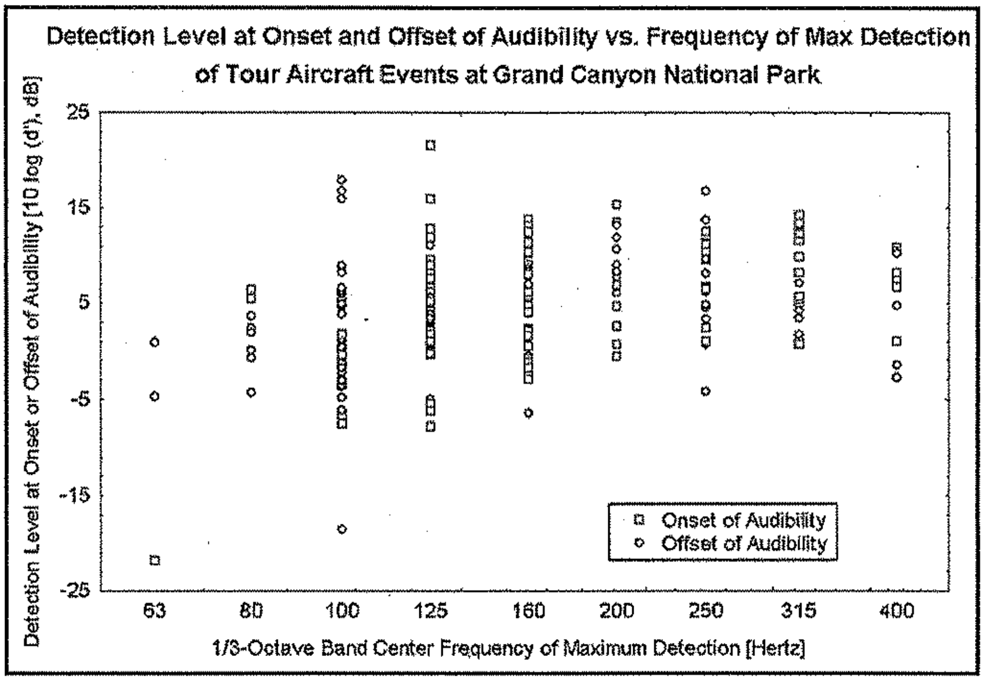

Figure 72. Computed Detectability Level by Frequency of Maximum Detection

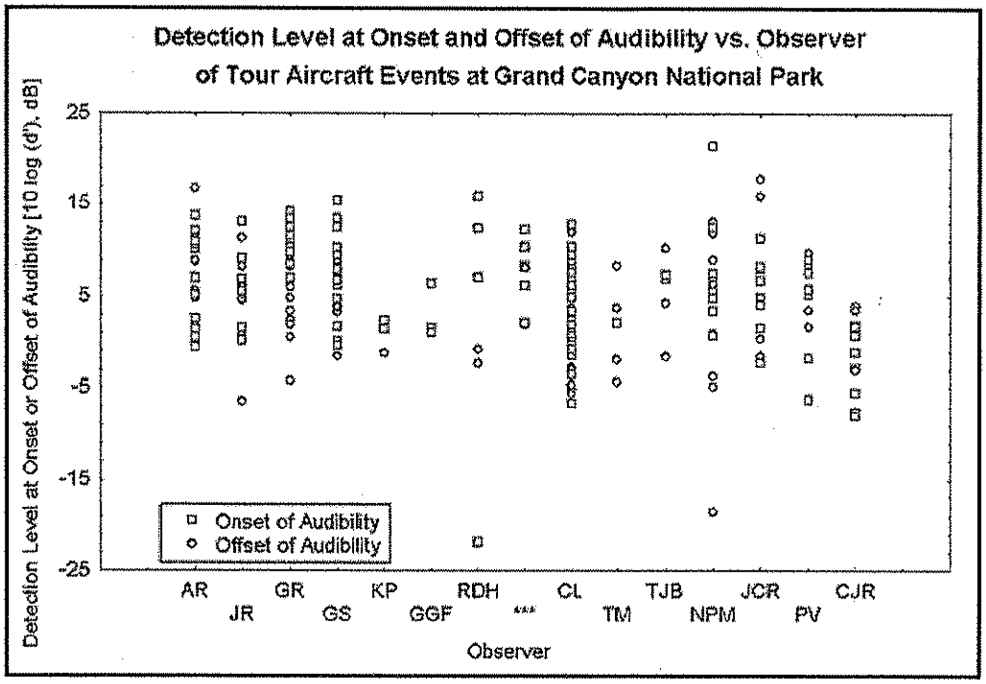

Figure 73. Computed Detectability Levels by Observer

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CPC #89

#23-02

TOWN OF OLIVE
West Shokan, N.Y. 12494

OFFICE OF THE SUPERVISOR
Berndt J. Leifeld, Supervisor
(914) 657-8118

March 18, 2002

Alex Ciesluk
New York State DEC, Region 3
50 South Putt Road
New Paltz, NY 12561

Dear Mr. Ciesluk:

State Route 28 is the main artery in the Town of Olive. This Route has one travel lane in each direction through the entire length of the town. Recently, it was learned that Crossroad Ventures' DEIS for its Belleayre Resort project includes no traffic study data for Route 28 in our town which is the principal access route to the proposed resort.

The DEIS projects peak traffic volume to and from the resort in excess of three hundred (300) new vehicular trips per hour above and beyond the existing traffic flow. There are intersections with less volume than many intersections along Route 28 in the Town of Olive through which the vast majority of those same vehicles must pass. It therefore seems likely that the proposed resort would also require the installation of a number of traffic control devices throughout the length of Route 28 in the Town of Olive.

We believe that the people of Olive have a right to know everything about the proposed resort's impact on traffic in our town, including any projected changes in average speed and travel time, and whether or not the current configuration of one (1) lane in each direction is adequate to provide for the proposed Belleayre Resort as well as for future growth in Olive and along the entire Route Corridor West of our town.

Sincerely,

Berndt J. Leifeld

Berndt J. Leifeld
Supervisor

BJL:bs

TOWN OF OLIVE
OFFICE OF TOWN CLERK
SYLVIA B. ROZZELLE
PO BOX 96
WEST SHOKAN, NY 12494
914-657-2320 FAX 914-657-2016
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November 19, 1999

Town of Shandaken Town Board
Supervisor Ted Byron
PO Box 134
Shandaken, NY 12480

Dear Supervisor Byron and Town Board Members,

The Olive Town Board at its November 8th meeting discussed areas of concern relating to the proposed large development project near Belleayre. The Town Board and residents of Olive are well aware that any decision concerning this project lies totally within your jurisdiction. There has, however, in the past been two-way communication between our Towns, inter-governmental support for projects, and even shared services. Therefore, we do hope that Town of Olive concerns about this project are taken as simply voicing neighborly concerns and not as interfering.

Since we share streams, forests, and highways that are all systems within our region; any problems within these systems are interrelated and spill over beyond arbitrary political boundaries. We respectfully request that your Board and the Planning Board keep us informed as to meeting dates regarding this proposed project. Town of Olive residents, as well as Town Board members, have expressed desire to attend your public meetings. We feel the effectiveness of local planning could reap positive rewards when all that are effected by the development have a chance to be heard during the planning and SEQR process.

The Olive Town Board does feel it would be in the best interest of all to require the developers post a performance bond. A project not completed could be detrimental to the economic stability of the Route 28 corridor and could result in unanticipated depreciated land values. We realize the need to promote rational development of our lands for human needs of housing, jobs, services, and light industry but not at the expense of jeopardizing the high level of environmental quality that is the basis of our current economy.

On behalf of the Town Board, thank you for keeping us informed of public meetings relating to this proposed project. At your request the Olive Town Board would support the appointment of a liaison to act on our behalf.

By Request of the Town Board,

Sylvia Rozzelle

Sylvia B. Rozzelle
Town Clerk/Tax Collector/RMO/Registrar

cc/ Shandaken Planning Board
Wayne Gutmann, Shandaken Supervisor-Elect

TOWN OF OLIVE
OFFICE OF TOWN CLERK
SYLVIA B. ROZZELLE

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West Shokan, NY 12494
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March 2, 2004

Alexander F. Ciesluk. Jr.
NYS DEC Region 3
21 S. Putt Corners Road
New Paltz, NY 12561

TOWN OF OLIVE TOWN BOARD COMMENTS ON CROSSROADS VENTURES DEIS

Since 1999 the Town of Olive Town Board has expressed written concerns regarding the Shandaken based Crossroads Ventures project. In correspondence dated 11/19/1999 (letter attached) the Olive Town Board requested the Shandaken Planning Board keep Olive advised of meetings regarding this project noting that as an impacted community we would like to be heard during the planning and SEQR process. The Olive Town Board also publicly discussed the traffic impact issues concerning State Route 28--which runs the entire northern part of Olive through the hamlets of Ashokan, Shokan, and Boiceville.

In correspondence addressed to you personally on 3/18/2002 (letter attached) the Town Board again stated that Olive is an impacted community and expressed concerns about the State Route 28 artery.

At its 2/5/2004 meeting the Olive Town Board reiterated that the Town of Olive be included in the Crossroads Ventures DEIS as an impacted community and requests knowing what measures will be taken to include a traffic study of Route 28 through Olive.

Perhaps briefly outlining only <u>one</u> of the issues regarding Olive's Route 28 corridor will be helpful in understanding our concerns. Olive's Route 28 problems are more complex than those of adjoining towns since Route 28 is actually "Main Street" for the hamlets of Ashokan, Shokan, and Boiceville.

The most recent investigation project report on Route 28 through Olive was in 1990 when the NYS DOT completed the ROUTE 28 FEASIBILITY STUDY FINAL REPORT FOR THE TOWN OF OLIVE. This 1990 report identified transportation problems on Route 28 within the hamlet of Shokan and proposed five alternatives: 1. Do Nothing, 2. Interim Improvements Alternative, 3. Widen to Four Lanes on Existing Alignment Alternative, 4. Two Lanes on New Alignment Alternative; and 5. Four Lanes on New Alignment Alternative.

This extensive report analyzed existing conditions such as traffic volumes, operations, and safety; and environmental and physical conditions. A few findings were: compared to the statewide average the accident history along this stretch of road is higher; passing demand is very high but passing capacity approaches zero; and the Annual Average Daily Traffic (AADT) grew at twice the annual growth rate from Route 375 in West Hurley to Boiceville than from Boiceville to Mt. Tremper.

The final outcome was that the NYS DOT chose the second alternative of implementing interim improvements. However, **the report states very clearly that due to existing traffic volumes capacity improvements (widening to four lanes through Shokan or constructing a new two lane or four lane road around Shokan) would be considered when the current Design Hour Volume increases to a range of 1,400 to 1,600 vehicles per hour.** Will the increased traffic generated on Route 28 from the Crossroads Ventures project result in the NYS DOT either building a bypass around Shokan or constructing a four lane road as indicated in this 1990 report? If this one aspect of the Crossroads Ventures proposal creates such a result in the Town of Olive, one shudders to think of the devastating effects this would have on our Route 28 businesses, homeowners, and community as a whole.

Again, this is only one issue regarding Olive's concerns about the increased traffic on Route 28. The Route 28 problems near the Onteora Central School in Boiceville should also be addressed in the DEIS.

Thank you for recognizing that Olive is an impacted community and for seeing that a detailed Route 28 traffic impact study is included in the environmental review.

By Request of the Town Board,

Sincerely,

Sylvia Rozzelle

Sylvia Rozzelle
Town Clerk

enc/5

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CPC 90

Fly Fishing with Bert Darrow
P.O. Box 153 •Tillson, NY 12486
Phone (845) 658-9784 • Fax (845) 658-3692 • E-Mail: BD Flycaster@aol.com

Offer of Proof of Bert Darrow on Behalf of the Catskill Preservation Coalition

Tuesday, August 24, 2004

Dear Sir:

I am here today to register my concerns about the construction of the proposed golf courses and the hotels and homes associated with it. I believe that the whole project will have a deleterious effect on the community in general and especially the environment surrounding the Esopus Creek watershed that flows partially from Birch Creek and its tributaries.

My family settled in the Kingston area in the 1600s and has lived here since then. I am a resident of Tillson, N.Y., a small hamlet just south of Kingston. I have lived there since 1969 but prior to that I have lived in Kingston and Hurley on the lower Esopus.

Fly fishing was a way of life for the people along the Esopus Creek and Birch Creek even before the portal was opened for water transport by New York City in the latter part of the 1920s. There were many small boarding houses and inns that were frequented by anglers from all around the northeast. The Esopus was a world class river that became a magnet for trout anglers from everywhere. The Catskills rivers attracted well known anglers from everywhere during the 1800s and became known as the birthplace for fly fishing in America. Theodore Gordorn fished on the Esopus as well as the Neversink in the late 1800s and early 1900s. He was known as the father of dry fly fishing in America and promoted the rivers as a great place to fish to anglers in England. Fly fishing in the Catskills became the passion of many because of the local rivers.

I developed a serious interest in fly fishing over 30 years ago and have spent much of my time in pursuit of that sport on the Esopus Creek from the Ashokan Resevoir to Big Indian. More importantly than the years engaged on the river is the number of hours I have spent on the Esopus Creek that now well surpasses over 10,000 hours. I have walked most of the river hundreds of times fishing by myself, guiding others or teaching people how to fly fish, My teaching of this life time sport started in 1978.

Because of the years and hours spent in and around the river, I have been able to observe the positive and negative impacts on both the river and the communities in close proximity when the river has been in a good healthy condition and when it has not. In the 1960s, 70s and 80s, the river fished wonderfully except for brief cyclical storm events that caused temporary problems. The village of Phoenicia was a booming village with 2 fly fishing stores as well as many other types of shops and restaurants. There was also a store selling flies and tackle in the nearby hamlet of Boiceville. Also, there were stores at Winchell's Corners and Shokan Bend as well as a store just west of Phoenicia that sold tackle and bait. A new fishing store opened at Catskill Corners that was only open for a short time, a few seasons I believe before finally closing. The only store that is fishing related today left in the area is in the Village of Phoenicia. It was once the well- known Folkert Brothers store but now has only a very small supply of fishing related items compared to what it once had.

The loss of most if not all of these fishing businesses came about after the flood of January 19, 1996. The river ran red or brown for almost six years because of water coming from the portal, a diversion of water from one NYC reservoir to another. We called it Yohoo Creek because it looked so much like that popular drink with the same name. The river was not only ugly and depressing to look at by everyone that saw it but was really not fishable for many reasons. The river above the portal has remained clear most of the time and although holding less trout that below the portal, mostly because of the volume of water and size of river, has remained a steady producer of both wild rainbow and brown trout.

When taking part in an electro-shocking study to check the trout population as well other fish species in the Esopus Creek a couple of years ago with the NYSDEC and students from Ulster County Community College, I was able to observe the importance of the upper Esopus Creek, above the portal with regards to numbers of trout in the river. While at three areas tested below the portal there were many more trout than the section shocked above the portal, the ratio of fingerlings to adult trout above the portal far exceeded the numbers below. The ratio of fingerlings to adults above the portal was about 11 to 1 and below the portal the ratio was between 1 to 1 or less than 2 to 1. I have read that for good survivability of the species it should be around 10 to 1. This emphasized to me the importance of the Esopus Creek above the portal and its tributaries for the wild trout to spawn.

The main reason I didn't fish the Esopus below the portal much after the 1996 storm event or take people fishing in those years was because of the safety factor when wading. It was impossible to see where you were wading. Even in knee deep water, you never knew how deep a hole the next step might put you in or what you might trip over. Also the number of fish that were seen by the anglers that did fish that section of the river was far fewer than what had been there in the previous years. The insect life had changed drastically in their numbers and in a negative way. They were greatly reduced.

As the fishing decreased so did the people visiting the area and this affected other businesses as well like restaurants, motels, local merchants, antique shops etc. Most of the people that I taught or guided came with other family members that looked for other things to do and most stayed overnight at a local motel.

Along with the reduction in people, fish and aquatic insects, there has also been a reduction in the bird and animal life along the river that survives on what grows in it when it is healthy. Many different types of birds have had their numbers reduced due to the lack of food that they get from the river.

The aquatic insects have now started to come back but still not in the numbers that were there before. The trout that survive on those insects seem to be holding their own as far as their numbers go, but now they seem to be smaller in size. The silt in the river had definitely taken a toll on the stream life.

Birch Creek is a major tributary to the Esopus above the portal and is a spawning area for wild fish. I do not fish it nearly as often as the Esopus from Big Indian down but it has never failed to provide beauty in the form of wild rainbows and browns when I do go there.

As I stated on the outset of this comment, I have concerns about the Crossroads project. The upper section of Birch Creek and its tributaries are streams of a high gradient for the water to flow down, so it does so quickly and with little warning most of the time during heavy rain events. I have watched as people have done small excavations for single driveways or dug holes for foundations and when fast moving strong storms move through that area, there are rivers of red that flow down the hills and into those mountain streams. They become swollen quickly and bleed red with silted water only to ultimately flow into the Esopus Creek and then Ashokan Resevoir.

I have seen the effects of catch basins, pipes and roadside ditches that overflow because of blockage into the Esopus Creek and many other rivers. They may work when in perfect condition and under moderate storms but the problem of maintenance is something that is always present. This is not a short lived project and I don't know of any guarantees that will make sure these types of mitigation will be maintained. Once the ground has been disturbed, erosion in that type of gradient takes place very quickly and silt will swiftly be moved downhill to the big river.

In my guiding and teaching experiences with people from all over the world, I have heard the same idea expressed over and over again. The Esopus valley is beautiful and is a great place to visit because of its intimate atmosphere. The mountains are beautiful and it is not over developed like so many areas are.

In closing, I must say that the idea of golf courses and the hotels and home complexes would be a tragic idea for the mountain top environment and communities, the Esopus River valley below them as well as the communities along that river.

Respectfully Submitted,

Bert Darrow

Bert Darrow

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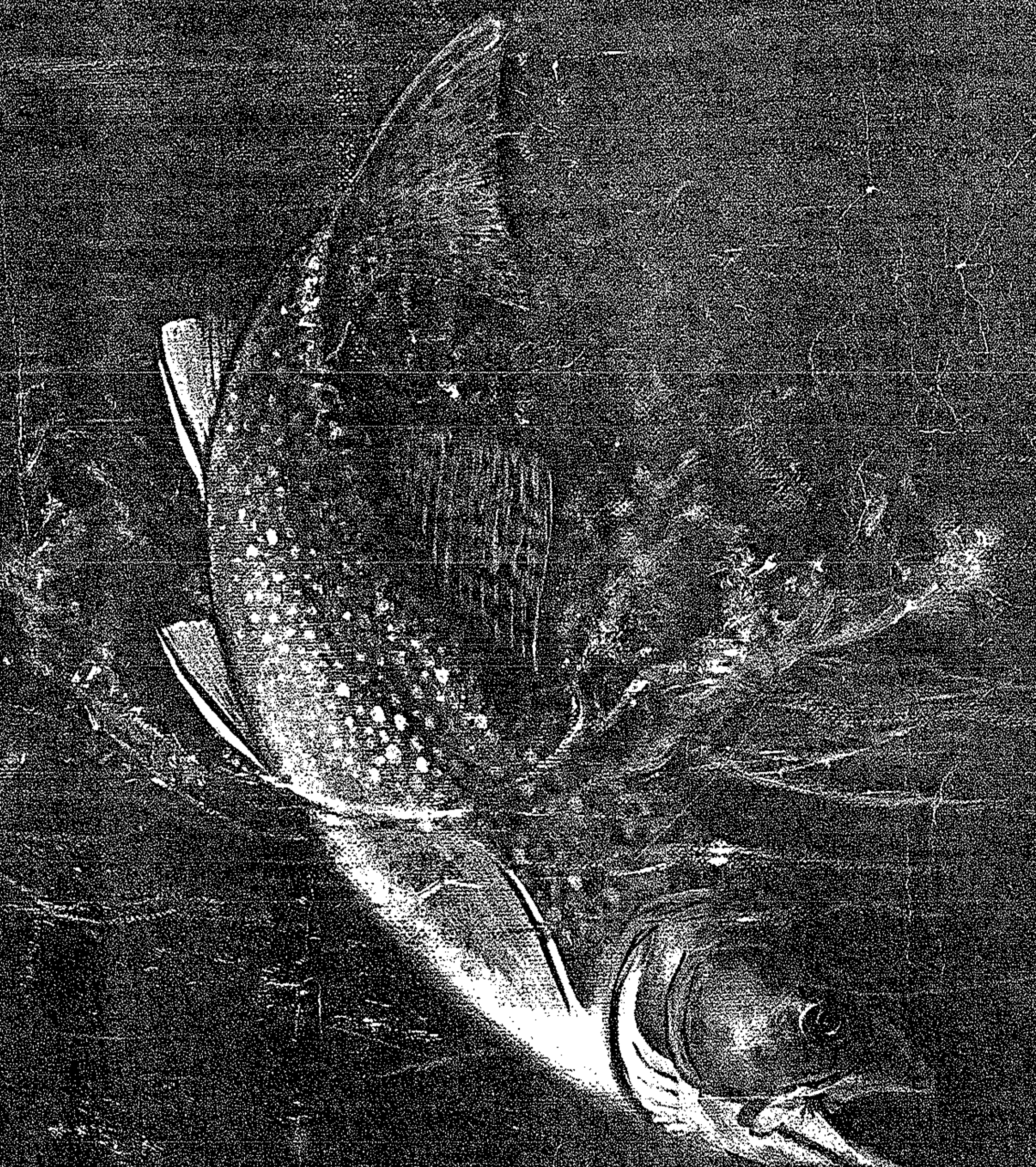
FOREST AND STREAM



THE CHARM OF THE ESOPUS (PC#91)

ITS ATTRACTIONS LIE NOT ALONE IN THE BOUNTY OF ITS YIELD IN TROUT, BUT PARTLY IN ITS MAGIC

By T. ALLEN PARSONS

WHEN I was a very little lad, and just beginning my novitiate in trout fishing, I used to hear the Esopus called the grandest trout stream of the East. There was something in the very name that was luring, tantalizing, eloquent of fascinating pool and riffle.

As I grew older, and passed pleasant days along the streams of Maine, Quebec and Nova Scotia, like every other brother of the angle I seized eagerly upon all the fishing literature I could find—outdoor magazines, books by W. C. Prime, Frank Forester, and all the rest of that brilliant company. And again and again I came upon that unforgettable name—Esopus; Beaverkill, Willowemoc, Neversink; Esopus. Those four words seemed to embrace all that was best in the gentle sport that makes all men kin; the sport that, being gentle, makes its true devotees gentle—gentlemen of the angle indeed.

For years I had hoped some day to cast my line upon those famous waters. But it was not until 1915 that I finally accomplished my wish. I persuaded a good friend and his wife to make up a party with "the Mrs." and myself and go up to Phoenicia for two or three days and try it out. Mac is ever willing to lisen to reason where the reason is fishing, and we picked out the last three days in May as being a most reasonable time for the trout to rise.

ON the trip up, the railroad tracks for some miles follow the windings of the stream, and the valley through which it flows, hemmed in by the mountains, is charming country.

The morning after our arrival four of us made an early start. The ladies had come up prepared to do some fishing themselves, appropriately garbed in sweaters and wading boots. No sooner had we left the hotel than they exclaimed with delight at the scenery. Mountains were all around us. Down a beautiful valley between banks of emerald came the river, a noble stream—when normal not too large for wading, yet large enough everywhere for casting. With few overhanging branches, and its long deep pools and many dancing stretches of riffles, it is truely an ideal little river.

Perhaps a mile up the road, at a bridge with a fine pool below, we tried first luck. But the stream was high and the wading precarious. One of the ladies went over her boots on the second step, and after trying it myself for a few minutes, buffeted by the tremendously swift current and tormented by the large and slippery rocks hidden by the water, we were all ready for sport a little less strenuous.

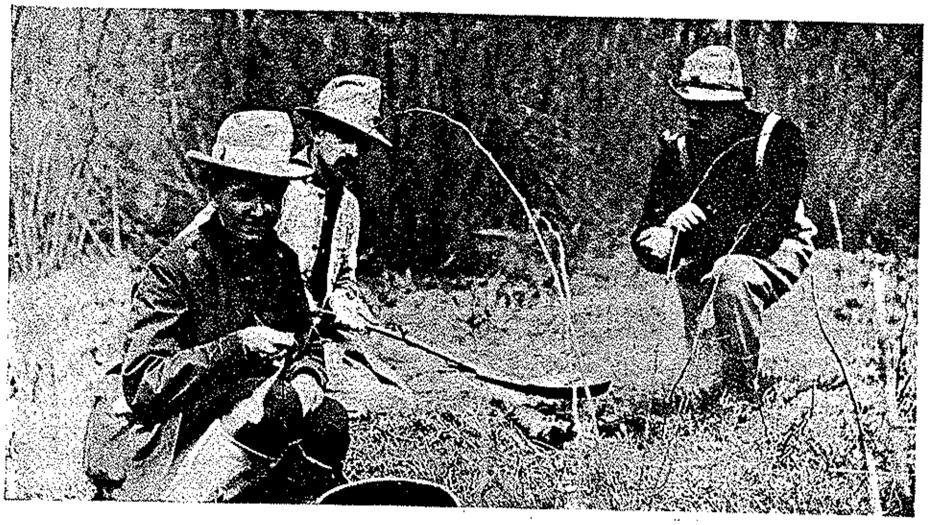
A farmer, driving by, drew up when we hailed him, and told us of the Woodland Valley stream not far distant. Following his directions we made our way to it—a little beauty that looked trouty. It had several nice pools, but after fishing all the morning, we finally gave it up, with not a strike to either worm or fly as our lot.

WE spent a delightful three days on this first trip to the Esopus, but our fishing luck could not have been worse. Mac and I caught several baby trout in a stream which runs through the village, but we didn't have the heart to keep them—they just made six inches. And had it not been for a splendid string of trout caught by a fisherman stopping at the hotel, some dozen in all, one of which would go to two pounds, we would have been excused for thinking the Esopus a trout stream of the past.

But the charm of the Catskills and the Esopus had penetrated deep. And I often thought afterwards of the scent of the lilacs and the cool sweet mountain air, of that noble stream and of those fine trout the other fellow caught. Something must have been wrong with our methods. The trout were there waiting for the fisherman who knew how, and I determined to try it again—and be that fisherman.

So in the merry month of May I persuaded another friend to try it with me. The good doctor and his wife have fished many of the famous streams of the West and many are the bouncing trout they have caught in partnership, but this was his first attempt at the more educated waters of the East. I didn't dare tell him of the luck (or lack of it) we had had the year before and only prayed that good fortune might so smile upon us that my perfidy would be not discovered. The doctor suggested we go up from New York in his big automobile, take along our better halves for luck and good company, and his chauffeur as general factotum. And I hailed his amendment to my original motion with considerable enthusiasm.

We Built a Fire by the Roadside, Gypsy Fashion, In Beautiful Orange County



AN afternoon late in May found us gliding away from Times Square, New York, loaded with equipment sufficient for ten days' camping in the North Woods—a nested cooking outfit, pasteboard boxes of bacon that looked good enough to eat uncooked, knives, forks, spoons, cups, plates and everything else that civilized man has learned not to do without. There were canned goods "for emergency". There were—well, lots of other things. And the car held all the "chuck," suit cases, fishing tackle, and wading boots, until you would have thought the doors would refuse to hasp.

Once clear of New York, we ate up the miles on the east side of the Hudson to Nyack, ferried across, and to Suffern, through Tuxedo, and up through beautiful Orange county to Newburgh. Warned here by the "low descending sun" that supper time was drawing nigh, we built a fire by

(CONTINUED ON PAGE 230)

its waters. But evolution is throwing around them a mantle of protection, and they are becoming keenly sensitive to the danger that lurks in the bold and obtrusive coloring of the ordinary artificial lure. There is no true sport in which the element of chance between the pursuer and pursued is not fairly even. This river is persistently bait fished, and it is merely a question of time when the fish will be decimated by this unsportsmanlike procedure, over which the effort of evolution in their defence has no control.

THE river has whispered to me its story, and if I have interpreted it aright, the remarks I have made in this article are correct. If fate is propitious, we will journey down it together, and there will be ample scope for an interchange of our opinions and ideas. The catching of fish will contribute to only a portion of our pleasure. Inside the charmed circle of Angler's Land—without whose borders black Care and the avenging Furies forever pitch their tents, but never enter—there is a world of beauty. The rhythmic cadence of the classical pastoral poetry of Merrie England dwells in the heart of its dawns, its eves and cloudless days.

If we possess an admiration and love for the beauties of nature, it will so influence us that the cares and sorrows of life will fade like the phantoms of unpleasant dreams,—for in this land of forgetfulness, Hope with her radiant arch spans all its green hills, and its flowers.

THE CHARM OF THE ESOPUS

(CONTINUED FROM PAGE 200)

the roadside gypsy fashion, and envied by the occupants of other cars that shot by, we supped on bacon and eggs and coffee, with fruit and cake for dessert. Packed up and on our way again, the time went swiftly, and it was almost with a shock of surprise that we reached Kingston, where we called mein host at Phoenicia, to tell him that we might get in late, and to be sure and keep the door open for us. This little forethought was prompted by experiences at coming to country hotels "after closing hour".

KINGSTON was as far as any of us had gone in a car, and we looked upon the next twenty miles with some foreboding. But our anxiety was unnecessary. We found the road with no trouble at all, and it was a good one. It was now deserted; almost every house we passed was dark from door step to peak of roof. The countryside was asleep. So we shot along, guided by the white fences which seemed put there just to guide such nocturnal journeyers as we. Despite the approach of June the air was cold and almost frosty, so it was with a sigh of relief that we finally slid up to the door of our hotel in Phoenicia.

As I dressed I wondered if I had given the doctor a "bad tip," if we should get enough sport with the trout to make the trip worth while.

We met at breakfast, dressed for business in flannel, khaki, and waders, and I suggested (influenced by the trip of the year before) that we put in a number of miles up stream. So at a bridge between Shandaken and Big Indian I was elected to make the start. They would meet me for lunch a mile down stream. So with the time-hallowed salutation and valedictory of all good fishermen the world over—"Good luck!"—we parted.

FROM the time of my first fishing trip I have never failed to have what must be a distant cousin to "buck fever," when I approach a stream for my first fishing of the year. I find myself so eager to wet the line that my fingers seem all thumbs. I prick myself with the hook. I twist the line around the rod as I weave it through the guides. I drop my fly hook and strew the ground with the flies. Altogether, I act like the green and gawky youth in his first evening dress, as he walks into a ballroom where beautiful women and handsome men are at ease.

But finally, after many false starts and much wasted motion, I slid down the bank and into the cold rushing water. The stream here is perceptibly smaller than at Phoenicia, but is still splendid fishing water. I tangled my first cast—I always do—but after a few of them I got myself in hand and performed creditably—with two flies, a Cahill for a tail fly and a Black Gnat for dropper.

Commend me to a stream like this!

It is rarely straight, twisting and turning, not perhaps like that old Grecian river Maeander in the classics, but with many a charming bend and curve, here with banks cut through a blossomed meadow, and there with walls of rock. Here a patch of pleasant, sweet-smelling woodland, there a bristly growth of alders and small underbrush.

And the river itself:

Pools? Plenty of them, deep enough for whales of trout, with shingly riffles in between, beloved of feeding trout at certain hours of the day.

THE time flew. I was doing my casting right manfully—yet catching nothing. Disappointed? Of course—some, but having a splendid time all the same. I had a new and fascinating stream to study, the sunshine was bright, the birds were singing in harmony with the song of the waters, the air was mild, nature was smiling, and all the world was young and innocent, green and beautiful with May, blossomed with June.

I changed flies several times—Stone, Alder, Queen, and Coachman—but couldn't hit upon the lucky combination. I had seen but one trout rising, and he was evidently a small fish. He was advertising his presence in a long shallow pool, where there was no cover and where he doubtless had been watching my steps for a half hour before I found him. But several casts into the rings made by his rises proved of no avail.

Toward noon—I was not far from the spot where we were to meet for lunch—I came upon a neat pool straddled by a bridge. Beyond, the river broke into a long stretch of riffles, which carried it down a descent of considerable pitch, and disappeared in a miniature gorge below. The pool looked no better than many that I had fished that morning without success, and the riffles seemed positively unpromising.

(TO BE CONTINUED)

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CPC 92

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Education

1984 Ph.D. in Agricultural and Resource Economics, Oregon State University.

1977 M.S. in Agricultural and Resource Economics, University of Newcastle-upon-Tyne, England. Study on a Rotary Foundation Fellowship.

1976 B.A. cum laude in Economics, Harvard University.

Planning Experience

July 2003-
Present

Full Professor with Tenure, Department of City and Regional Planning, University of Pennsylvania.
Teach: Land Use Planning, Environmental Planning, Metropolitan Regional Planning, and Land Preservation.

August 1998-
July 2003

Full Professor with Tenure, Department of Geography and Planning, The University at Albany-State University of New York.

Director of the Planning Master's Program, Fall 1998-December 2001.

Fulbright Senior Fellowship, University of New South Wales, Australia, February-June, 2002.

May 1989-
July 1998

Director, Agricultural Preserve Board of Lancaster County, Pennsylvania.
Administered a nationally-recognized farmland preservation easement acquisition program with an annual budget of over $4 million. Preserved over 16,000 acres in 188 easement projects. Assisted Planning Commission staff with growth management and agricultural zoning issues. The program received the 1993 Outstanding Program Award from the Small Town and

Rural Planning Division of the American Planning Association. Received the 1996 National Achievement Award from the American Farmland Trust.

Aug. 1987-
May 1989
Associate Professor with Tenure, Department of Regional and Community Planning, Kansas State University.

Jan. 1985-
July 1987
Assistant Professor, Department of Community and Regional Planning, Iowa State University. Taught in Semester Abroad program in London, Fall 1986.

Publications

Books

2003 The Environmental Planning Handbook for Sustainable Communities and Regions. Chicago: American Planning Association (Senior author with Katherine Daniels).

1999 When City and Country Collide: Managing Growth in the Metropolitan Fringe. Washington, D.C.: Island Press.

1997 Holding Our Ground: Protecting America's Farms and Farmland. Washington, D.C.: Island Press. (Senior author with Deborah Bowers).

1995 The Small Town Planning Handbook, 2nd edition. Chicago: Planners Press. (Senior author with John Keller and Mark Lapping).

1989 Rural Planning and Development in the United States, New York: Guilford Publications. (Second author with Mark Lapping and John Keller).

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(forthcoming) “The State of the Art in American Metropolitan Regional Planning,” Landscape and Urban Planning.

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1996 "The Two Rural Americas Need More, Not Less Planning," Journal of the American Planning Association, Vol. 62, No. 3, pp. 285-288. (Senior author with Mark Lapping).

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"The Goals and Values of Local Economic Development Strategies in Rural America," Agriculture and Human Values, Vol. 8, No. 3, pp. 3-9.

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"A Rationale for the Support of the Medium-Sized Family Farm," Agriculture and Human Values, Vol. 6, No. 4, pp. 47-53.

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"Farmland Preservation Policies in the United States: Successes and Shortcomings," Farmland Preservation Conference – Protecting Farmland for Farmers," Guelph, Ontario, Canada, June 28, 2004.

"Metropolitan Expansion Policy: Forging the Package," American Planning Association National Conference, Washington, D.C., April, 27, 2004.

2003 "Farmland Preservation in Local Land Use Planning," Paper presented at the What the Public Values About Farm and Ranch Land Conference, Baltimore, MD, November 14th, 2003.

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"Farmland Preservation and Smart Growth," 1000 Friends of Minnesota Conference on Smart Growth, Minneapolis, MN, June 10, 2003

"Strategic Uses of LESA for Farmland Protection," Soil and Water Conservation Society Land Evaluation and Site Assessment Workshop, Lied Conference Center, Arbor Day Farm. Nebraska City, NE, June 4, 2003.

"Variations in Conservation Easement Duration and Payment Options," Landowner Compensatory Options for Conserving Agricultural Land: A Research and Policy Conference, Davis, California, April 15, 2003.

"Using an Easement Payment in a Like-Kind Exchange," American Farmland Trust Conference, Monterey, CA, March 14, 2003.

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2001 "The Land Use-Water Quality Connection: The Case of the Lower Hudson Watershed," Association of Collegiate Schools of Planning Conference, Baltimore, MD, November 22, 2002.

"Smart Growth and Farmland Preservation," National Land Trust Rally, Austin, TX, October 29, 2002.

"Like-Kind Exchanges and Escrowed Easements," National Land Trust Rally, Austin, TX, October 28, 2002.

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"Purchase of Development Rights and Urban Growth Boundaries," The Ultimate Land Use Conference, Lansing, MI, February 28, 2000

1999 "Planning, Zoning, and Land Preservation for Growth Management: A Comparison of Neighboring Counties." Paper presented at the Association of Collegiate Schools of Planning Conference, Chicago, October 23, 1999.

"Future of Agriculture in the Northeast", Northeast Agricultural Policy Meeting, Burlington, VT, August 8, 1999.

"Community Development and the Challenge of Sprawl," International Community Development Society Conference, Spokane, WA, July 28, 1999.

"Protecting and Preserving Farmland," Smart Growth: From Rhetoric to Reality Conference, Portland, OR, July 23, 1999.

"Balancing Development and Farmland Protection in Pennsylvania," Keep America Growing Conference, Philadelphia, June 7, 1999.

"What to Do About Rural Sprawl?," American Planning Association Conference, Seattle, April 28, 1999.

"Smart Growth: What is it, Where is it Being Used?" Smart Growth Conference, March 4, 1999, Albany, NY.

1998 "Transfer of Development Rights, Agricultural Preservation, and Other Land Use Policy Tools: The Pennsylvania Experience," The Farm Foundation National Public Policy Education Conference, Portland, OR, September 22, 1998.

"The Struggle to Manage Growth in the Metropolitan Fringe," American Planning Association Conference, Boston, MA, April 6.

1997 "GIS and Farmland Preservation," American Planning Association Conference, San Diego, CA, April, 6. (Senior author with Jay Parrish and Jordan Henk).

1994 "The Conversion of Farmland and Farmland Protection Techniques in the United States," Agriculture and Rural Industries on the Fringe Conference, September 21, Melbourne, Australia.

1989 "Evaluating Farmland Retention in Oregon: A Comparison of Agricultural Zoning Performance," Association of Collegiate Schools of Planning Conference, Portland, OR, October, 1989.

1985 "Is the Oregon Farmland Protection Program Working?" American Planning Association Conference, Montreal, April, 1985.

Professional Reports

2004 Ranking System for Auctioning of Keyspan Property, Suffolk County, NY, for Peconic Land Trust and the Trust for Public Land, January 2004.

2003 Dakota County, Minnesota, Farmland and Natural Area Preservation Program Guidelines, 54 pp., co-author with Jean Coleman, June, 2003.

2002 Policy and Program Approaches to the Growth, Development, and Water Quality Connection: A Comparison of Two Estuaries: The Hudson River and the Chesapeake Bay. For the Hudson River Foundation, 230 pp. (Senior author with Katherine Daniels and Robert Leslie), September, 2002.

Vermont's Current Use Program: An Evaluation of Policy Options and Their Land Use Implications, for the Joint Fiscal Office of the Vermont Legislature, January, 2002.

Purchase of Development Rights Feasibility Study for Tompkins County, New York (Third author with George Frantz and Teri Ptacek), January, 2002.

2001 Three Farmland Preservation Proposals for the Metropolitan Council of the Greater Twin Cities, December, 2001.

Evaluation of Farmland Protection Techniques and Programs, for the Metropolitan Council of the Greater Twin Cities,(Lead author), October, 2001.

State and Local Efforts in Conserving Privately-Owned Working Landscapes, Background Paper prepared for the National Governors' Association, March, 2001.

Local Techniques for Managing Conflict Between Farmers and Non-Farmers, Minnesota Department of Environmental Quality. St. Paul, MN, March, 2001.

Local Land Use Planning Techniques for Accommodating CAFOs, Minnesota Department of Environmental Quality. St. Paul, MN, March, 2001.

2000 An Evaluation of the Agricultural Opportunities Subdivision Amendments to the Southampton, NY Town Code, and a Review of the Draft Generic Environmental Statement (DGEIS), November 2000.

Economic Revitalization Through Technology and Education-Based Institutions in the Mohawk Valley and Capital Region of New York (senior author with Ray Bromley), for U.S. Department of Housing and Urban Development, September, 2000.

Points-Based Appraisal Systems to Estimate the Value of Development Rights of Farm Properties in Lancaster County, Pennsylvania, for Lancaster County, PA Agricultural Preserve Board, May, 2000.

1999 Options for the Creation of a Formula-Based Appraisal Method to Estimate the Value of Development Rights of Farm Properties in Michigan, for Michigan Department of Natural Resources, Lansing, MI, December 1999.

Confined Animal Feeding Operations in Minnesota, Minnesota Department of Environmental Quality. St. Paul, MN, January 1999.

1997 Agricultural Zoning Ordinance, for McLean County, Illinois, November, 1997.

1994 Trenton Mill Farms and the Agricultural Industry of Northwestern Baltimore County, Maryland, for The Valleys Planning Council, September, 1994.

1992 A Critique of the Final Report of the Economic Impact Assessment of the New Jersey Interim State Plan, with Particular Emphasis on the Environmental Assessment and Impacts on Agricultural Lands, for New Jersey Future, March, 1992.

1991 A Critique of the Methodology for the Assessment of the Impacts of the New Jersey Interim State Development and Redevelopment Plan on Population, Employment, Frail Environmental Lands, and Agricultural Lands, for New Jersey Future, December, 1991.

1989 An Economic Analysis of the Conservation Reserve Program in Kansas, Kansas State University Agricultural Experiment Station, May, 1989. (Senior author with Dwight Dickson).

1986 Regional Economic Development Strategies for Rural Iowa, Design

Research Institute, College of Design, Iowa State University.

Grants

2002 Open Space Institute, Study of Sprawl and Land Use Change in the Capital District of New York, $40,000. Project associate.

2001 Hudson River Foundation, Study of Land Use Planning Techniques in the Chesapeake Bay Estuary and the Hudson River Estuary, $61,396, Principal Investigator.

2000 Project Associate, U.S. Department of Housing and Urban Development, Economic Revitalization Through Technology and Educational Institutions, $4,000.

1998 Federal Farmland Protection Act (1996 Farm Bill),
$70,000 for farmland preservation in Lancaster County, PA.

1997 Federal Farmland Protection Act (1996 Farm Bill),
$306,947 for farmland preservation in Lancaster County, PA.

1989 Kellogg Foundation Grant for Rural and Small Town Development, Kansas State University, $940,000. Project Associate.

Kansas State University Agricultural Experiment Station. Research on the performance of the Conservation Reserve Program in Kansas, $5,000. Principal investigator.

Reviewer:

Agricultural and Resource Economics Review
Blackwell Publishing
Conservation Ecology
Economic Development Quarterly
Geographical Review
Growth and Change
Fulbright Committee on Australia and New Zealand
Iowa State University Press
Island Press
Journal of the American Planning Association
Journal of the Community Development Society
Journal of Environmental Planning and Management
Journal of Planning Education and Research
Journal of Planning Literature
Journal of Rural Studies
Journal of Soil and Water Conservation

Land Use Policy
Ohio State University Cooperative Extension Service
Oxford University Press
Prentice-Hall
U.S. Department of Agriculture, Economic Research Service
U.S. Department of the Interior, National Park Service, Cuyahoga Valley National Recreation Area
University of Illinois Press
University of Massachusetts Press
University of Vermont, Center for Studies on Vermont

Professional Memberships

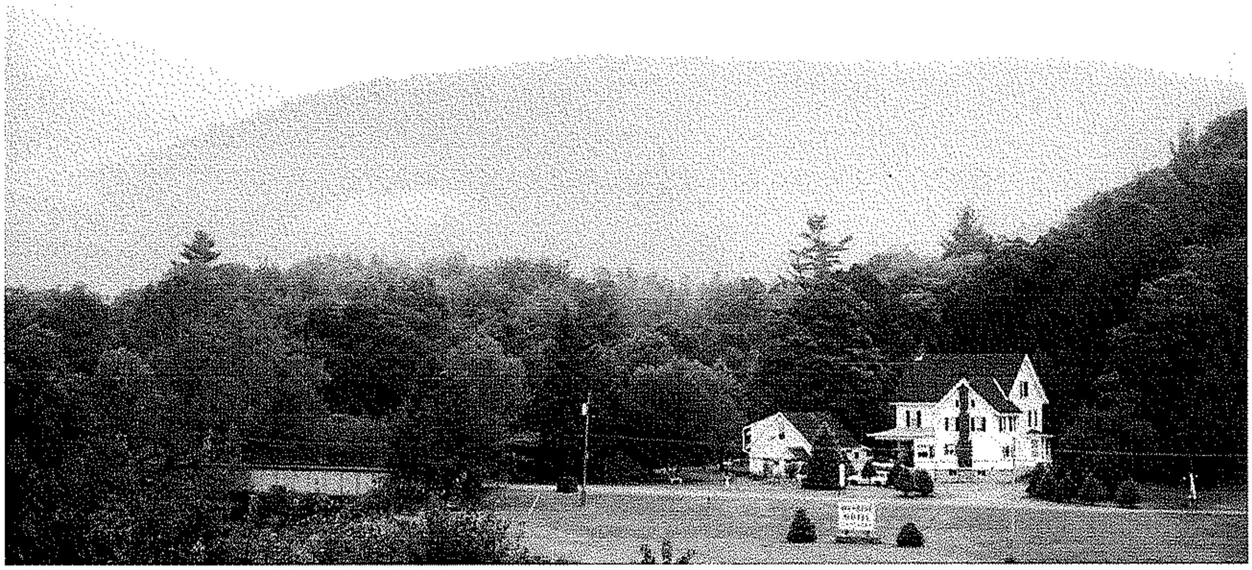
1992 - 1998	Member, Editorial Board, Journal of the American Planning Association
1979 – Present	Member, Center for Studies on Vermont
1983 - Present	Member, American Planning Association
1999 - 2002	Board Member, Albany County Land Conservancy.
1999 - Present	Contributing Editor, Farmland Preservation Report.
1999- 2003	Editorial Board, State University of New York Press
2004- Present	Member, Land Stewardship Committee, Lancaster County Conservancy

93

CPL 93

Balloon location

○



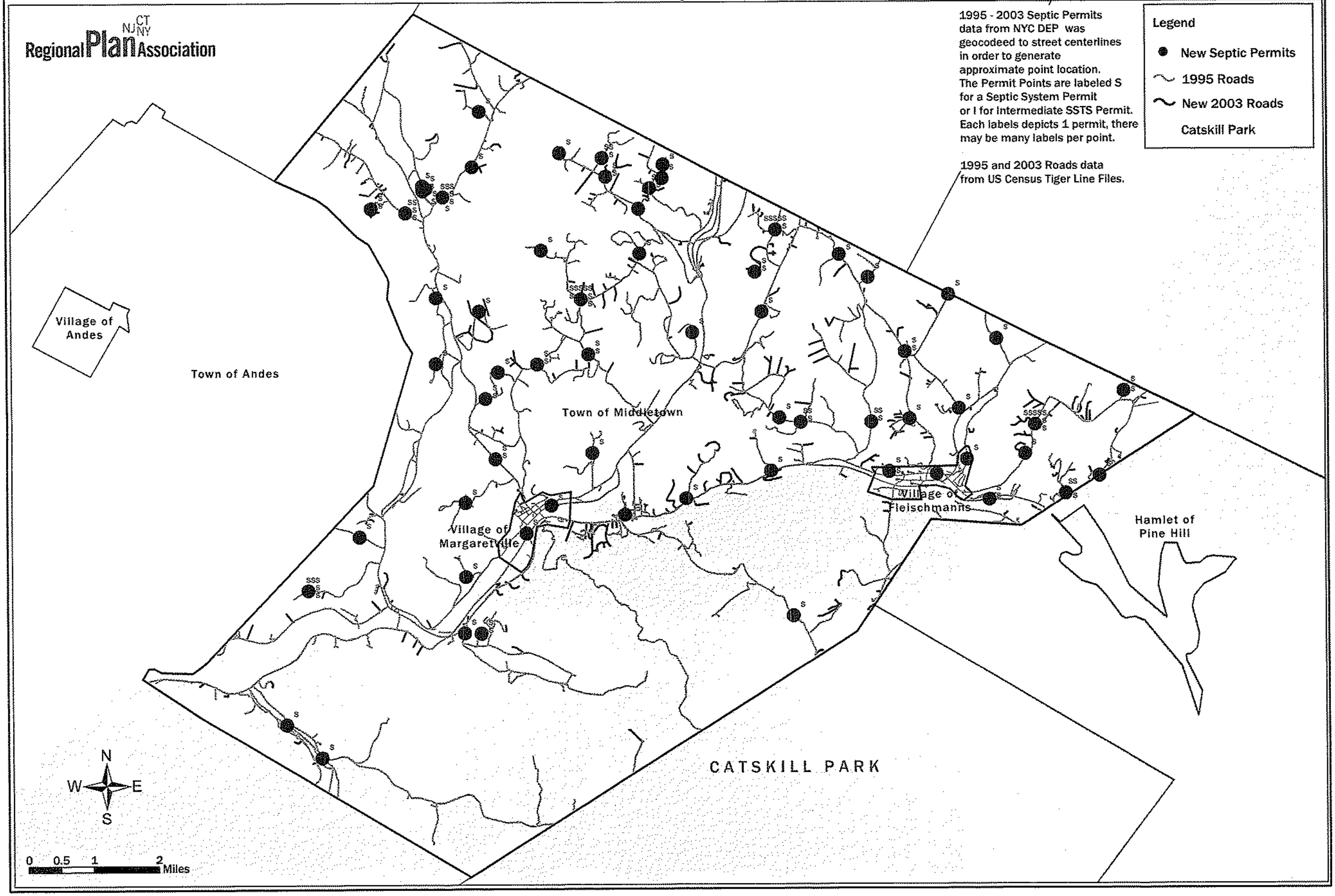
View of Eastern Portion of Belleayre Ridge from Route 28 East of Big Indian

94

95

CPC Ex 95

New Roads & Septic Permits (1995 - 2003) in the Town of Middletown
Delaware County New York



1995 - 2003 Septic Permits data from NYC DEP was geocodeed to street centerlines in order to generate approximate point location. The Permit Points are labeled S for a Septic System Permit or I for Intermediate SSTS Permit. Each labels depicts 1 permit, there may be many labels per point.

1995 and 2003 Roads data from US Census Tiger Line Files.

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CPC #96

CT
NJ NY
Regional Plan Association

4
IRVING PLACE 7TH FLOOR / NEW YORK, NY 10003 / TEL: 212.253.2727 / FAX: 212.253.5666

MEMORANDUM

DATE: August 23, 2004

TO: Thomas Dallessio, Director, New Jersey

FROM: Rob Pirani, Director Environmental Programs
Jennifer Cox, GIS Manager

RE: Analysis of Bellayre Resort DEIS

After examining recent development trends in the project study area, it appears that the Draft Environmental Impact Statement does not adequately account for or address the impacts caused by secondary housing growth to be expected by the Crossroads Ventures' proposed Belleayre Resort at Catskill Park.

In Section 7 of the DEIS, "Growth Inducing, Secondary, and Cumulative Impacts of the Proposed Action," Crossroads acknowledges only "minimal new potential residential and commercial development" which "may be accommodated by improvements to existing businesses. re-occupancy of existing structures or in-fill development in hamlets and villages" along the Route 28 corridor east and west of Belleayre.

Crossroads' claims that "environmental and regulatory constraints within the study area make new 'greenfield' development less attractive to potential developers." Recent local development trends suggest that new growth would certainly not be limited to older residential clusters. Indeed, Crossroads' proposed Belleayre Resort is but one example of such proposed "greenfield' development. This is corroborated from several sources of information. Information for the Town of Middltown and Villages of Fleischmans and Margaretville is illustrated on the attached map.

According to the Town of Middletown and the Villages of Fleischmanns and Margaretville, 68 new homes were built in Middletown since 1997. Of those, two homes are in the Village of Fleischmanns and none are in the Village of Margaretville. At a conservative estimate of about 7% impervious cover per 4 acre lot, these 68 homes resulted in about 20 acres of impervious surface being added to the watershed.

NYCDEP received 153 applications for new septic systems in Middletown during the same period. Three of those applications were for locations within the Village of Fleischmanns; one was for a location within the Village of Margaretville. New York City Department of Environmental Protection data for new septic tank permit applications also indicates that recent (post 1997) residential development in the Towns of Shandaken, Olive, Middletown, Roxbury, and Andes also has occurred largely in rural and unincorporated areas and not in existing villages and hamlets.

According to the U.S. census, roads built between 1995 and 2003 suggest substantial development activity in areas remote from villages and hamlets. In 1995, there were 69 miles of roads in Middletown. In 2003, there were 79 miles of roads, for a 14% increase. Assuming that the new roads average 30 feet wide, that means 1,584,000 square feet of new roads—36 new impervious acres. In Shandaken, road mileage increased 14% from 44 to 50—22 new impervious acres. To the west, in Andes, total road mileage increased 17% from 63 to 74—40 new impervious acres.

Such new development will cause impacts that are now not addressed in the DEIS. New homes and new or newly paved roads increase the extent of impervious areas, which concentrates and pollutes storm water carrying nutrients, petrochemicals, pesticides, and metals associated with human land use into surface water supplies as well as groundwater. Secondary growth will also destroy and fragment remaining wildlife habitat. New home will also impair the vistas from Catskill roads, trails, and streams, including public recreation lands for which the State has invested considerable tax dollars to purchase and maintain.

We suggest that the DEIS be revised to address these impacts by undertaking further study – including a build out - to project where secondary growth is most likely to occur. Statements that simply define the issue away are not adequate. Once likely areas of growth are identified, potential impacts to water quality, habitat, and recreational resources can be truly evaluated.

Phillips Preiss Shapiro Associates, Inc.

Planning and Real Estate Consultants

MEMORANDUM

To: Rob Pirani

From: Ken Bowers

Job: Belleayre (04108)

Date: August 16, 2004

Re: Interim findings

Paul A. Phillips
Richard Preiss
John Shapiro
Kenneth Bowers
Paul Grygiel

434 Sixth Avenue
New York, NY 10011
212 475 3030
Fax 475 0913
info@ppsaplanning.com

54 Shrewsbury Avenue
Red Bank, NJ 07701
732 764 0550

The purpose of this memo is to question the methodology and assumptions of the Belleayre DGEIS as they relate to economic impacts and growth inducing impacts. Note that in this case the growth inducing impacts are largely (but not exclusively) a function of the economic impact analysis, and that and under- or overstatements of the economic spin-off of the project leads to an under- or overstatement of the off-site development impacts.

This memo specifically addresses the following areas:

- The assumptions underlying estimates of off-site spending.
- The methodology used to extrapolate from spending to new retail square footage.
- The contention that new retail development will be attracted to existing village and hamlet centers rather than Route 28.
- The neglected role of image and promotional improvements in spurring renewed interest in the Catskills.

For the first topic, we have utilized the REMI analysis undertaken on behalf of New York City DEP to show the potential impacts of flaws within the RIMS II model. For the other topics, we rely on a careful reading of the DGEIS, along with our own experience and analysis.

Off-site Retail Spending

The estimates of off-site retail spending by the guests of the resort facility appear low and are not adequately documented. Table 4-16 of the AKRF report contains estimated per-party off-site spending for a variety of unit types and locations for timeshare visitors. The report notes that the different units will attract different size parties (ranging from an average of 3.5 to 6 persons) and will stay different lengths of time—yet the estimated per-day spending for each party type is estimated to be exactly the same, at $85!

The estimates for hotel visitors are even lower, at $25 per visitor party per day. This figure is barely enough to fill the visitor's gas tank, much less allow for other off-site expenditures for antiques, gifts, restaurant meals, etc. With nearly 100,000 estimated hotel visit-days per year, a variation of $10 in this estimate would change the estimated annual spending by almost $1 million.

Amount of New Retail

Based on the total amount of off-site retail expenditures, the DEIS calculates the amount of new retail development by dividing the total number by an average sales figure of $250 in annual sales per square foot of retail space. This method, as applied, is crude and likely to lead to a misestimation of the total square footage.

As shown in table 7-1 of the AKRF economic impact analysis (which was used as the basis for the DEIS), total retail sales were estimated for a variety of retail categories. Yet, the same average sales per square foot figure (which is taken from averages for entire shopping centers) is used for each retail category, notwithstanding the fact that different retail categories tend to have very different sales per square foot averages. For example, many restaurants have sales per square foot figures significantly lower than general merchandise stores. To the extent that much of the visitor spending is in categories such as restaurants, the DEIS may have underestimated the amount of retail square footage that the estimated spending would support. Sales figures for specific retail categories are readily available from sources such as ULI's *Dollars and Sense of Shopping Centers.*

Moreover, of the total of $23.4 million in estimated new spending due to increased wages and off-site visitor spending, the AKRF report (and hence, the DEIS) assumed away $4.2 million. Page 7.4 of the AKRF report states "the balance of spending between the total estimate of $23.4 million and the 19.2 million in the major SIC categories would be spread between other SIC categories found in the NYSA Route 28 corridor but would not have a measurable impact. Using the average of $250 in annual sales per square foot, this additional $4.2 million should support over 16,000 square feet of retail over and above the 76,000 square feet estimate, an impact which should be measurable whether the spending corresponds to a major SIC category or not.

Further, this analysis assumes that the existing retail market is in a state of balance, i.e., that the existing square footage perfectly matches existing local demand. Further, it assumes that an introduction of new spending power into the area will lead to no more development than can be supported by the new increment. There are several reasons to question whether this is true:

- As noted earlier, the amount of offsite spending by resort patrons may be significantly underestimated.
- Many if not most rural areas are underserved in key retail segments. As a result, spending that might be captured locally is leaking outside of the region. To the extent that the lure of the new resort population induces retailers in these underserved segments to locate in the area, they can capture not only the resort-related spending, but also the spending of local residents currently spent outside the region. The DEIS contained no analysis comparing estimated sales to trade area spending power, and therefore the amount of leakage that might be captured in this manner is unknown.
- Related to this, many national and chain retail tenants may have bypassed the Route 28 area because the demographics and traffic counts did not meet their site location criteria. To the extent that the new resort population changes these variables, these chains and franchises may be much more likely to locate in the vicinity, particularly along major transportation routes.

Location of New Retail

The DGEIS also argues that new retail spending will not induce development along Route 28, but rather will register in the form of reduced vacancy rates in the hamlets; an increase in sales for existing merchants; and limited infill development. This analysis is overly simplistic, and ignores the draw that the visibility of a Route 28 location will have for retailers.

First, retailers looking to capture spending from the new resort patrons will tend to located in areas near the resort itself, and preferably in the area east of the resort, where they can be seen by resort patrons en route between the resort and I-87. This description includes the centers of Phoenecia, Pine Hill and Mount Trempor; but does not include such centers as Arkville or Margaretville.

Moreover, many of the patrons of the new resort will be new to the Catskills—in fact, due to the exchange privileges offered by many timeshare plans, at least some of these visitors may only use the resort once. Businesses hoping to capture some of their business will be competing for visibility with these patrons, most of whom will be unfamiliar with the village centers, such as Phoenicia and Fleishmanns, that are located off of the main road. A Route 28 location clearly offers a competitive advantage by providing a location that is highly visible to all passersby.

Restaurants are a key business category likely to benefit from the increased demand of resort patrons. The DGEIS assumes that new restaurants will not induce new construction along Route 28: "New construction to meet the additional demand is not foreseen, especially as clusters of new restaurants (e.g. several restaurants in one strip-mall) are not typical" (page 7-7 of AKRF report). This discussion of strip centers ignores the fact that free-standing restaurants are a common feature of the rural roadside—indeed, several can be found along Route 28. Indeed, based on the type of restaurant, existing small-footprint spaces in village centers may be unsuitable. Many restaurants in seasonal locations tend to favor larger formats with higher seating capacities, to better capture the peak business periods (since a seasonal business depends on generating a large amount of revenue in a short period of time). For such operations, new construction may present the only viable option.

The DEIS also notes that much of the land along Route 28 is not zoned for commercial use. This may be true, but zoning is not immutable, and zone changes (or variances) in response to development pressures are not uncommon, especially in areas where municipal budgets are constrained and additional tax ratables welcome.

In short, the contention that nearly all the additional commercial development spun off from the new resort will be absorbed in existing Village centers seems based more on wishful thinking than on development realities.

Tertiary Impacts

The Route 28 corridor is a three-hour drive from the largest metropolitan population concentration in the nation. Yet, it has not captured its share of tourist dollars. The natural features of the area are of high quality. However, it lacks the concentration of amenities—quality lodging, a large variety of dining opportunities, and a critical mass of unique shopping—necessary to support repeat visitation and extended stays.

The Belleayre Resort has the potential to transform this situation. It will radically increase the number of hotel units and vacation homes. It will heavily market both itself and related attractions such as the ski center and nearby natural areas. It will also attract new off-site amenities including tourist-oriented dining and shopping. While the goal of the resort may be to capture all or most of this new activity on-site, its ability to expand beyond the proposed development program is limited. Further growth in the tourist market would therefore necessarily occur off-site.

Economically, the growth of the tourist economy is a virtuous cycle, in which increases in visitation spur the development of more tourism infrastructure, which in turn attracts more tourists. In this way a substantial tourist industry can grow from a single catalytic investment. Yet this growth has the potential to strain the infrastructure and environmental resources of an area not equipped to accommodate such growth.

Such tertiary impacts have been all but discounted in the DEIS, in part based upon the limited number of case studies examined. Yet RKG's study of two comparable resort areas—Snowshoe Mountain in West Virginia and Mountain Creek Resort in Vernon, New Jersey—show that follow-on development can and does occur around developments of this type, including significant amount of residential development. Even a modest amount of such development has the potential to place significant strains on local infrastructure and on sensitive environmental features.

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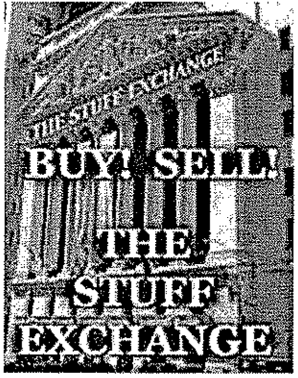
THE PHOENICIA TIMES

Covering the Town of Shandaken, Wild Heart Of The Catskills' High Peaks

Mt. Tremper, Mt. Pleasant, Phoenicia, Woodland Valley, Chichester, Allaben, Shandaken, Big Indian, Pine Hill, and Highmo

May 22 , 2003 - Home - Editorial - POV - Masthead - Contact The Phoenicia Times



CALENDAR

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Not Born Yesterday

30 Years of Comprehensive, Land Use, And Economic Planning in Shandaken

By Brian Powers

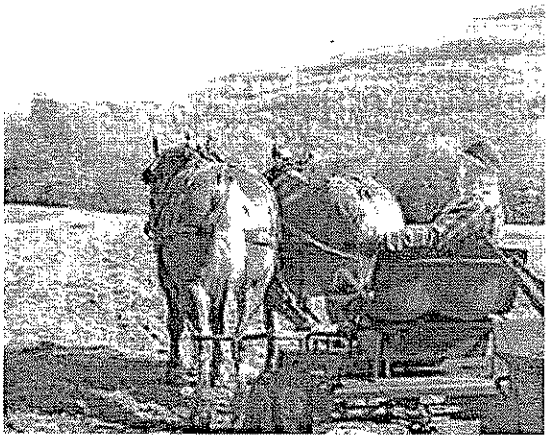
Olive finished theirs in 1995 but it's never been adopted by their Town Board. Woodstock's been working on one since 1998 but whether it's nearing completion is anyone's guess.

In light of how interested people have been recently in developing some kind of Comprehensive Plan for Shandaken, one might think the idea was fairly new. Actually, much of the current draft has been around for close to 10 years, though it's only recently that it's come under intense public scrutiny. And while some of the things that have drawn fire in the current draft were relatively new suggestions, others were taken straight from the draft before it, and from other planning documents that came before that.

Continue>>>

Hardening Positions

Coalition Backs Town On Resort Review Fees, Gitter Promises Legal Challenge



PHOENICIA'S AMOSY PECK, who's b logging with draft horses since FDR President, gives Dick & Jim a break fr their morning workout. Though g listeners, at 4,600 lbs for the pair cauti still in order around them. "You can their brains in neutral" says Amosy, " horses are always in gear".

The June Public Hearing at Town will be cablecast on channel **23** Wednesday **June 11 at 7 PM.**

Praying For Whom?

Onteora Students Question National Policy As Board Passes Required Mandate

By Eric Hersey

The Federal Government has decided ensure that each of the country's pu schools follows guidelines protecting student right to pray. But at Onteora Hi and other schools around the coun students are wondering whether the

THE PHOENICIA TIMES
Covering the Town of Shandaken, Wild Heart Of The Catskills' High Peaks
Mt. Tremper, Mt. Pleasant, Phoenicia, Woodland Valley, Chichester, Allaben, Shandaken, Big Indian, Pine Hill, and Highmo

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Follow Up on the News

Planning

There is a history to Comprehensive and land use planning in Shandaken, and th
is a continuity to that history and to the process. That continuity is reflected
what's in the draft plan and what's not, and by some of the people who've b
working on its text these many years. As the current committee grapples with h
or if to proceed, much of the debate has turned to who's pulling which way at
given moment, and why. Without a historical context for understanding that,
difficult to make sense of. What follows was compiled from a number of sour
including town, county, regional, and state officials, past and present.

Sept.1972 Shandaken's first zoning statute, a 4-page "Interim Zoning" progran adopted as Town law, at the initiation of the Town Planning Board. Planners: Cla & Associates, Rye. NY.
Sept.1973 Zoning Board of Appeals created, amidst explosive anti-zon sentiment. First Chairman, Michael Bobbick.
May 1976 Shandaken's first Zoning Ordinance adopted, along with Town's Zoning Map. Planner: Clarke & Associates.
June 1979 Amendments to Town Zoning Ordinance adopted to simplify some of suburban-oriented language adopted in 1976.
Dec. 1987 Current Zoning Code adopted. Planner: Arthur Brod, Troy, NY
May 1991 Councilman Marty Millman receives a copy of the town of Hunt Comprehensive Plan, and announces that Shandaken will hold its c Comprehensive Plan meeting.
Dec. 1992 Amended Zoning Map adopted, to correct confusion caused by error earlier mapping.
Feb 1993 Town Supervisor Neil Grant appoints Dean Gitter as Shandak representative to the Coalition of Watershed Towns, the DEC, and other agencies water resource management issues and their economic impact. Board also requ Planner Dan Schuster to apply for Watershed Planning Award program.
June 1993 Shandaken Town Board passes resolution forming the Route 28 Corri Committee "at the request of resident Dean Gitter", who is appointed Ch Committee members: Dick Clark, Erich Griesser, Harry Jameson, Don Kerr, Der Metnick, Glen Miller, Rick Petterson, Alan Rosa, Faye Storms, Geddy Sveikausk
Oct. 1993 Town Board appoints Al Frisenda to Route 28 Corridor Committee, replacing Dick Clark.March 1994 Route 28 Corridor Committee releases

Resource Protection and Economic Development Strategy for the Route Corridor, with principal recommendation for the "master planning, financing, development "of a major resort in proximity to Belleayre Mountain ski area. Ch Dean Gitter. Planner, Dan Schuster.

April 1994 Town contributes $2,500 toward incorporation expenses for the Cen Catskills Planning Alliance. July 1994 Central Catskills Planning Alliance forn Original President, Dean Gitter, Subsequent President, Erich Griesser. Planner, I Schuster. Consultants selected by Dean Gitter. Committee members: Jenn Gould, Beth Waterman, Sindy Becker, Al Frisenda, Geddy Sveikauskas, D Barnet. Funded by $75,000 grant from NYS Rural Economic Development (l restructured as NYS Empire Development Corp). No public meetings held development of report.

Oct.1996 According to town records of 5/99, a "Town of Shandaken Master F Committee" completes its "Goals and Policies for the Future of Shandaken". first of 8 goals is expansion of Belleayre, "supported by year-round sports cultural facilities connected to lodging, restaurant, and entertainment facilities". public meetings are held and no submission of this
plan is made to Town Board, County Planning Dept. or any other agency.

Jan. 1997 Town signs Memorandum of Agreement with NYC Dept. Environmental Protection. Feb. 1997 Town Board passes a resolution supporting privatization of Belleayre Ski Center along with unspecified "year-round sport cultural facilities".

June 1998 Town Board applies for $10,000 grant to NYS Dept. of State "Belleayre Gateway / Catskill Watershed Museum Project", under "Round 1" MOA Comprehensive Plan funding.

Aug.1998 Acquisitions begin of properties totaling 9% of Shandaken's private la Holdings later identified as comprising proposed Belleayre Resort at Catskill P project.

Nov. 1998 Central Catskills Planning Alliance releases Tourism Development F for the Central Catskills. 4 of 5 Development Policies proposed conc development in proximity to Belleayre Mountain, including development o "destination resort". Presidents:Dean Gitter, Erich Greisser. Planner, Dan Schuste

Dec. 1998 NYS Dept. of State denies Town's application for "Belleayre Gatew project funding on the basis that it is both site and project specific, not a town-w planning project.

Phoenicia Community Empowerment Project begins, facilitated by Planner He Budrock of the Catskill Center for Conservation & Development. Brian Powers l voted Chair with Exec. Committee members Mike Ricciardella, Declan Feehan, Harry Jameson.

Jan. 1999 Town Board under Supervisor Neil Grant appoints Zoning Rev Committee consisting of Glen Miller, Keith Johnson, Al Frisenda, Harry James Elizabeth Callahan, Art Christie, & Ted Byron. Liaison to Town Board: Edna H Planner appointed: Dan Schuster.

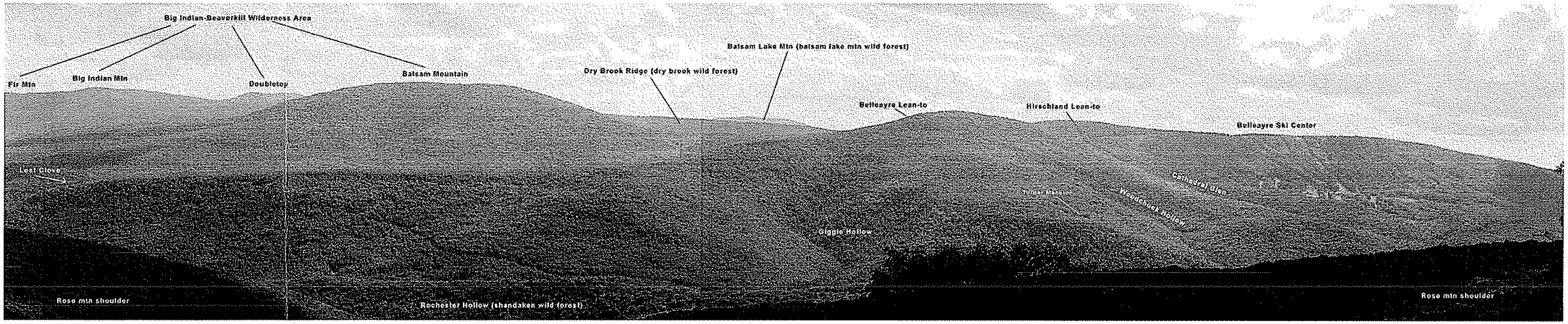
April 1999 Zoning Review Committee finalizes 22 amendments to the Cc withholding 10 for possible future action. 12 amendments are submitted to Town Board and adopted into law, including a revision of the Schedule of Regulations to allow "golf courses and Country Clubs" in all districts except wit hamlets. Super-majority vote of Town Board permits overriding of binding Ul County Planning Board recommendation opposing this. All changes drafted by I Schuster.

98

CPC # 98

180 Degree View From Atop Rose Mountain

CPC# 98a


Big Indian-Beaverkill Wilderness Area
Fir Mtn
Big Indian Mtn
Doubletop
Balsam Mountain
Dry Brook Ridge (dry brook wild forest)
Balsam Lake Mtn (balsam lake mtn wild forest)
Belleayre Lean-to
Hirschland Lean-to
Belleayre Ski Center
Lost Clove
Cathedral Glen
Turner Mansion
Woodchuck Hollow
Giggle Hollow
Rose mtn shoulder
Rochester Hollow (shandaken wild forest)
Rose mtn shoulder

99

CLU Ex. 99

Catskill Watershed Museum

MISSION/VISION

- MISSION/VISION
  - MUSEUM STUDY
  - MUSEUM LOCATION
  - **PROGRESS TO DATE**
- [illegible]
- [illegible]
- MUSEUM TOUR
- NEWS
- ABOUT US
- CONTACT US
- RESOURCES

Progress To Date

The Catskill Watershed Museum chartered by the New York State Board of Regents and has been established as a 501c(3) organization. Through the support of the Catskill Watershed Corporation, the O'Connor Foundation, the Crossroads Foundation and the Town of Middletown, we have secured an option on 44 acres of land. Architect Joe Hurwitz has done the preliminary designs for our building and Leonard Levitan has done initial exhibit design plans.

Our Board of Directors has begun to develop programs on the site and a charter membership program has been initiated.

Catskill Watershed Museum P.O. Box 10, Big Indian, NY 12410
845-254-5354 info@catskillwatershedmuseum.org

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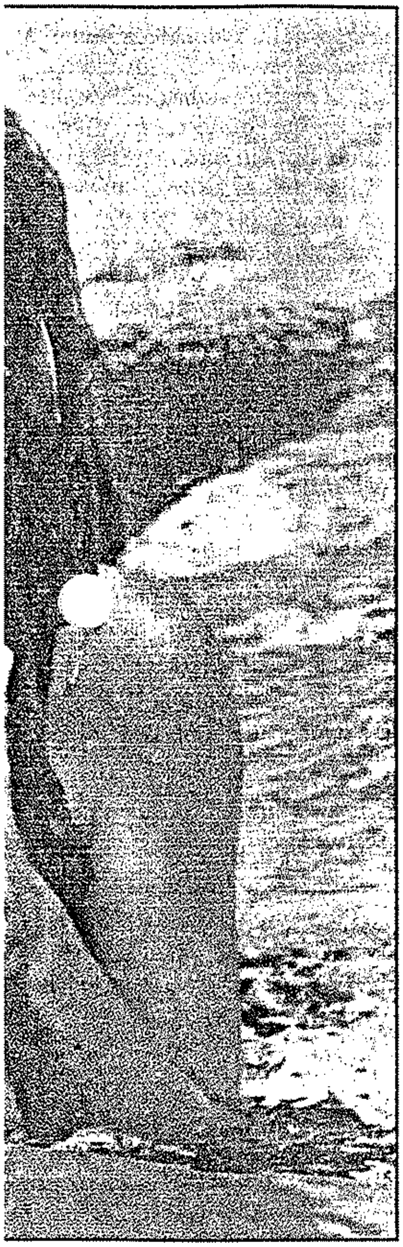
CPC #100

skill Mountain News

ETVILLE, NEW YORK 12455 Wednesday, Aug. 11, 2004 Periodical Postage Paid at Margaretville, NY 12455 Published Weekly 75¢



sh

session of swimming last week at ram. Above, Max Greenberg gives Sara[illegible]gakore and Tiffany Zullin ers. — Photos by Jodie Barber

M-ARK wins housing funding; director announces resignation

The Margaretville-Arkville Revitalization (M-ARK) Project formally announced this week that it has won approval of a funding package that will help bring a $4.6 million housing project to the Town of Middletown.

The positive news, long awaited by the community, comes on the heels of a less positive announcement that M*ARK Executive Director. Jennifer Gould, will leave that post next month and return to her native England.

The housing project, on the drawing boards for more than eight years. will create new housing opportunities for area senior citizens and for young families entering the work force. through construction of 14 family-style townhouses and 30 apartments on county Route 38 (the Crossroads) in Arkville.

"We are deeply grateful for the patience, tenacity and cooperation of everyone who made this milestone possible," said Gould, who has led the M-ARK Project for the last decade. "This housing is critical for the future of our community and I feel especially happy to see this come to fruition during my tenure here."

Plans for the project, developed in a partnership between M-ARK and Two Plus Four Construction of Syracuse, include the purchase. at market rate prices. of property currently owned by the town and originally slated for industrial development. Gould told the *News* that 30 – 40 constructions jobs would result, as will two new permanent, part-time jobs for operations. In the planning for eight years, the housing complex will use funding from NYS Housing Trust Fund, HOME and Low Income Housing Tax Credits.

In announcing the funding, Gould cited the cooperation of State Senator Bonacic who not only represents the area but also serves as the chair of the senate's housing committee. "These grants are very, very competitive," said Gould, "we needed support from Middletown Supervisor Leonard Utter and Assemblyman Cliff Crouch all the way up to Governor Pataki, and it was great to see that the support never wavered."

She said that new construction like this is especially important to a community because it gives seniors some place to move when they want to downsize and it frees up existing housing stock in the community for younger families who want to stay here.

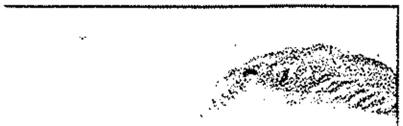
Gould, who led the M-ARK Project through some turbulent financial and organizational waters, got her feet wet, quite literally, during the 1996 floods that devastated the community. In the aftermath, she helped put together the program that saw New York City buy out 22 properties, many of which have been turned into mini-river parks or other well-used public spaces. Gould has facilitated completion of a number of long-planned projects since the turn of the century including a new entrance to Margaretville's village park and expansion of services to nearby communities like Andes and Roxbury.

She worked doggedly behind the scenes and then as a board member to help Margaretville Memorial Hospital and Mountainside Residential Care Center through threatened closure to more solid footing with the Kingston Regional Health Care System and was a key member of the team in a cooperative effort that saw Margaretville achieve the coveted Quality Community Award for Excellence from Governor Pataki's office.

Known for her indomitable spirit and inclusive approach, Gould says her greatest accomplishments at M-ARK revolved around helping the organization become more effective for more people. This included a shift in mission from "just housing" to a point where as a registered Rural Preservation Company (RPC) about 40 percent of organizational effort is in economic development while 60 percent remains housing driven. "We're much more interconnected with others than we were when I arrived," says Gould, "and I hope that's a legacy that continues."

M-ARK Board President Doug

(continued on page 3A)



War of words

M-ARK Project

(continued from page 1A)

Reeser said "My time with Jennifer Gould has been very enjoyable and she can take great pride in what she's accomplished." Reeser went on to say Gould was exacting in her approach and vital to her community. "Brenda and I have the deepest admiration and respect for Jennifer and wish her nothing but great success."

JR Lawrence, a member of M-ARK's board of directors concurred with Reeser. "She has been great for the community and for the region. She will be sorely missed."

Gould, who has lived in the US for 30 years and spent 16 of those in the Catskills, leaves with some sadness in addition to a record of achievement. "I love it here and deeply appreciate the friendships I've made and the opportunities I've had to serve my adopted homeland. But I never meant to stay this long and it's really time for a change."

Gould will leave in September to assume a similar post with a housing agency in Dorchester England. Though it's a much bigger organization – with 40 employees as compared to M-ARK's two, Gould says it's location two hours by train from London is not all that different from being two and a half hours from New York City.

"I'm really going to miss everyone," Gould added, "but with the funding in place for this new housing complex, I feel that I'm leaving the organization and the community in a good place. If M-ARK continues to look at the needs of our middle and working class population, and continues to work cooperatively with other organizations and the region's political leaders, I'm sure it will continue to grow and prosper through the next decade and beyond."

101

CPC 101

ULSTER COUNTY LEGISLATURE

P.O. BOX 1800
KINGSTON, NEW YORK 12402-1800

DANIEL L. ALFONSO, Chairman
WARD TODD, Majority Leader
FRANK DART, Minority Leader
RANDALL V. ROTH, Clerk
GERARD DE FELICIS, Deputy Clerk

Telephone: (914) 340-3900
FAX: (914) 340-3651

July 7, 2000

Assemblyman Kevin Cahill
1 Albany Avenue/Suite G-4
Kingston, NY 12401

Dear Assemblyman Cahill:

Thank you for the opportunity to present a proposal to you and your leadership for funding for the Catskill Mountain Rail Road in the Town of Olive. Ulster County is seeking $300,000 from the Assembly multi-modal funding program to supplement a grant coming from New York State Senator John Bonacic in the sum of $700,000.

The money would be used to construct a new railroad bridge trestle linking two portions of the CMRR tourist rail line. It is our hope that this major improvement in the rail line will result in increased ridership and with it, more tourist dollars. In fact, a study commissioned by Ulster County and conducted by Fairweather Associates of New Paltz, New York, indicated that if ridership can be increased to 50,000, we could anticipate an additional $1.6 million being spent by tourists in Ulster County and create as many as 35 new jobs. (A copy of the report is enclosed).

As evidence to our commitment to this project, Ulster County has secured more than $1 million in funding for improving the quality of the rail line in the last 18 months.

Thank you for your consideration. If you require any further information, please do not hesitate to contact me.

Sincerely,

Ward Todd

Ward Todd
Majority Leader

WT:ko

Enclosure

"Ulster County Makes It Happen"

FAIRWEATHER
CONSULTING
Assistance for Communities & Organizations

16 Grove Street
New Paltz, NY 12561
Telephone/Fax: 914-255-0611
Internet: *www.fairweathergroup.com*

CATSKILL MOUNTAIN RAILROAD
ECONOMIC IMPACT STUDY

completed for

Ulster County

By

FAIRWEATHER CONSULTING

March, 1999

EXECUTIVE SUMMARY

The purpose of this project is to create an estimate of the potential economic impact associated with the development of the Catskill Mountain Railroad Corridor as a tourism railroad. This project is intended to provide a definitive, objective description of the economic benefits such a railroad would have for Ulster County.

The Catskill Mountain Railroad can be a Viable Tourism Railroad

It appears that the Catskill Mountain Railroad has the potential to become a very successful tourism railroad. In no small part this is due to the hard work of a handful of extraordinarily dedicated and talented volunteers. Since leasing the right of way from Ulster County in 1983 (and signing a 25-year lease in 1991), the Catskill Mountain Railroad has established and maintained a right of way that can host a highly successful tourism railroad. This is no small achievement and one that should be commended and recognized.

The Economic Impact of Various Levels of Ridership for the Tourism Railroad

The economic impact of the growth of the ridership of the Catskill Mountain Railroad has been estimated by creating four scenarios of ridership. Each scenario assumes a certain level of annual ridership ranging from 15,000 (the "worst case" scenario) to 50,000 (the "most likely" scenario for the short-term, given the experience at other railroads) to visitation levels of 100,000 to 200,000 (the most optimistic cases).

Worst Case: If one assumes that ridership is at the 15,000 visitor level, that generates approximately $475,000 in new spending and $12,805 in sales tax revenues for the County. The additional income induced is $716,000, and ten jobs are directly induced, with the possibility of between four and 22 jobs induced indirectly.

Most Likely: If ridership can be grown to 50,000, the new spending in the County rises to $1.6 million, producing 35 new jobs directly, and inducing an additional $2.4 million in output in the County, with the possibility of between 12 and 72 additional jobs.

Most Optimistic: Should the CMRR attract 200,000 riders, it could generate 243 new jobs for the County and almost $17 million in induced income.

Next Steps

As this study has indicated, the Catskill Mountain Railroad has solid potential as a tourism railroad. Further, as indicated in the economic impact analysis, if CMRR ridership can be raised, the benefits to the County could involve millions of dollars of new tourist spending and potentially tens or hundreds of new jobs. Realizing this potential will involve the following steps:

INTRODUCTION

The purpose of this project is to create an estimate of the potential economic impact associated with the development of the Catskill Mountain Railroad Corridor as a tourism railroad. This project is intended to provide a definitive, objective description of the economic benefits such a railroad would have for Ulster County. The project outcomes are intended to be easily incorporated into a financial prospectus, funding requests and grant applications seeking to develop the corridor.

This project pays particular attention to the issue of feasibility. That is to say, it focuses its evaluation on a railroad corridor that has realistic chances of securing adequate financing, and which also has a critical mass (e,g., train trips and ancillary activities) to emerge as an even stronger tourist attraction for Ulster County.

A 1992 report issued by the Catskill Mountain Railroad Company, Inc. provides a concise overview of the origins of the Catskill Mountain Tourism Railroad:

> In the summer of 1916 the Ulster and Delaware Railroad, the original builder of the [Kingston-to-Highmount] line, scheduled three passenger trains daily each way between Kingston on the Hudson River and Oneonta in New York State. This was to handle the influx of summer visitors to the hotels and lodges in the surrounding mountains. All of those famous wooden structures are gone now but the area has remained vibrant with both summer visitors to camps and motels and with the winter sports enthusiast as well.
>
> The Ulster & Delaware Railroad was merged into the West Shore Division of the New York Central before it too was taken over by the Consolidated Rail Corporation (Conrail). Passenger service was discontinued in 1954 and all operations ceased in 1976. At that point the line was to be sold for scrap. However, [in 1979,] the Ulster County government stepped in and purchased the 38 miles from Kingston westward to Highmount.
>
> The Catskill Mountain Railroad Company (CMRR) was organized in 1983 and has entered into a [25-year] lease agreement with the County to operate trains over this historic rail line as a tourist railroad.
>
> The first of several sections of the 38-mile lease to be rehabilitated was the 2.8 miles between Mount Pleasant and Phoenicia over which the Esopus Creek Shuttle Train is now providing service to the community and its summer visitors. [See Figure 1.]

The Catskill Mountain Railroad Company, Inc.,
A Business Plan to Introduce the Scenic Train, 1992, p. 2.

This project uses existing studies and data to estimate the job and income creation potential of a Catskill Mountain tourist railroad for Ulster County. Establishing the railroad's economic impact involved the following tasks:

Task 1: Define a Commercially Feasible Corridor for Catskill Mountain Railroad.
The study uses information on operating railroads to define the minimum components necessary for a commercially viable tourism railroad (e.g., minimum miles required for a tourism railroad to serve as a destination, amenities/ facilities required, etc.) These criteria have been used to define a corridor along the existing Catskill Mountain right-of-way that could support such a tourism railroad.

Task 2: Create Economic Impact Model.
Using existing data and previous studies, a model has been created to estimate the income and job generating potential of the development of the defined corridor into a tourism railroad in the County. One of the most important aspects of this study is the estimation of indirect "ripple effects" associated with the jobs and income directly generated by the railroad. In order to assure the most accurate and objective assessment of these indirect benefits, the analysis uses multipliers developed specifically for Ulster County by the US Bureau of Economic Analysis under its Regional Income Multiplier System (RIMS). The multipliers were applied to estimates of direct spending by category of expenditure. The resulting model examines the economic impact of the creation of a tourism railroad in terms of:

- Jobs created
- Income generated
- Increases in retail sales
- Associated increases in tourism related sales tax revenues for the County.

Task 3: Estimate Economic Impacts of Railroad Corridor.
The model is used to generate a range of potential impact, based upon three sets of visitation rate: most likely (50,000 annual visitors), most optimistic (100,000 to 200,000 visitors), and most pessimistic (15,000 visitors).

Task 4: Develop a Program of discrete projects that can be Conducted in Phases to Create a Commercially Feasible Tourism Railroad.
One of the major deterrents to the completion of a Catskills tourism railroad in Ulster County is the sheer enormity of the undertaking. Estimates to re-establish a Kingston-to-Highmount track run in the tens of millions of dollars. Therefore it is essential that the development of the railroad be defined as a series of discrete projects that are both administratively manageable and financially feasible. So in addition to providing an estimate of economic benefits, this project developed a phased work plan for re-establishing a tourist railroad in Ulster County.

The work plan will use the elements of a commercially viable tourism corridor developed in the first part of the study as the endpoint toward which all railroad improvement

Table 1. Summary of Tourism Railroads with Track of 15 Miles or Less.

Tourism Railroad	Valley Rail Road Co., Essex, CT	Georgetown Loop Railroad Georgetown, CO.	Strasbourg Railroad, Strasburg, PA	Arcade and Attica Railroad Arcade, NY	Tioga Scenic Railroad Owego, NY
Contact	Henry Thorpe, CEO	Lindsey G. Ashby, CEO	G. Fred Bartels, CEO	Linda Kempf, Gen. Mgr.	Steven May, Proprietor
Length of Ride in Miles	14-mile round trip	6.5- mile round trip	9-mile round trip	15-mile round trip	22-mile round trip
Duration of Ride	2 hours 30 min.	70 minutes	45 minutes	1 hour 40 min.	2 hours 30 min.
Target Markets	Connecticut area is 50% of ridership	Summer visitors to Denver and Vail.	Major metro. Areas within a 2.5 hour drive time (NY, DC, Phil.)	2/3 from local area 1/3 from "rest of world"	Local schools & orgs. for developmentally disabled Senior bus tours
Special Features of Railroad	• Steam Engine • Connects with Riverboat ride • A "Connecticut River" experience	• Spectacular Mountain Scenery • Steam Engine • Provides access to State Mining Museum	• Exclusive use of Steam Engines • Dining Car Service • All coaches wooden	• Steam engine • "Hawker on all non-school rides to entertain & sell souvenirs •	• Dining on train • Link to 1840 "living museum" • Entertainment on every train
Approximate Annual Visitation/ Ridership	160,000	124,000	390,00	30,000	20,000
Basis of Attraction	"A Connecticut River Tourist Attraction"	Highly scenic route, midway between Denver and Vail, CO	Historic Experience /re-enactments. State RR museum is across the street; National Toy Train Museum w/in walking distance	Historic experience (steam & wooden cars) Entertainment (murder mystery trains, Civil War re-enactments, summer barbecues w/ local fire departments	Tourism railroad is sideline to freight (linked w/ Conrail and Norfolk So.) 1930s-40s theme to appeal to Seniors

Cross-promotion was also identified as essential. As one operator put it, they look to cross-promote with other large attractions that look for high-volume visitation, regardless of the type of attraction. Their current cross-promotions involved nearby theme parks and a Renaissance fair.

In summary, the most important attributes for a successful tourism railroad appear to be:

1. A location which provides access to major markets within two to two-and-a half hours drive time. (The trains with ridership over 100,000 annually shared this characteristic.)

2. Creation of a Larger Tourism Experience of which the Railroad is only a Part.

3. Marketing and promotion, including:
    a. a professional-quality brochure distributed as widely as possible (through a professional firm, if possible);
    b. creation of special events to draw ridership;
    c. well-developed directional signage.

Preliminary Conclusion: The Catskill Mountain Railroad can be a Viable Tourism Railroad

Based upon the interviews conducted to date, it appears that the Catskill Mountain Railroad has the potential to become a very successful tourism railroad. In no small part this is due to the hard work of a handful of extraordinarily dedicated and talented volunteers. Since leasing the right of way from Ulster County, the Catskill Mountain Railroad has established and maintained a right of way that can host a highly successful tourism railroad. This is no small achievement and one that should be commended and recognized.

The next questions focus on how the potential of this asset is to be fully realized. Specifically:

- What are the specific steps that should be taken to further develop ridership on the CMRR?
- What will be the economic impacts of that increased ridership?
- What role should the County play in that process?

These questions will be the addressed in the remainder of this report, beginning with a description of the methodology for determining the potential economic impacts of the further development of a tourism railroad in Ulster County.

The far right-hand column of Table 2 estimates the average expenditure per visitor based upon the reported amounts spent by those who made expenditures adjusted by the proportion of the respondents who actually spent money. Once the expected levels of visitation are estimated, they can be multiplied by these expenditure figures to estimate direct expenditures by visitors to the Catskill Mountain Railroad. The County's 3.75 percent sales tax rate is applied to estimates of spending in the categories of meals, souvenirs, books and other to estimate the fiscal impact of the railroad's development on the County.

Note that this analysis focuses strictly on the economic impact associated with bringing new tourism dollars into the County. The study does not include admissions and fees paid to the CMRR by riders. Nor does it consider the impacts of CMRR spending for such things as staff wages, and maintenance of track and rolling stock. While these items are not likely to be on the same order of magnitude as the tourism spending, it should be remembered that the estimates produced in this analysis do not include income earned by the CMRR or direct spending by the CMRR. Therefore this study understates the total economic impact of the Railroad at any given level of ridership.

Creating a Model of Tourism Visitation—Estimating Indirect Impacts: Once direct expenditures have been estimated, the study then estimates the indirect effect this new spending has on the Ulster County economy. This indirect effect measures the "ripple effect" of the direct spending. For example, if a tourist buys a hot dog from a vendor, that vendor must replenish his or her supplies of hot dogs, mustard, napkins, etc. This means that the first direct expenditure on a hot dog by the tourist sets off a chain of spending that creates new demand for the people who supply the hot dog vendor.

This estimates the "ripple effect" of spending in the categories of meals, transportation, lodging, souvenirs, books and other spending using multipliers developed by the US Bureau of Economic Analysis under its Regional Income Multiplier System (RIMS) that have been developed specifically for Ulster County. Thus the analysis will provide the most accurate possible model of how the direct and indirect effect of tourism spending associated with the Catskill Mountain Railroad might affect the overall economy of the County in terms of income and jobs.

THE ECONOMIC IMPACT OF VARIOUS LEVELS OF RIDERSHIP FOR THE TOURISM RAILROAD

The economic impact of the growth of the ridership of the Catskill Mountain Railroad has been estimated by creating four scenarios of ridership. Each scenario assumes a certain level of annual ridership ranging from 15,000 (the "worst case" scenario) to 50,000 (the "most likely" scenario for the short-term, given the experience at other railroads) to visitation levels of 100,000 to 200,000 (the most optimistic cases). The economic analysis focuses on those riders that come from outside the County and therefore bring new money into the County. At an annual ridership of 15,000, it is assumed that one-half of the riders will come from within the County. (This is consistent with the experiences of the tourism railroads interviewed for this study.) As ridership increases, the analysis

Table 3.

Scenario 1: 15,000 Annual Ridership

Projected Outside Visitors 7,500

Category	Total Spending	County Sale Tax Revenue	Directly Induced Jobs	Directly Induced Output
Meals	$ 242,325	$ 9,087	6.1	$ 368,988
Transportation	50,850	-	0.8	72,670
Lodging	82,275	-	1.3	127,288
Souvenirs	67,500	2,531	1.4	100,265
Books	15,750	591	0.3	23,395
Other	15,900	596	0.3	23,618
Total	$ 474,600	$ 12,805	10.4	$ 716,223

	Low	High
Range of Indirectly induced jobs	3.6	21.5

Table 4. Scenarios 2 through 4.

Scenario 2: 50,000 Annual Ridership

Projected Outside Visitors 25,000

Category	Total Spending	County Sale Tax Revenue	Directly Induced Jobs	Directly Induced Output
Meals	$ 807,750	$ 30,291	20.5	$ 1,229,961
Transportation	169,500	-	2.8	242,232
Lodging	274,250	-	4.3	424,292
Souvenirs	225,000	8,438	4.8	334,215
Books	52,500	1,969	1.1	77,984
Other	53,000	1,988	1.1	78,726
Total	$ 1,582,000	$ 42,684	34.6	$ 2,387,410

	Low	High
Range of Indirectly Induced jobs	11.9	71.6

Scenario 3: 100,000 Annual Ridership

Projected Outside Visitors: 75,000

Category	Total Spending	County Sale Tax Revenue	Directly Induced Jobs	Directly Induced Output
Meals	$ 2,423,250	$ 90,872	61.4	$ 3,689,883
Transportation	508,500	-	8.4	726,697
Lodging	822,750	-	13.0	1,272,877
Souvenirs	675,000	25,313	14.4	1,002,645
Books	157,500	5,906	3.3	233,951
Other	159,000	5,963	3.4	236,179
Total	$ 4,746,000	$ 128,053	103.9	$ 7,162,231

	Low	High
Range of Indirectly Induced Jobs:	35.8	214.9

Step 1. Defining the "Tourist Experience."

Our research has made it clear that all successful tourism railroads position themselves as a tourist experience. This is the next logical step for the Catskill Mountain Railroad. This experience should be defined based upon:

The existing inventory of rolling stock. While many tourism railroads use steam engines to create a nostalgia experience, it is not necessary for a tourism railroad. One diesel operator has committed his line to providing "entertainment on every train," which includes musicians, magicians, storytellers and dining. The opportunities for creating an "experience" must be realistically grounded in the rolling stock of the railroad. If the stock itself is not distinctive, the experience must be derived from other factors (e.g., programming, promotions, the countryside through which the train moves, etc.)

The nature of the right of way. The Georgetown Loop Railroad in Colorado can use its right of way as the core of its experience due to its spectacular scenery. For most tourism railroads (including the CMRR), the scenery by itself will not be enough to build ridership. Nonetheless, there may be ways to use sites and venues along the right-of-way to begin to build a tourism experience. The existing relationships with the Empire State Railway Museum and the Esopus "tubing" operations may provide a solid basis for developing this experience.

Potential partners for cross-programming and cross-promotions. Every operator indicated that a tourism railroad could not be a stand-alone tourism experience. Its "draw" is created by partnerships with other nearby tourism attractions. In its early plans, CMRR was very interested in building upon the momentum created by the Catskills Interpretive Center that was originally proposed for the region. While the future of the Interpretive Center is not clear, there are other attractions that may make good partners for the Railroad. These include Catskill Corners, the proposed Watershed museum, Belleayre and the other ski areas, various restaurants in the area, and the existing partnerships with the Railway Museum, the tube rental operations and the hamlet of Phoenicia.

Step 2. Developing a Business Plan for the "Tourist Experience"

Once an inventory of local resources has been completed and a potential tourism experience defined, the next step is to create a plan to realize the experience. The elements of the plan should include:

A clear statement of the nature of the experience being provided. This statement should describe the kind of experience (e.g.,"1940s nostalgia," "rural America," "wilderness train,"etc.), the target market to which this experience will appeal (e.g., seniors on motor coach tours, school groups, families visiting the ski areas, etc.), and the facilities, programs, partnerships, and other items which will contribute to this experience.

A facilities and operations plan to realize the experience. This element should describe the ways in which facilities and operations will be developed to help provide the experience. The plan should include estimates of costs of development for both facilities and programs. For example, the signage and ticket booths used may need to be reconfigured to better communicate the experience sought. There may need to be some additional track restoration to better integrate the ride with other aspects of the total experience. (For example, the track between the current Mount Pleasant station and Route 28 might be restored, and the station itself moved slightly southward to provide a

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New York State Department of Environmental Conservation. *Proposal for a Catskill Interpretive Center*. May, 1987.

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Dr. Ann Davis & Dr. Peter Winne. *Impact of Visitors to Historic Sites in the Hudson River Valley: A Marist-Greenway Survey of Visitors*. Hudson River Greenway Council, June 19, 1997.

Shuster Associates. *Catskill Mountain Railroad Environmental Assessment, Ulster County New York*. January, 1991.

Steam Passenger Service Directory. Kalmbach Books, 1997.

Ulster County. *New York State ISTEA Transportation Enhancement Program: Catskill Mountain Railroad NYS Route 28 Crossing*. July, 1994.

U.S. Bureau of Economic Analysis. *Regional Income Multiplier System for Ulster County*, (Final-demand and Direct-effect multipliers), 1999.

Tourism Railroad____

Contact:______________________________________

Length of Ride in Miles

Duration of Ride in Hours/Minutes

Operating Season(s)

Special Events

Cross Promotions

Target Markets (geographically and by interest/demographics)

Special Features of Rail road

Annual Visitation/Ridership

Basis for Attracting Riders (special features, other destinations, etc.)

The multipliers used in this study are part of the Regional created by the US Bureau of Economic Analysis (BEA). According to the BEA:

☐

> The RIMS II model estimates multipliers for output, earnings and employment for any region in the United States composed of one or more counties. The two main data sources used to calculate RIMS II multipliers are BEA's 1992 benchmark input-output (I-O) accounts for the U.S. economy and BEA's 1995 regional economic accounts.

The multipliers used in this study included:

	Final Demand Multipliers	
Sector of Ulster Co. Economy	Output (dollars)	Employment (jobs)
Retail trade except eating & drinking	1.4854	22.4
Other lodging places	1.5471	16.7
Eating & Drinking Places	1.5227	26.7
Automotive repair shops & services	1.4291	17.3

☐

Each output multiplier measures the total dollar change in output in all industries in only Ulster County that results from a one-dollar change in the output of that particular industry.

Each employment multiplier measures the total change in number of jobs in all sectors in only Ulster County that results from a $1million change in the output of that particular industry.

The effects of increased spending in souvenirs, books and other spending were estimated using the multipliers for "retail trade except eating and drinking." The effects of increased spending on meals were estimated using the multipliers for "eating and drinking places." The effects for transportation were estimated using "automotive repair shops and services" (assuming all visitors to the railroad would travel by car to reach it). The effects for lodging were estimated using the multipliers for "other lodging places" assuming that most visitors would stay at motels and beds and breakfasts rather than hotels.

☐

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CPC102

TOWN OF SHANDAKEN
PLANNING BOARD

P.O. Box 134 - Rt. 28
Town Hall Building
Shandaken, NY 12480
914-688-5008

184

APPLICATION FOR SUBDIVISION AND/OR LOT ADJUSTMENT

OWNER OF PROPERTY: CHELSEA PARK COMPANY

MAILING ADDRESS: 17 RIVER STREET, WARWICK NY 10990

TELEPHONE #: 845.986.7737

LOCATION OF PROPERTY: On the WEST sides of PINE HILL RD Road being also State/County Highway # OLD RT 28 approximately 800 feet from ACADEMY STREET Road in the Hamlet of FORMERLY PINE HILL Zoning District R1.5

SECTION: 4.37 **BLOCK:** 1 **LOT#** 2.112, 2.5 and 4

DEVELOPER (if other than owner): SAME AS OWNER

MAILING ADDRESS:

TELEPHONE #

SURVEYOR OR ENGINEER: JOHN LEHMAN PE LEHMAN & GETZ PC

MAILING ADDRESS: 17 RIVER STREET, WARWICK NY 10990

TELEPHONE # 845.986.7737 845.986.0245 FAX lehman@lehmangetz.com

OTHER REPRESENTATIVE: PETER GOERTZEL, PARTNER

MAILING ADDRESS: 98 WALL STREET, WEST HURLEY NY 12491

TELEPHONE # 845.679.7009

TOTAL AREA OWNED AT SITE: 38± ACRES

NUMBER OF PARCELS BEING CREATED BY SUBDIVISION: 17

LOT #1	2.05 AC	LOT #2	1.62 AC	LOT #3	1.85 AC	LOT #4	1.51 AC
LOT #5	2.51 AC	LOT #6	1.91 AC	LOT #7	1.68 AC	LOT #8	1.70 AC
LOT #9	1.88 AC	LOT #10	3.48 AC	LOT #11	4.63 AC	LOT #12	1.68 AC
LOT #13	1.56 AC	LOT #14	1.51 AC	LOT #15	1.74 AC	LOT #16	2.00 AC
LOT #17	1.97 AC	LOT #18		LOT #19		LOT #20	

EASEMENTS, COVENANTS OR OTHER RESTRICTIONS NOW APPLYING TO THE PROPERTY:
ACCESS EASEMENTS FOR THE BENEFIT OF THE INTERNAL PROPERTY OWNERS

PURPOSE OF SUBDIVISION/PROPOSED USE OF PROPERTY:
RESIDENTIAL SINGLE FAMILY HOMES

The undersigned as individual owner(s) or as a qualified officer of the corporation of the above described property request approval of a proposed subdivision or Lot Line Adjustment of that property in accordance with a plat to be submitted with required supporting data as provided in the Subdivision Regulations of the Town of Shandaken and hereby authorize entry upon the property for site inspection by members and authorized representatives of the Planning Board.

Date: 6/8/04

Signature: JOHN LEHYMAN PE

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Robert Cross
Supervisor, Town of Shandaken;

Dear mister Cross, we would like to request an opportunity to introduce to the town board, a planned development of a 96 room hotel on the rt. 28 corridor just east of Pine Hill proper. We would like to describe our plan, it's scope and positive implications it would have on our community. At that time we are prepared to supply a site plan and an overview of the project. We would like to appear before the town board on May 3, 2004.

Please feel free to advise us as to anything else you may require at that time.

Respectfully,

Ron Odato
John Odato

MISSION STATEMENT

1. We are prepared to build a 96 room hotel within the hamlet town of Pine Hill on the North side of Rt. 28, directly across from friendship manor.
2. It's general appearance shall be a tasteful combination of log, stone and glass in a rustic yet contemporary Catskill styling.
3. Road side route 28 appeal will be enhanced by maintaining existing mature plantings and accenting and landscaping with native pines , birch trees and foundation plantings.
4. It's logistical implication will meet the lodging needs of an ever expanding Belleayre Ski Center and the ever growing popularity of the Forever Wild Catskill Mountain Forest Preserve who's clientele prefer moderate pricing and proximity to Belleayre, Pine Hill and the high peaks of this region.
5. Our intention is to tap into a well rounded four season economy by tailoring this hotel to accommodate other industries besides tourism, such as conferences, retreats, receptions and personal improvement seminars.
6. Incorporate a restaurant, gift and conveyance shop in gade fashion and Catskill motif, for local merchants to establish venues, and a wholesome theater venue for guests and local population.
7. Provide shuttle service to and from Pine Hill, Phoenicia and Belleayre Ski Center..
8. Encourage transport companies such as Pine Hill Trail Ways and Adirondack Trail Ways to incorporate this Hotel as a regular stop.
9. Develop small bus tours originating from the hotel, visiting local establishments and places of interest for the purpose of stimulating local economy and encouragement of further tourism.
10. Create employment opportunity on all levels for the local work force.
11. Significantly increase the tax base for the Township of Shandaken.
12. Encourage the stimulation of healthy growth which is in concert with one specific aspect contained in all developed comprehensive plans created for this immediate region ;
    A.. The enhancement and development of the eco-tourist industry along the route 28 corridor contiguous with hamlet or town boundaries.
    A.1. The creation of the necessary infrastructure, water and sewer, which we have.
    2. Increase the tax base, which it will significantly do.

A.3. Encourage and develop the "best use" for land which suffers from the "worst use" syndrom.

Currently, this land has inherited, through age and the rising cost of up keep, improvement and local taxation, the symptomatic degenerative disease known as " non viability". This condition has been seen as the ugly and detrimental aspect of of our beautiful countryside and has added to a diminishing prosperity for generations.

When entrepreneurial instinct and financial ability are in concert with the asthetic and socio-economic vision of an area, and when the positive fall out from such instinct and ability are so clearly identifiable and deemed desirable, then it is incumbent on local government and affected population to work toward the common good and not the myopic and narrow view of change.

A.4. Successfully and easily dovetail into the DNA of our region, which it does by virtue of the many aspects of positive fall out from such a development.

* Increased real estate taxation with no local government or service burden.
* The increased visitor numbers alone augment the exposure to all tourist businesses in this area. (increased tourist revenue) (increase tax revenue)
* The 2nd home market is stimulated, exposing the service oriented businesses in our area, (house cleaning, security, landscaping ,etc..) which in turn increases local population income and purchase power, thus adding prosperity and tax revenue.
  Our area appeal is well known and desirable, as can be attested to by the number of 2nd home and primary home purchases in recent years. Exposure derived from a 96 room hotel will magnify regional exposure to more prospective home owners.
* Helping to insure vitality in a real estate market will help insulate a market prone to adverse market conditions. This regions real estate market has historically been the first to reflect poor national economic news and the last to recover from good economic news. Historically, a real estate market which reflects limited availability and high degree of desirability results in stability, safety and enhanced value, something foreign to this region because of our inability to attract the right kind of development and improvement. .

A.5. Begin to build a legacy which will become the future DNA of our unique and fragile life style. Not change what we do, but rather, improve how we do it.

This will effect not only us but our children. Having a life style which they may desire and choose to return to following their education can be realized.
A new generation has moved to this region who have the financial means and intentions of raising families. The leading edge of the baby boom generation are retiring earlier. The crest of that generation now have children of their own who are affluent and are themselves attached to electronic businesses, creating a mobil life style never before dreamed of. They see themselves as families coexisting with rural living. We can help usher in this prosperity.

VISION STATEMENT

Create a beautiful, quality and affordable hotel which will draw it's vitality from the largest economic sector in this region, the eco-tourist industry. Build into it, the versatility to attract a broader spectrum of use. Concentrate this lodging establishment along the route 28 corridor within the hamlet boundary which existed prior to the dis-incorporation of Pine Hill. Capture and localize this growing industry, (tourism), in numbers which will create a significant and positive economic impact on the specific economy of Pine Hill and Shandaken in general. Utilize the entrepreneurial sensibility and desires of our town to help shape the appearance and type of hotel establishment which will ultimately reflect the character and economic plan our town desires. Begin to develop an economic legacy which will enable our children and children's children to live and work in this beautiful area of New York State. .

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CPC Exh 104

BELLEAYRE
MOUNTAIN

Our Mission Statement

1. To preserve and protect the environment

2. To provide recreation

3. To serve as an economic stimulus to the local region

4. At no cost to the tax payer

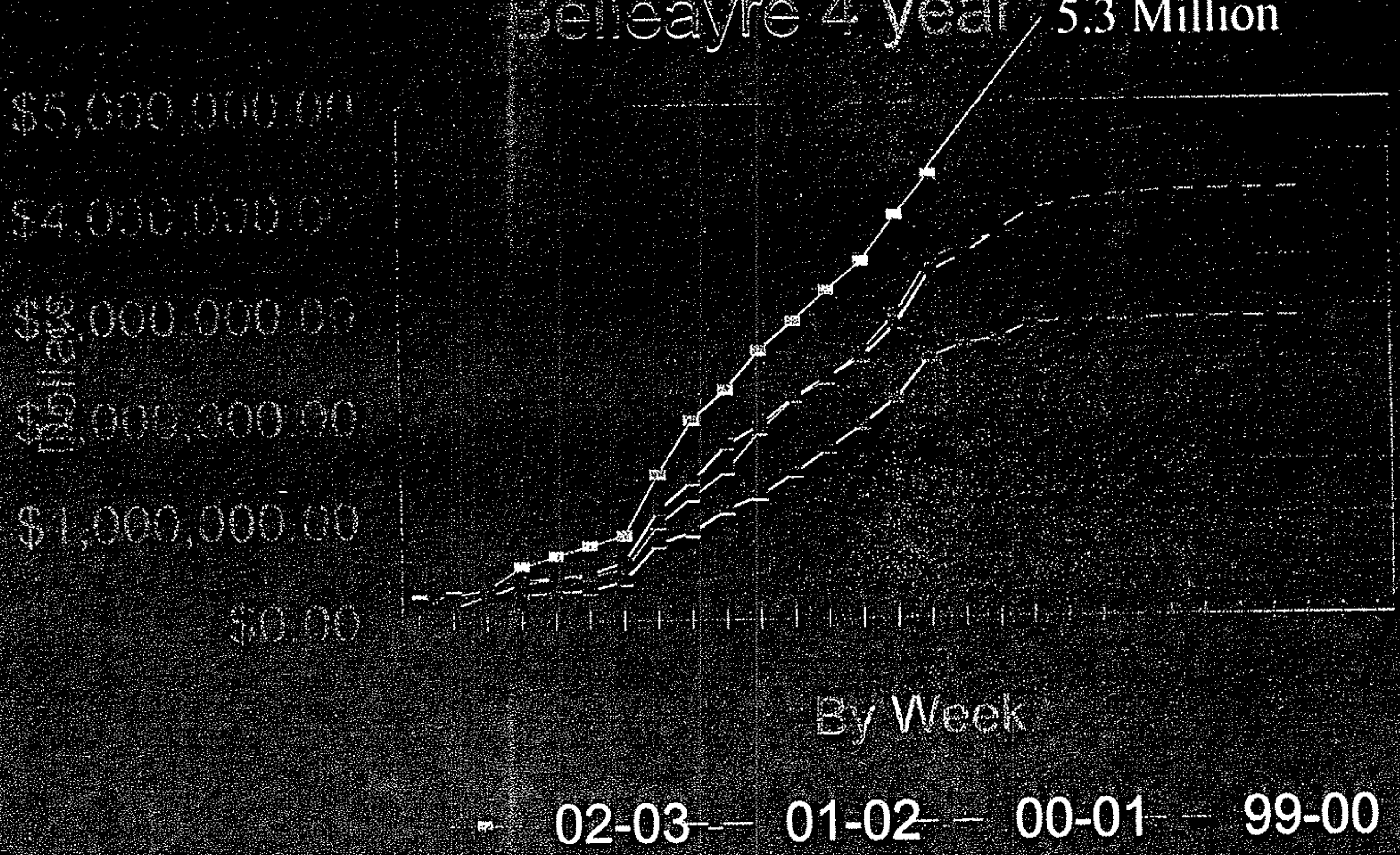
5. To serve as a model for future growth of other ski areas

Why we are here

In order to not only insure Belleayre's continued growth but to be certain that our vision is environmentally sound and consistent with that of our neighbors and guests, we are conducting an open forum to encourage the partnership we have enjoyed in achieving our shared goals. Our commitment to be in harmony with this community is steadfast. It is in this spirit that we are presenting our vision of the future of this mountain as it relates to our friends, neighbors and visitors.

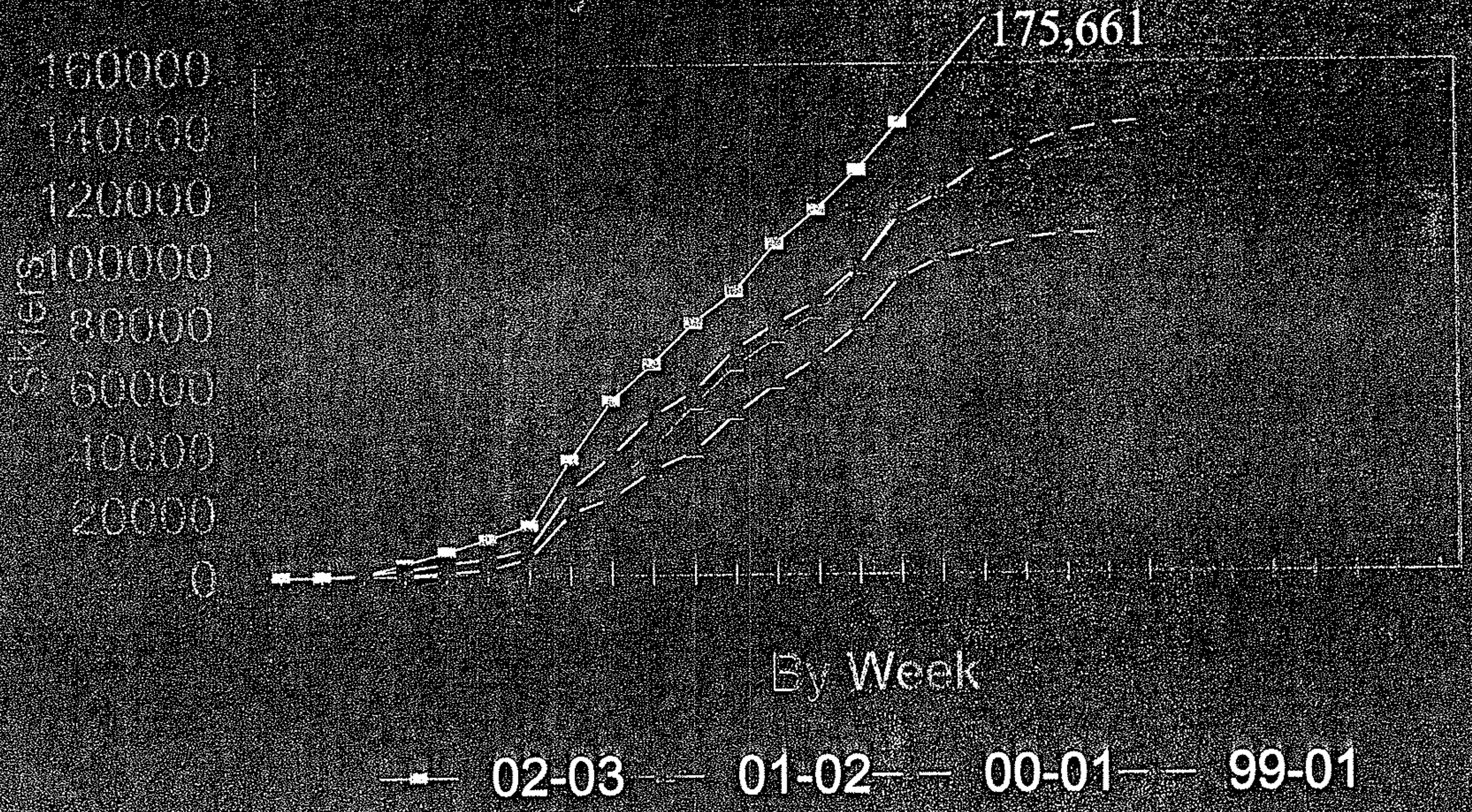
Revenues

Belleayre 4 year



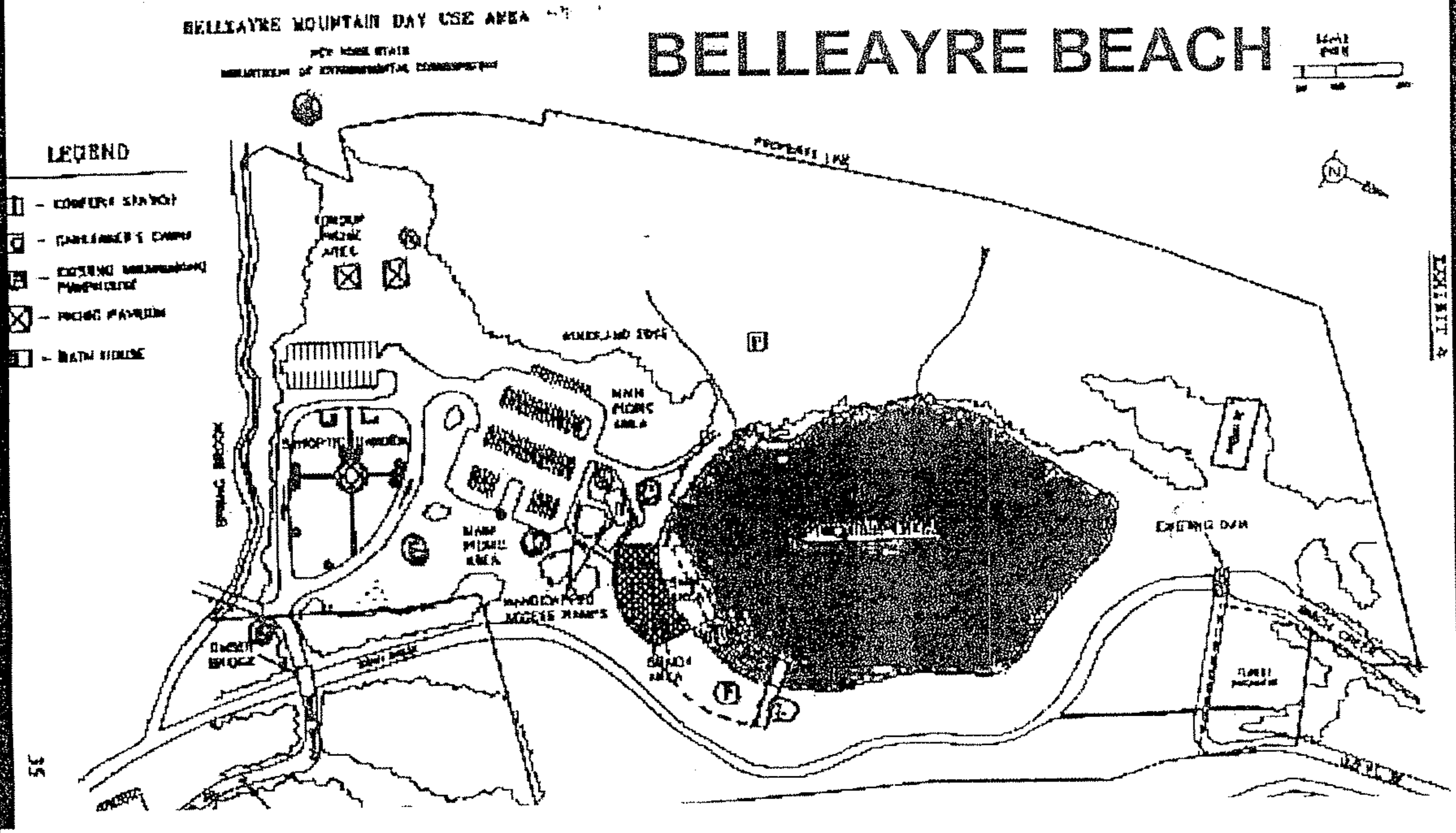
Skier Visits

Belleayre Mountain 4 Year



SUMMER OPERATION

BELLEAYRE BEACH

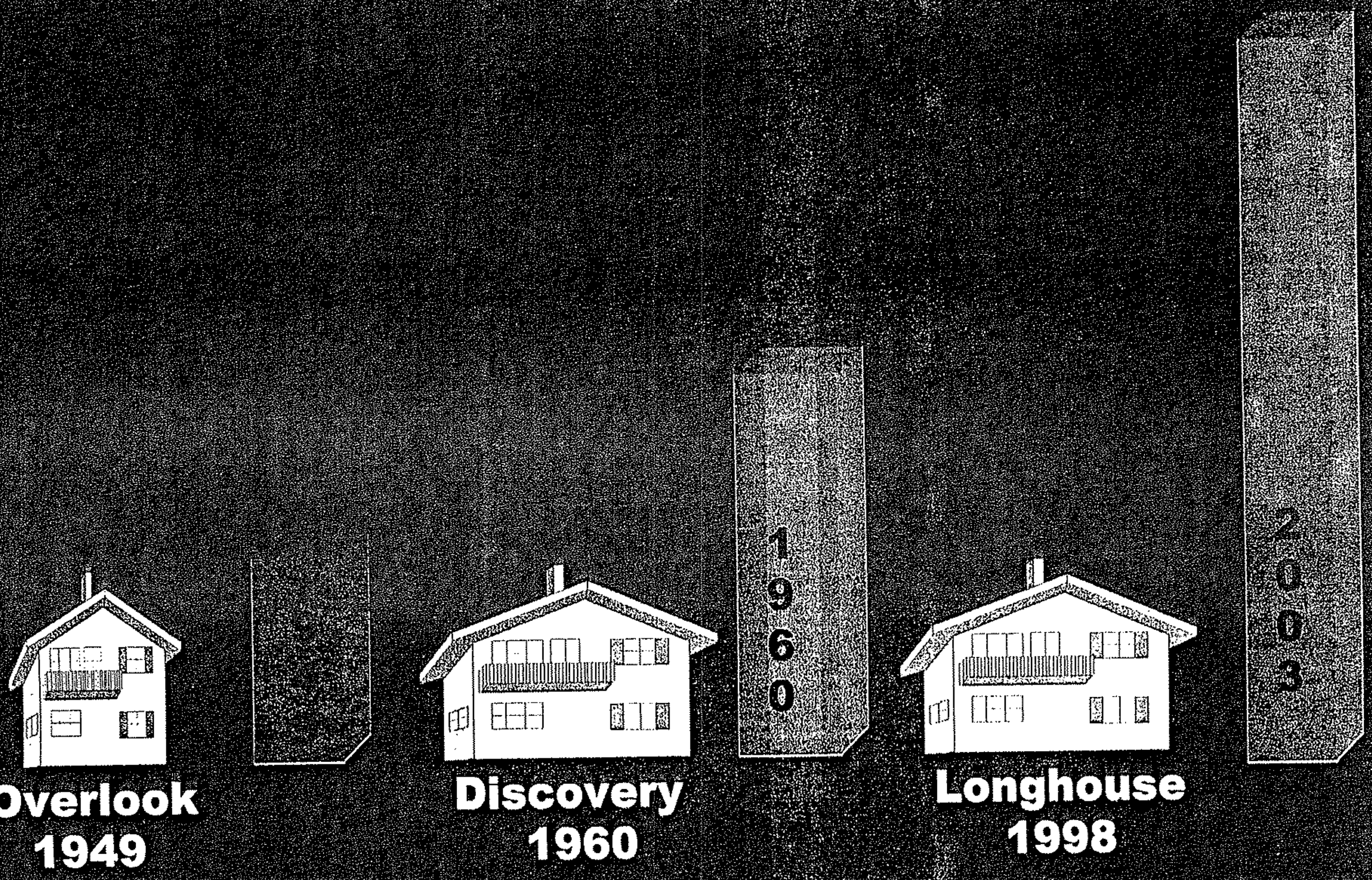


<u>Handicap accessibility</u>

- as a public agency, we are required to research ways to provide accessibility to the disabled
- a hardened ramp into the water would provide access into the water for wheelchair bound visitors

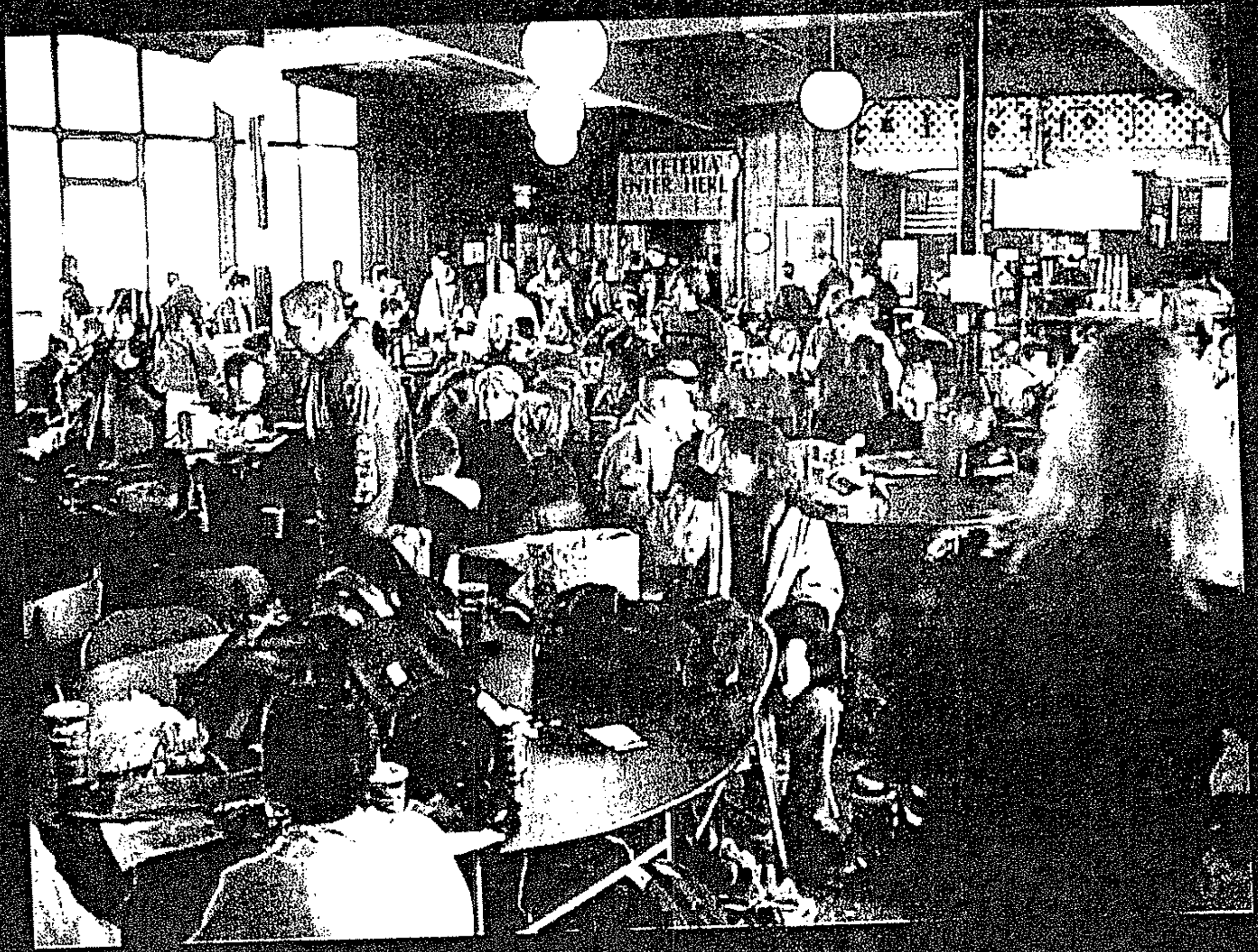
SUMMER COMMENTS/QUESTIONS

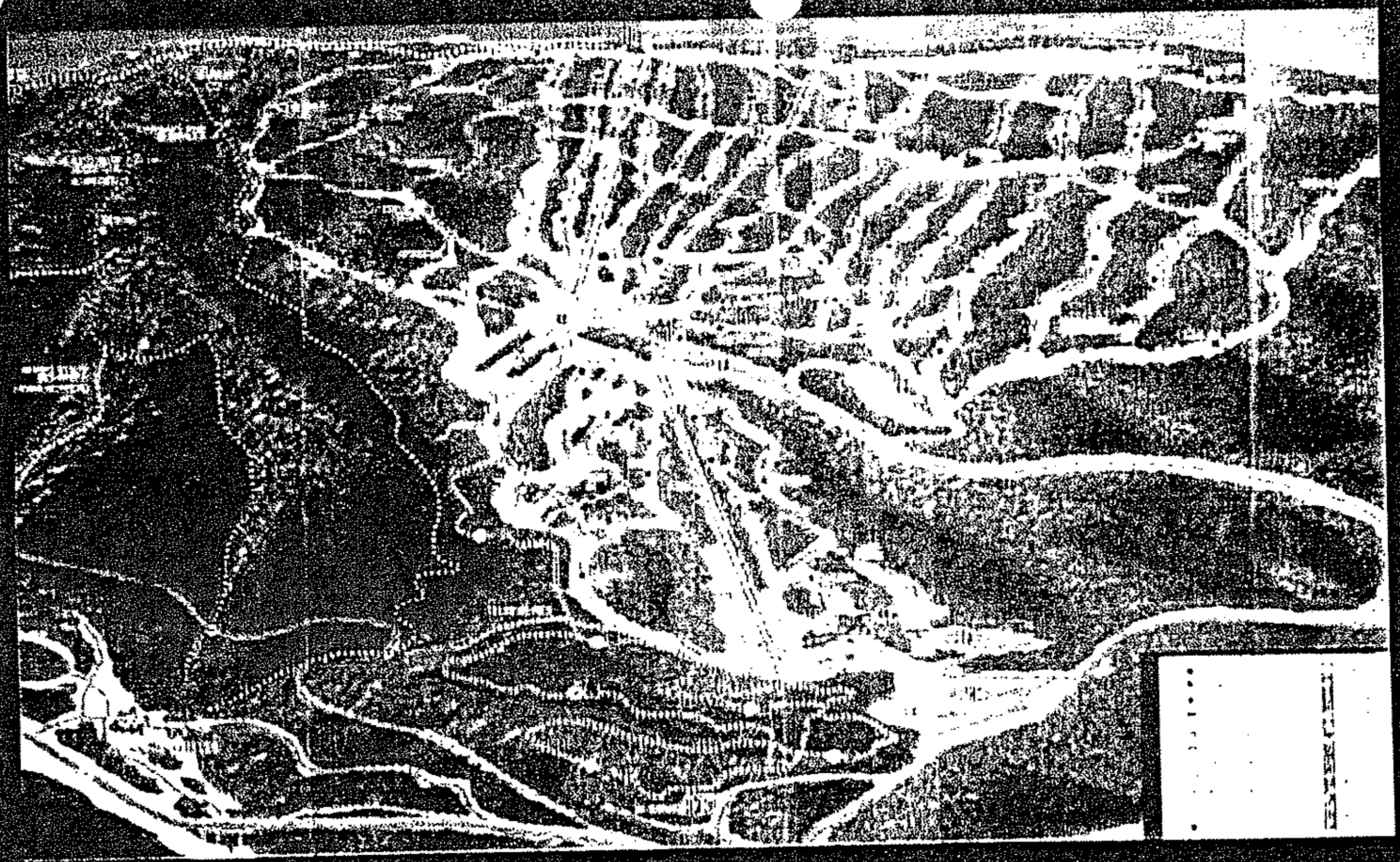
WINTER OPERATION


Overlook
1949
Discovery
1960
1960
Longhouse
1998
2003

OVER USAGE

OVER USAGE





Maintenance Garage

-a new maintenance garage was already approved in the 1998 UMP, but we are in the process of determining it's new home

-suggestions of where it should go?

WINTER COMMENTS/QUESTIONS

Belleayre Mountain Ski Center
Attn: Heather VanBenschoten
PO Box 313
Highmount, NY 12441

belleayr@catskill.net

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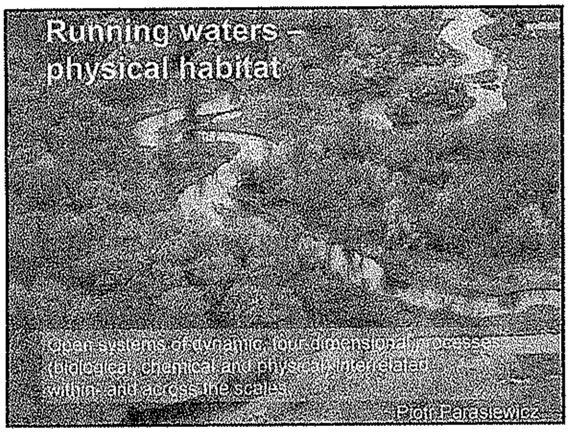
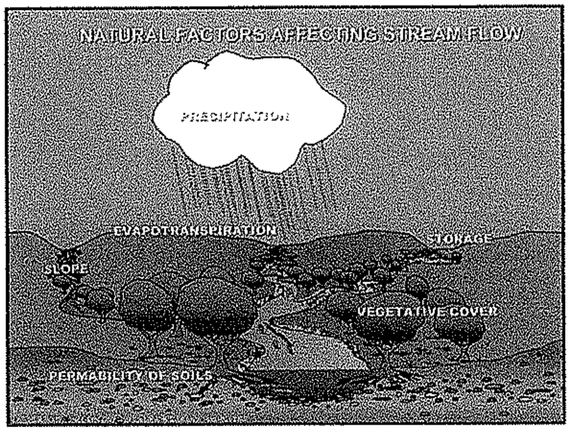
CPC Ex 105



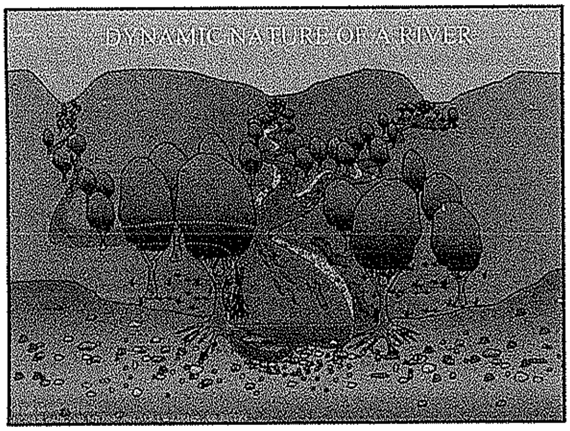
Running waters – physical habitat

Open systems of dynamic, four dimensional processes (biological, chemical and physical) interrelated within- and across the scales

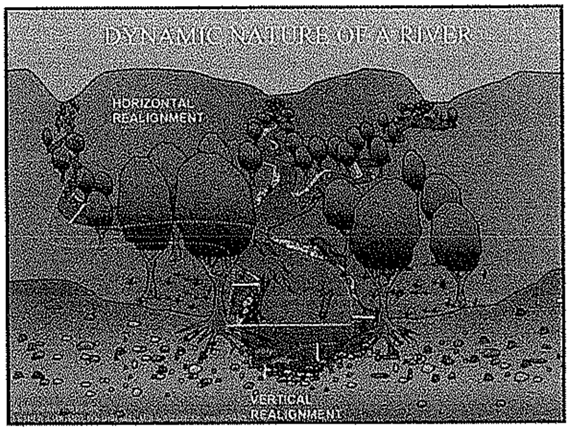
Piotr Parasiewicz



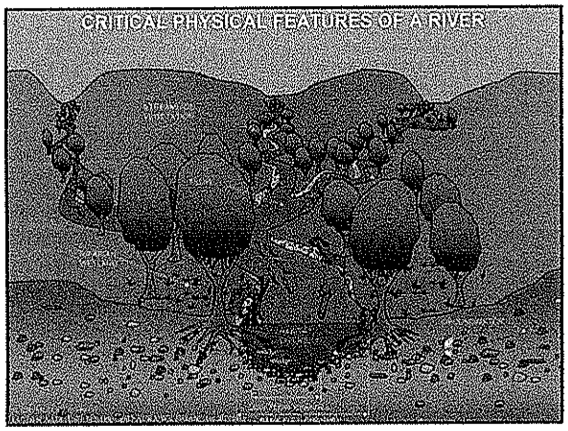
NATURAL FACTORS AFFECTING STREAM FLOW



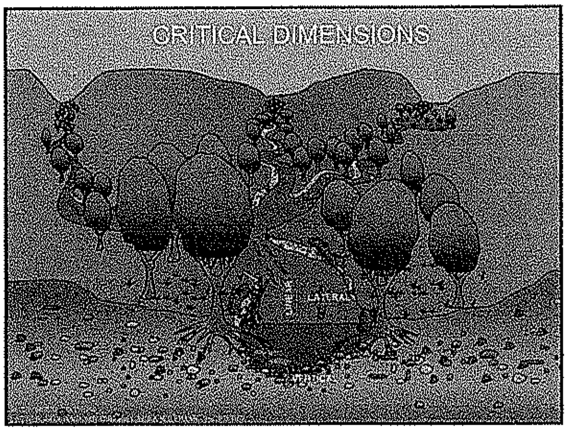
DYNAMIC NATURE OF A RIVER



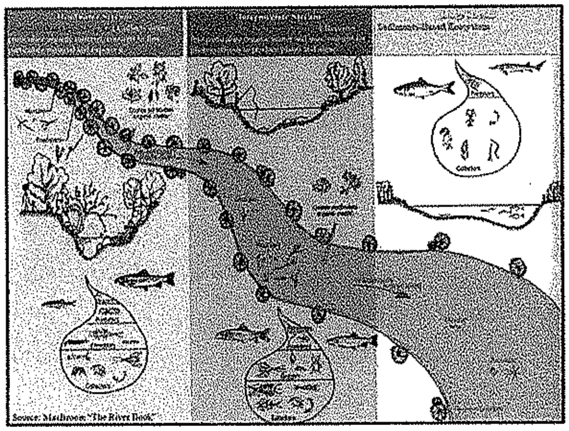
DYNAMIC NATURE OF A RIVER



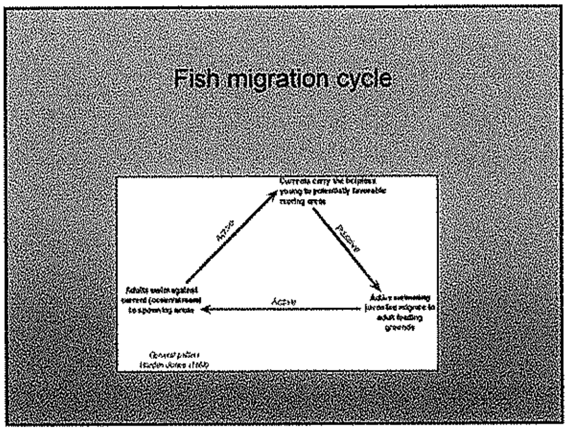
CRITICAL PHYSICAL FEATURES OF A RIVER



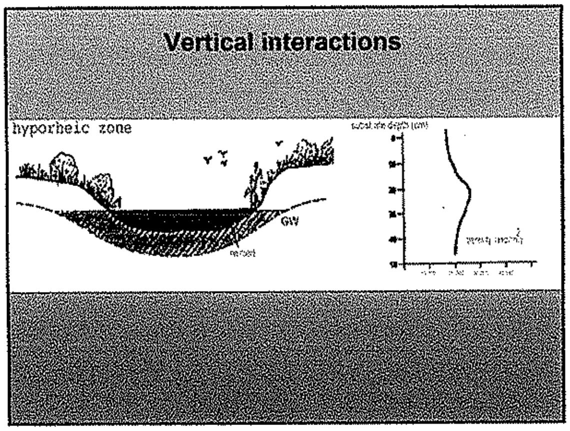
CRITICAL DIMENSIONS



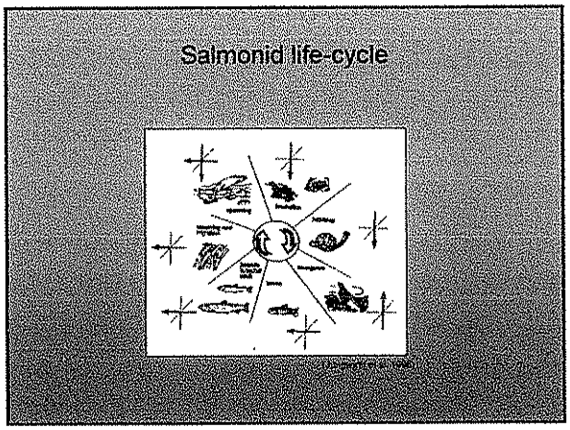
Source: Mathroom: "The River Book"



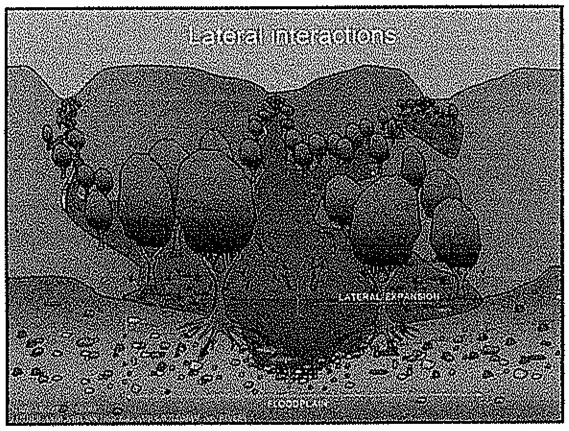
Fish migration cycle



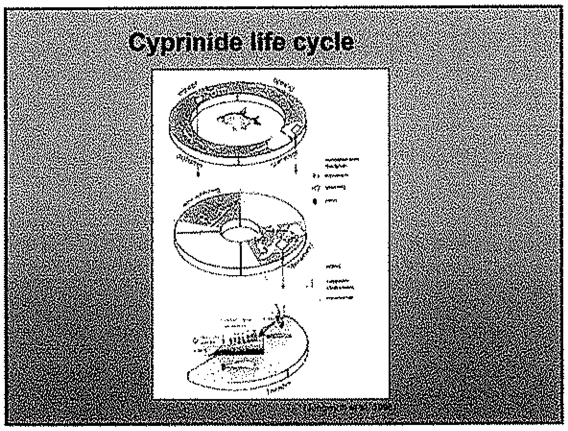
Vertical interactions



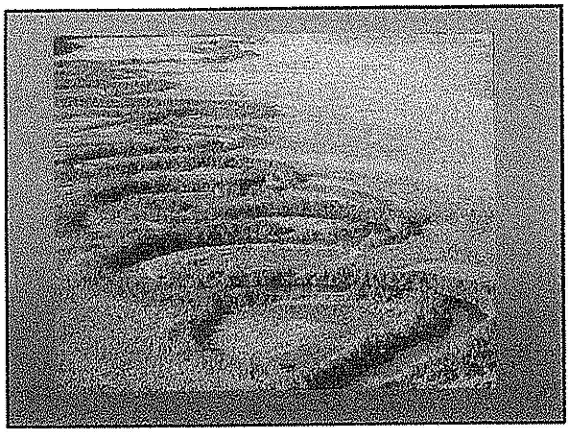
Salmonid life-cycle

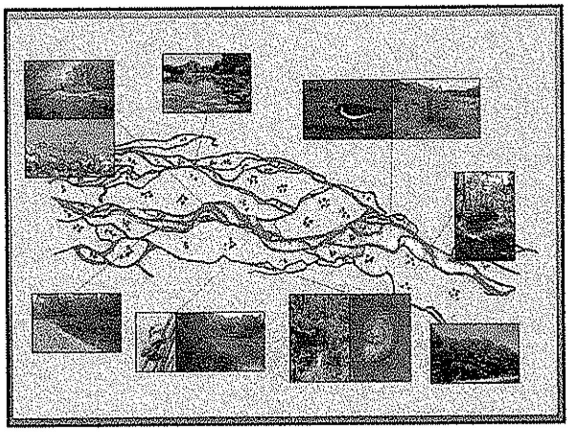


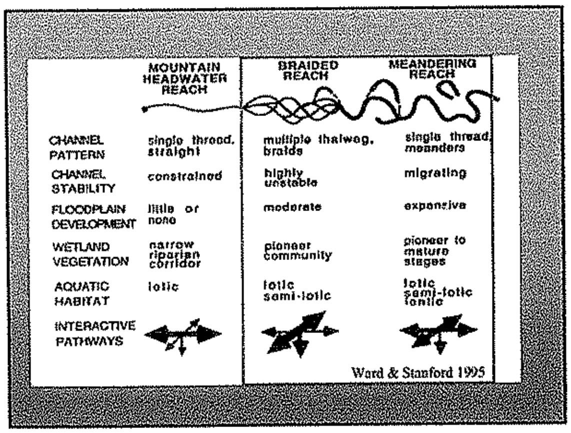
Lateral interactions



Cyprinide life cycle

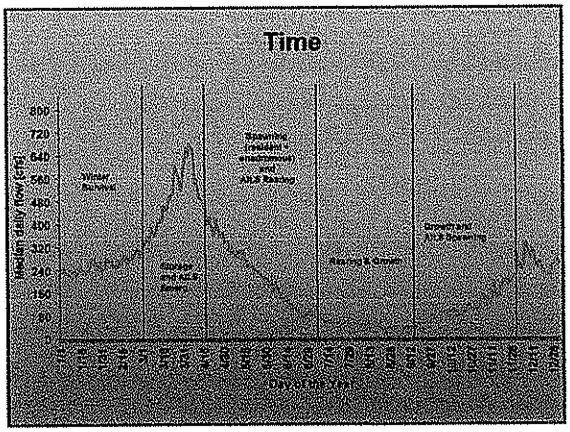






	MOUNTAIN HEADWATER REACH	BRAIDED REACH	MEANDERING REACH
CHANNEL PATTERN	single thread, straight	multiple thalweg, braids	single thread, meanders
CHANNEL STABILITY	constrained	highly unstable	migrating
FLOODPLAIN DEVELOPMENT	little or none	moderate	expansive
WETLAND VEGETATION	narrow riparian corridor	pioneer community	pioneer to mature stages
AQUATIC HABITAT	lotic	lotic semi-lotic	lotic semi-lotic lentic
INTERACTIVE PATHWAYS			

Ward & Stanford 1995



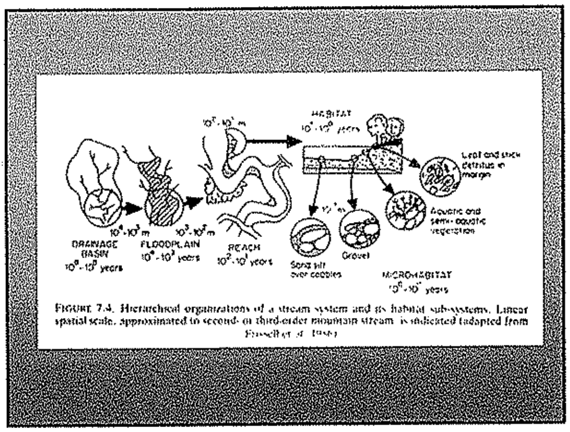
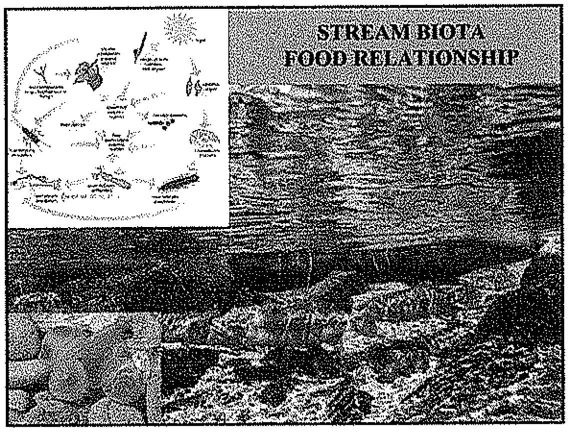
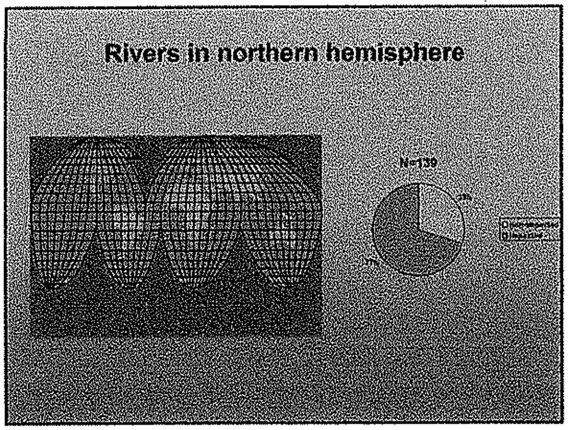


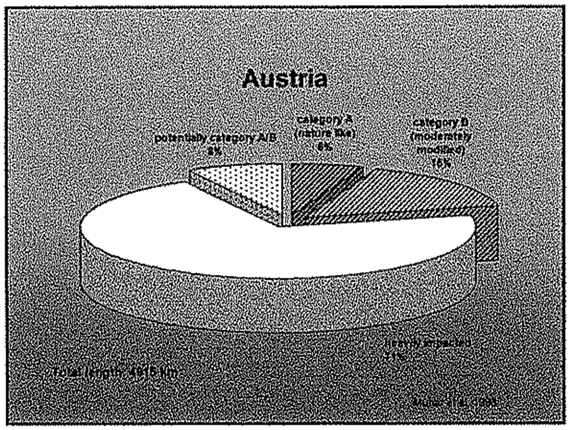
FIGURE 7.4. Hierarchical organizations of a stream system and its habitat sub-systems. Linear spatial scale, approximated to second- or third-order mountain stream, is indicated (adapted from Frissell et al. 1986).



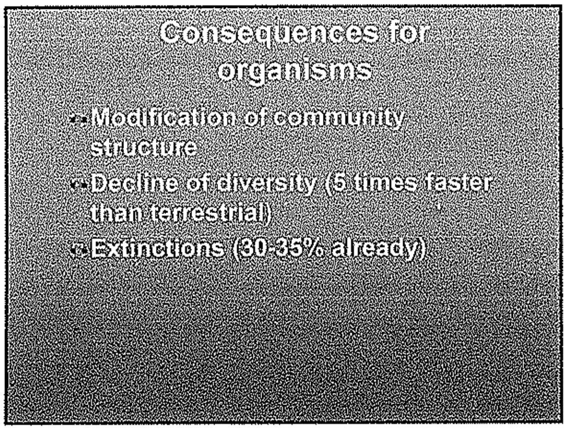
STREAM BIOTA FOOD RELATIONSHIP



Rivers in northern hemisphere

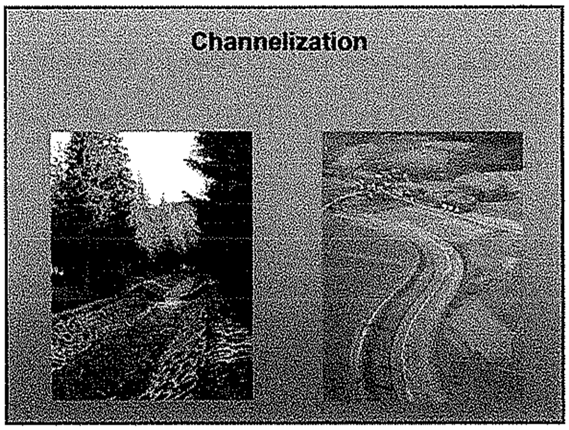


Austria

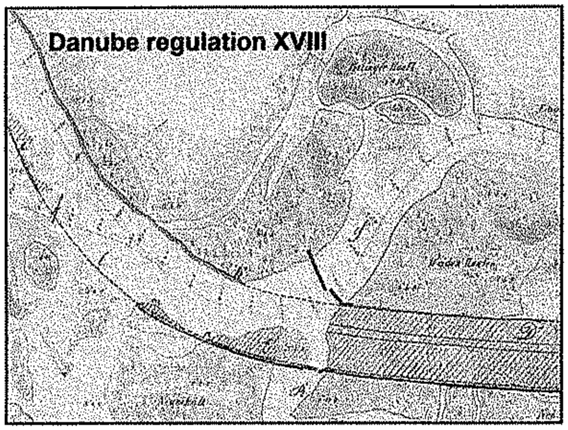


Consequences for organisms

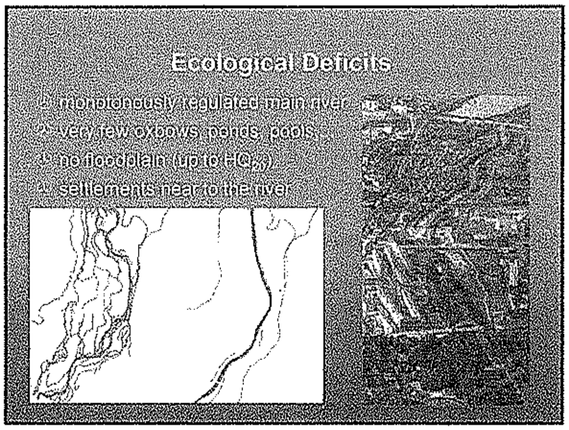
- Modification of community structure
- Decline of diversity (5 times faster than terrestrial)
- Extinctions (30-35% already)



Channelization

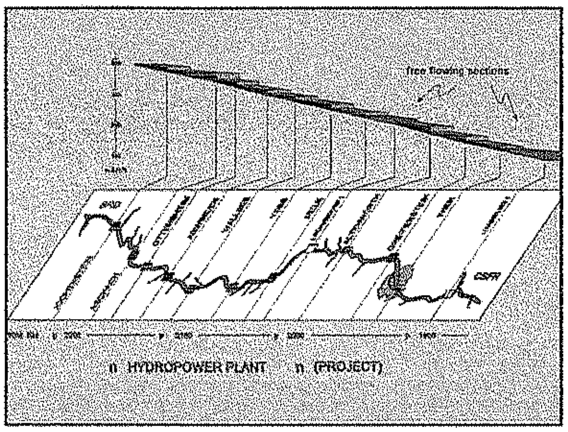


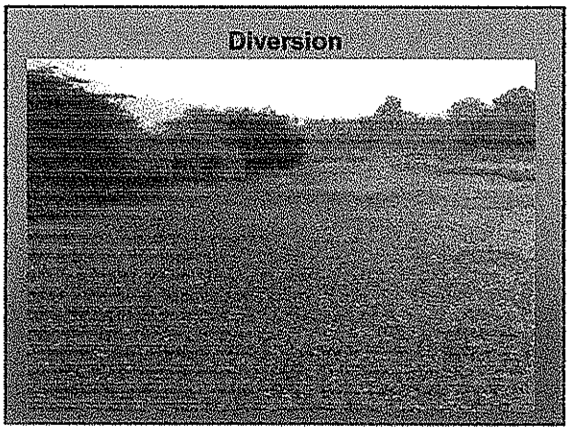
Danube regulation XVIII



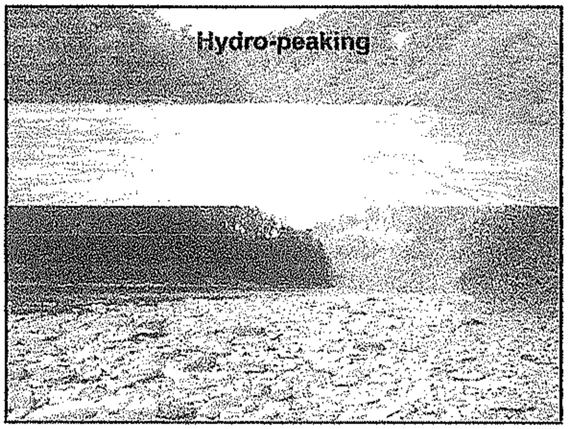
Ecological Deficits

- monotonously regulated main river
- very few oxbows, ponds, pools
- no floodplain (up to HQ_{30})
- settlements near to the river

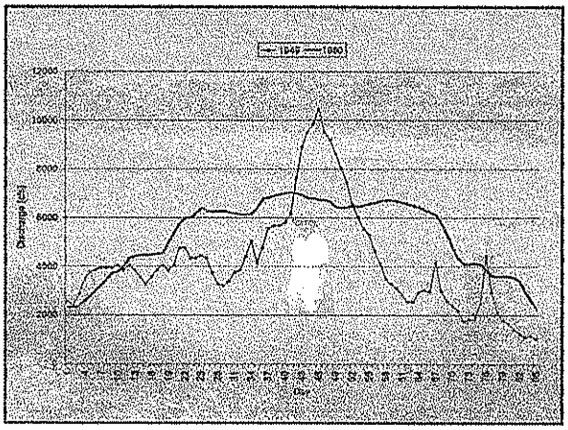


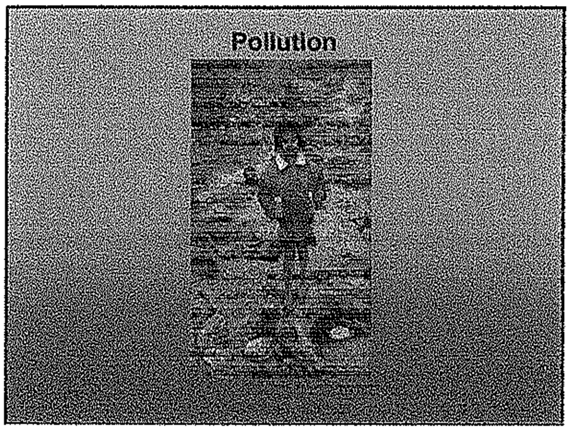


Diversion

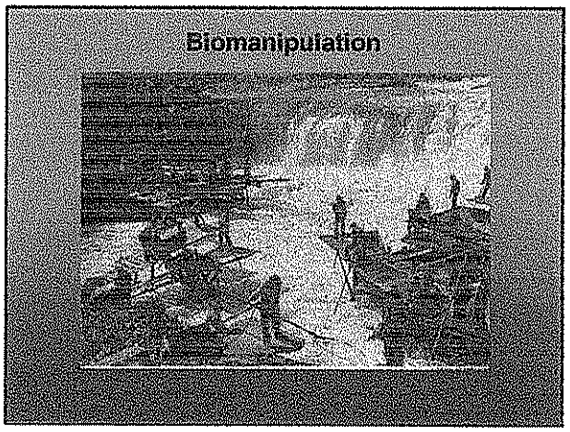


Hydro-peaking

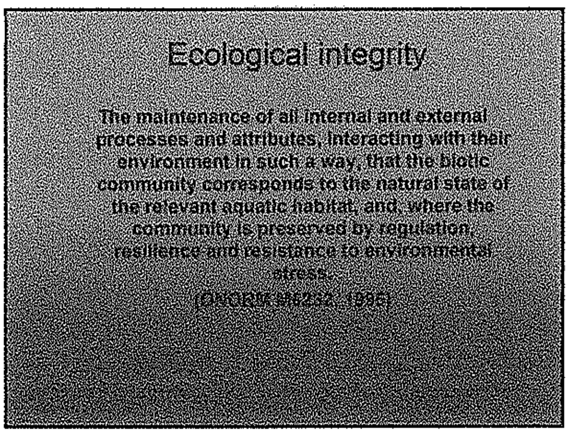




Pollution



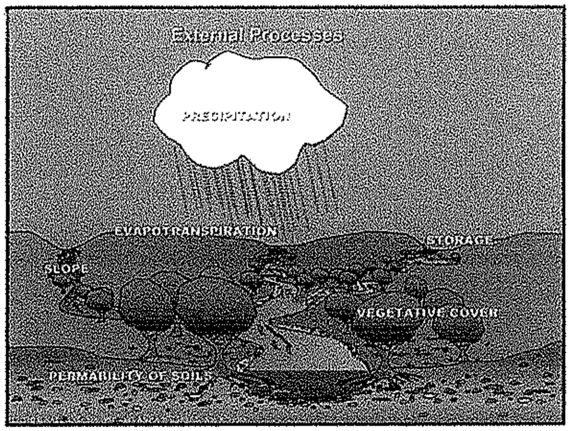
Biomanipulation



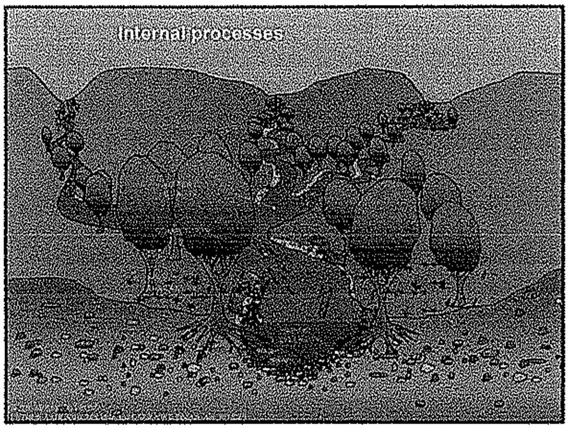
Ecological integrity

The maintenance of all internal and external processes and attributes, interacting with their environment in such a way, that the biotic community corresponds to the natural state of the relevant aquatic habitat, and, where the community is preserved by regulation, resilience and resistance to environmental stress.

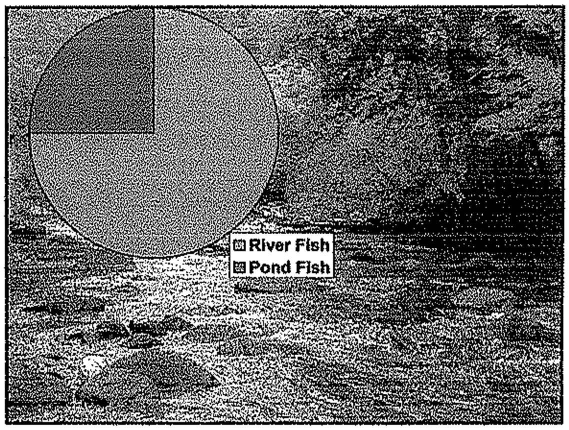
(ONORM M6232, 1995)

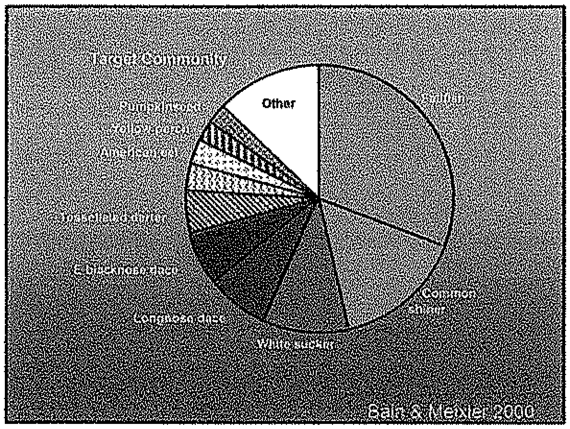


External Processes



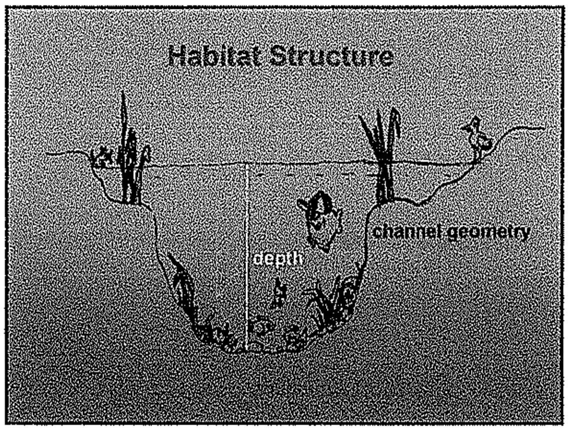
Internal processes



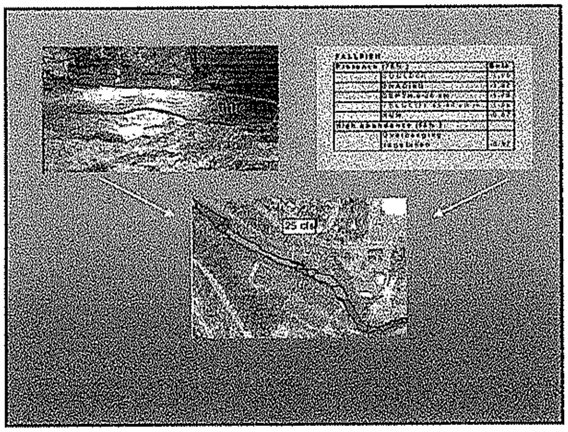


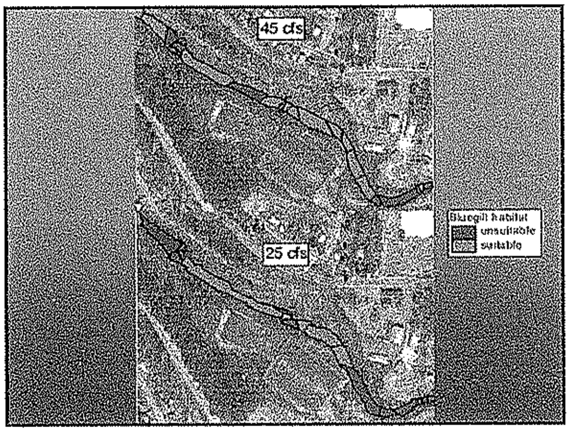
Target Community

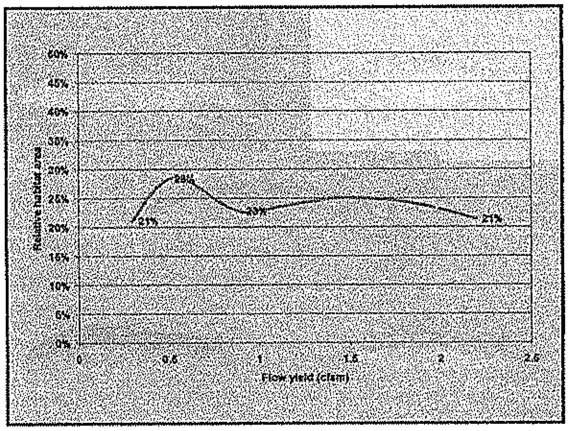
Bain & Meixler 2000

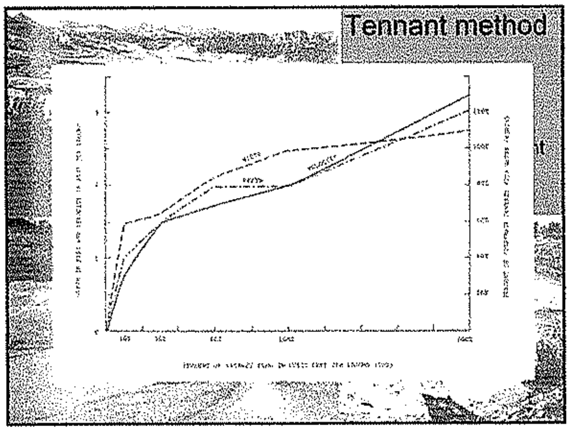


Habitat Structure









Tennant method

10% threshold Tennant Method

- Width, depth, velocities severely reduced
- Riverbed and substrate half exposed
- Gravel bars and sidearms dewatered
- Streambank cover diminished
- Temperature increases
- Fish crowding in pools
- Invertebrate fauna diminished
- Riparian vegetation suffers lack of water

Strategy for sustainable management of Upper Delaware River Basin.

TMB

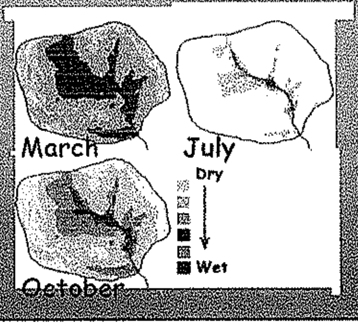
The and their , with intact covered surrounding mountains like deep sponge. Even the heaviest rain seldom raised the river's level appreciably or even clouded its waters. were practically . If they did occur, it was only in the late winter or very early spring, with the break up of river ice or when frozen ground couldn't absorb snowmelt. The river was because the were squared and closer together, not eroded by floods. They were well defined, , not lensing gradually up the valley sides. The Delaware was a classic example of freestone river, its bottom filled with (...) Silt was unheard of. The water was . Dense conifer forests interspersed with hardwoods kept tributary streams cool and helped keep water temperatures low in the main stream. Even the main river was because grew down to the banks and the river. Brook trout prospered...

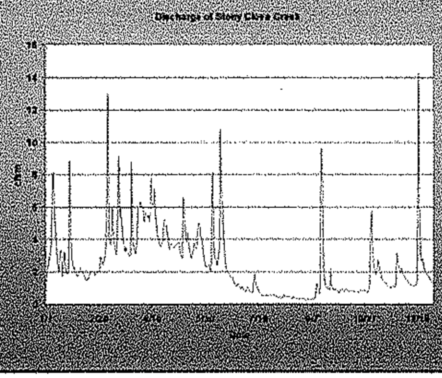
Nick Karas "Brook Trout"

Reference river character

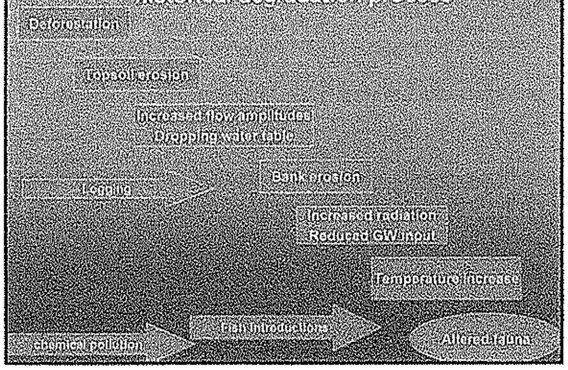
- Upland river (moderate gradient)
- Glacial geology (unstable)
- Snow-melt-driven flow regime
- High retention -> stable flow
- High ground water table
- Heavy shading of main stem and tributaries
- Low summer temperatures
- Cold water fish assemblage (Brook trout and Am. shad (seasonal))

Expansion and contraction of saturated areas for a Catskill watershed dominated by VSA hydrology





Ecological deficits historical degradation process


Deforestation

Topsoil erosion

Increased flow amplitudes
Dropping water table

Logging

Bank erosion

Increased radiation
Reduced GW input

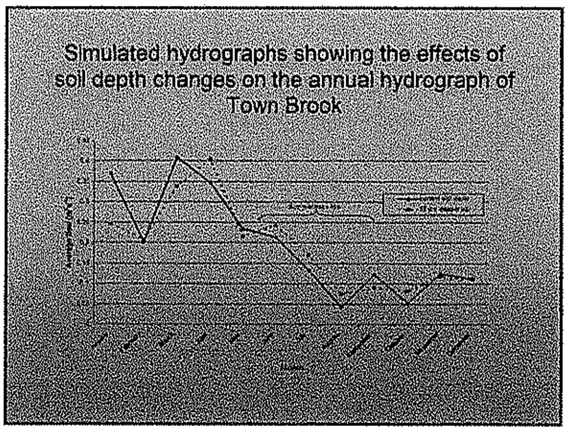
Temperature increase

chemical pollution

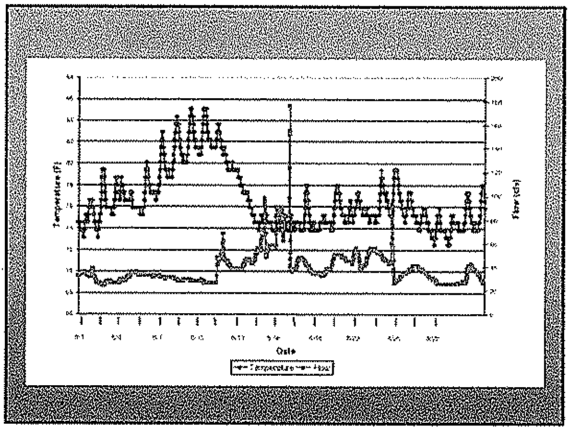
Fish introductions

Altered fauna

Simulated hydrographs showing the effects of soil depth changes on the storm hydrology of Town Brook



Simulated hydrographs showing the effects of soil depth changes on the annual hydrograph of Town Brook



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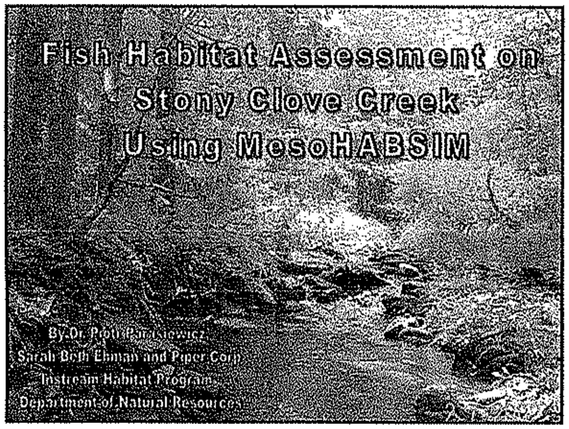
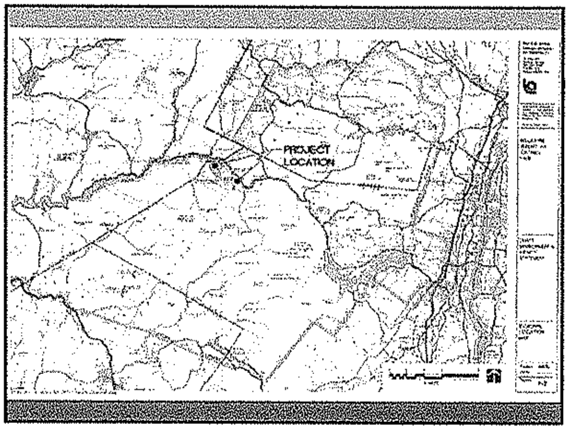
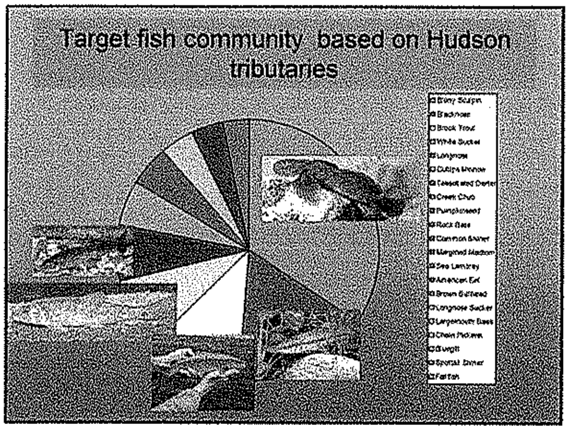


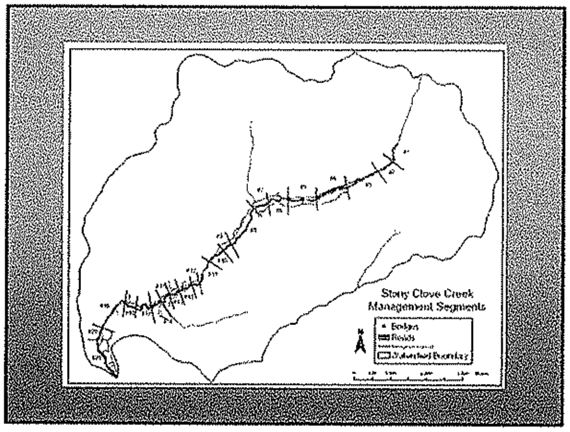
Fish Habitat Assessment on Stony Clove Creek Using MesoHABSIM

By Dr. Piotr Parasiewicz
Sarah Beth Ehman and Piper Corp
Instream Habitat Program
Department of Natural Resources

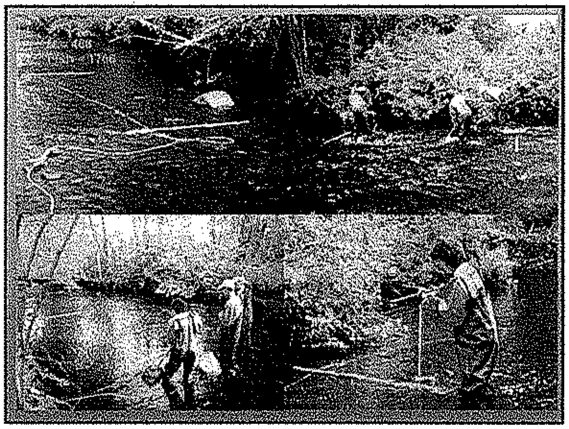


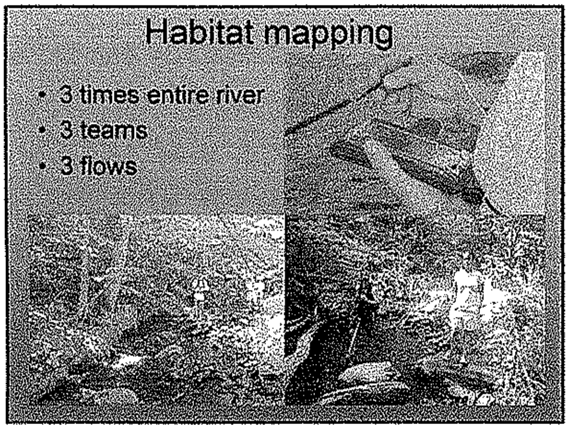


Target fish community based on Hudson tributaries



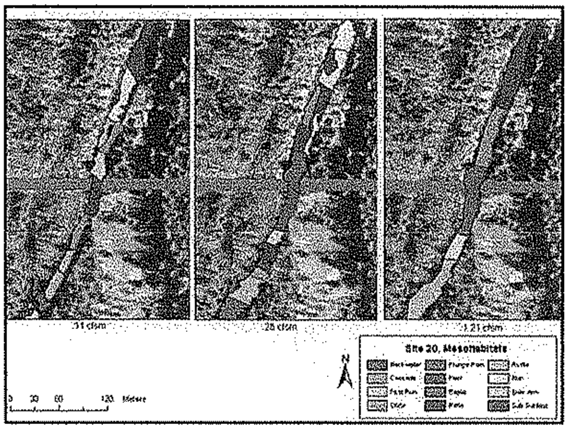
Fishing

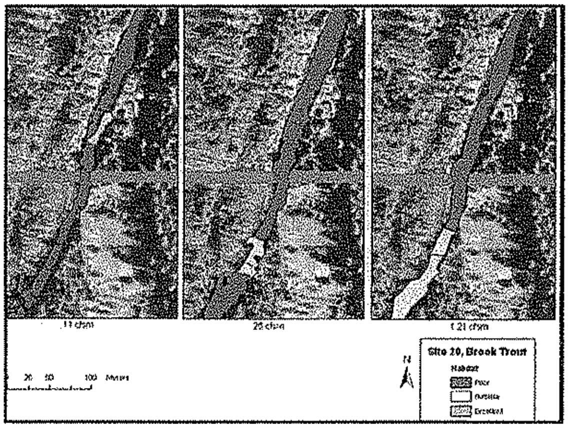


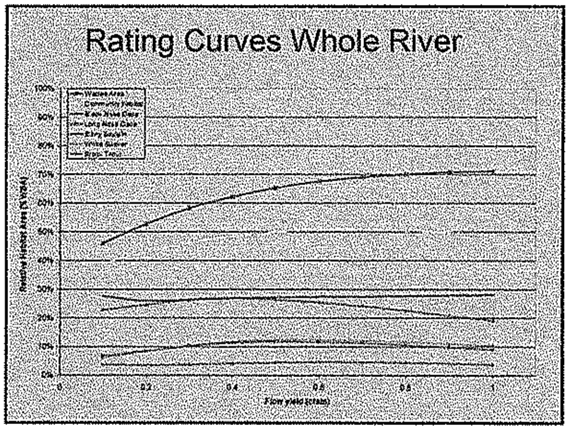


Habitat mapping

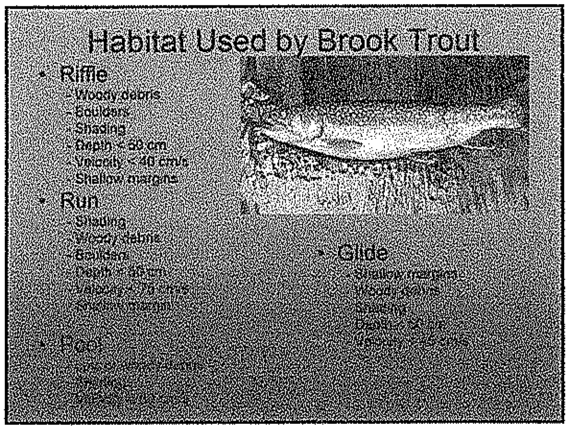
- 3 times entire river
- 3 teams
- 3 flows





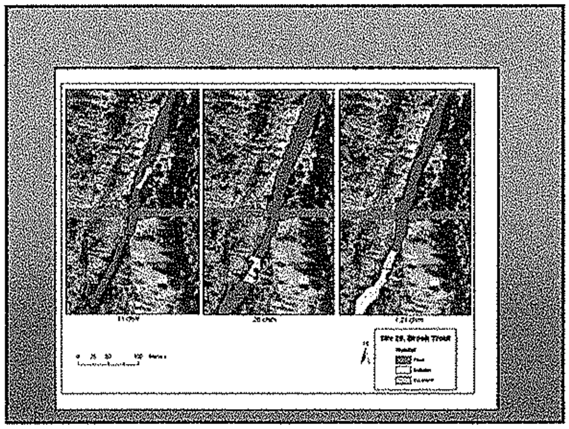


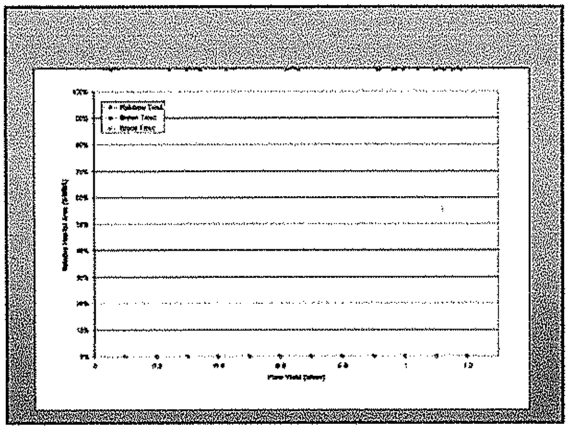
Rating Curves Whole River

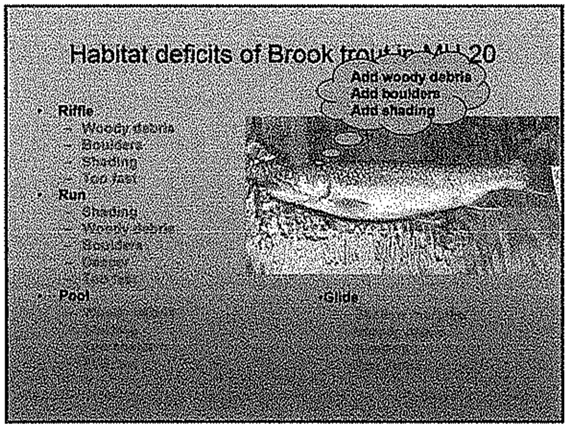


Habitat Used by Brook Trout

- Riffle
  - Woody debris
  - Boulders
  - Shading
  - Depth < 60 cm
  - Velocity < 40 cm/s
  - Shallow margins
- Run
  - Shading
  - Woody debris
  - Boulders
  - Depth < 60 cm
  - Velocity < 70 cm/s
  - Shallow margin
- Pool
  - [illegible]
- Glide
  - Shallow margins
  - Woody debris
  - Shading
  - Depth [illegible]
  - Velocity [illegible]



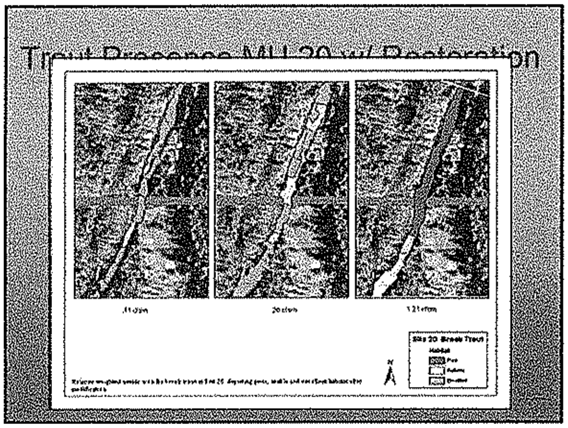




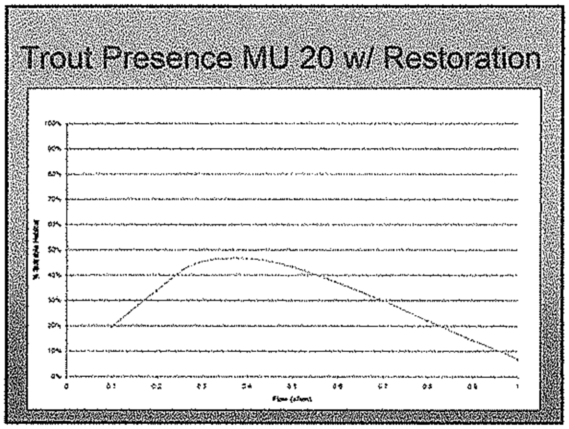
Habitat deficits of Brook trout in MU 20

Add woody debris
Add boulders
Add shading

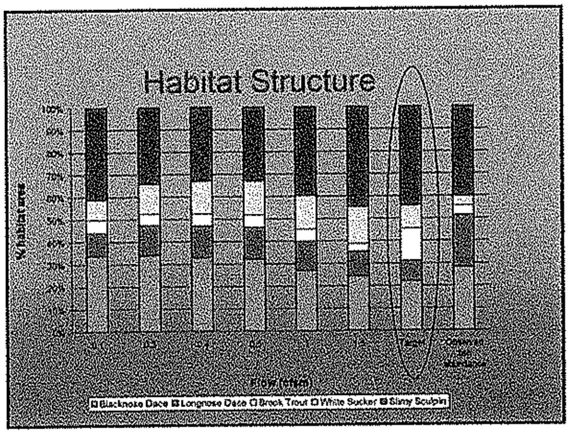
- Riffle
  - Woody debris
  - Boulders
  - Shading
  - Too fast
- Run
  - Shading
  - Woody debris
  - Boulders
  - Velocity
  - Too fast
- Pool
- Glide



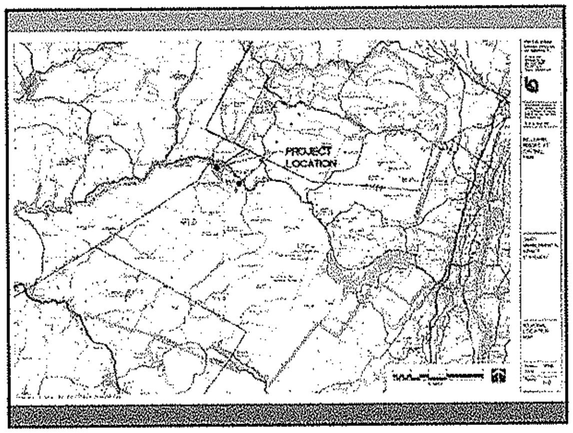
Trout Presence MU 20 w/ Restoration

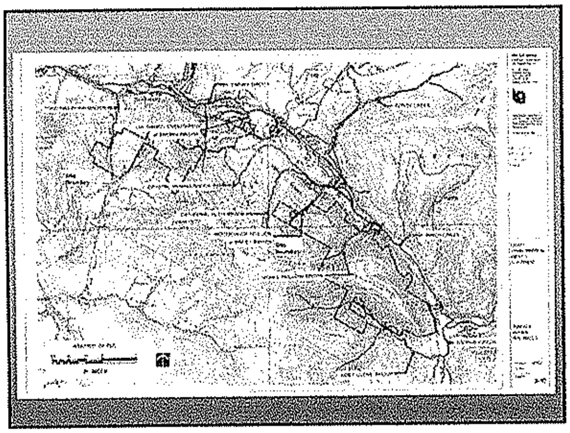


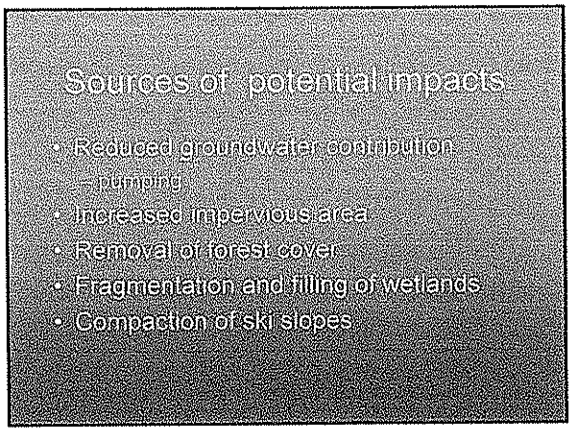
Trout Presence MU 20 w/ Restoration



Habitat Structure

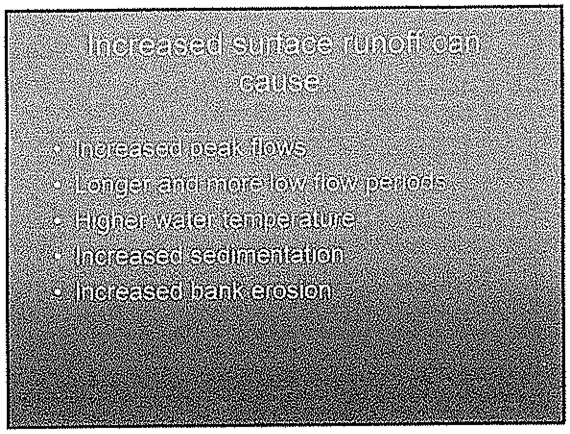






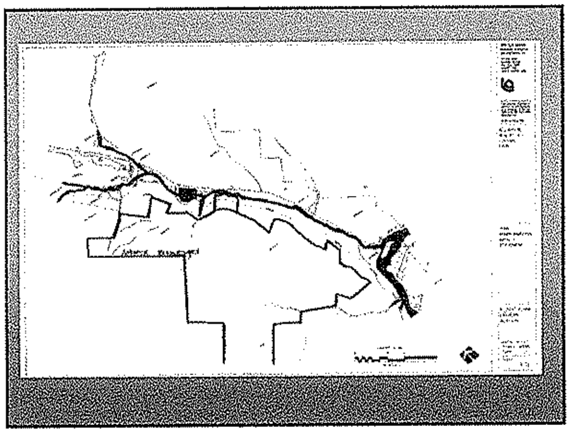
Sources of potential impacts

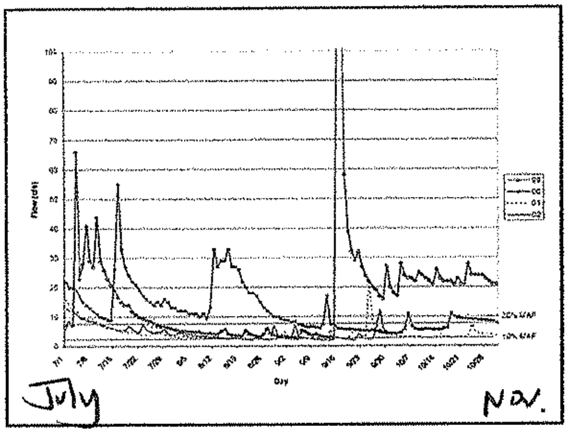
- Reduced groundwater contribution – pumping
- Increased impervious area
- Removal of forest cover
- Fragmentation and filling of wetlands
- Compaction of ski slopes



Increased surface runoff can cause:

- Increased peak flows
- Longer and more low flow periods
- Higher water temperature
- Increased sedimentation
- Increased bank erosion





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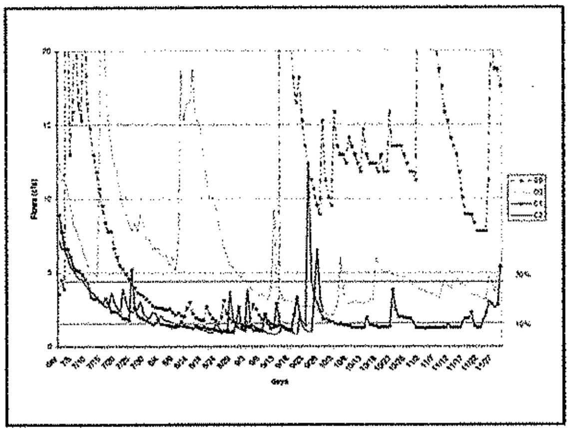

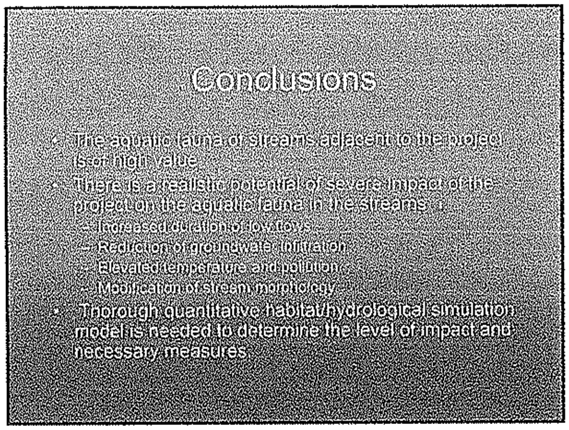

Conclusions

- The aquatic fauna of streams adjacent to the project is of high value
- There is a realistic potential of severe impact of the project on the aquatic fauna in the streams :
  - Increased duration of low flows
  - Reduction of groundwater infiltration
  - Elevated temperature and pollution
  - Modification of stream morphology
- Thorough quantitative habitat/hydrological simulation model is needed to determine the level of impact and necessary measures.

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A Method for Assessing Hydrologic Alteration within Ecosystems
Brian D. Richter, Jeffrey V. Baumgartner, Jennifer Powell and David P. Braun
Conservation Biology, Volume 10, No. 4, August 1996

Abstract: Hydrologic regimes play a major role in determining the biotic composition, structure, and function of aquatic, wetland, and riparian ecosystems. This paper provides a method quantifying the extent of human induced hydrologic alterations. The method, referred to as the "Indicators of Hydrologic Alteration", identified 32 streamflow parameters (in five groups) that are used to statistically characterize hydrologic variation within each water year. Using these 32 parameters the paper develops a method for analyzing and comparing the hydrologic regimes at are particular location in a river or stream "pre-impact" with the hydrologic regime of this location "post-impact." These parameters provide information on ecologically significant features of surface and ground water regimes influencing aquatic, wetland, and riparian ecosystems. The approach was developed as one method to measure the physical integrity of our water bodies and as such is useful in helping determine our progress toward meeting the national goal stated in the Clean Water Act to restore and maintain the "chemical, physical, and biological integrity of the nation's waters".

Summary: The paper groups the 32 parameters into five groups:

Magnitude – mean daily water level by month (12 parameters). Monthly means provide a general measurement of habitat availability or suitability.

Magnitude and duration of annual extreme conditions – 10 parameters measure the magnitude of extreme minimum and maximum annual water conditions, including the 1 day, 3-day, 7-day, 30-day and 90-day extremes. These flow events provide a measure of environmental stress and disturbance during the year and may provide necessary triggers or precursors for the reproduction of certain species.

Timing of Annual Extreme Conditions – 2 parameters that each measure the Julian date of the 1-day annual minimum and 1-day annual maximum water condition. The time of the highest and lowest conditions provide another measure of disturbance or stress by describing their seasonal nature. Key life cycles may be linked to the timing of annual extremes.

Frequency and Duration of High and Low Pulses – 4 parameters capture the number of annual occurrences above an upper threshold (above 75% of all daily values) or below a lower threshold (below 25% of all daily values) and capture the average duration of these events. These parameters portray the pulsing behavior of flows and the shape of these pulses.

Rate and Frequency of Change in Conditions – 4 parameters measure the number and rate of changes in water conditions from one day to the next. These can measure the relative abruptness of changes and the rate and frequency of changes in flow conditions.

Summarized by Mark P. Smith, The Nature Conservancy
April 5, 2004 --- Language from the article was excerpted for parts of this summary.

The Indicators of Hydrologic Alteration developed in this paper use these parameters to compare a single site before and after a known or estimated change or alteration (such as construction of a dam). This involves taking the hydrologic data for the period of record before the impact and comparing this to the period of record after the disturbance. The analysis (and the output from the associated computer program) is presented in terms of the differences in the central tendencies between the pre and post impact periods. While the IHA effectively aggregates information into a manageable level of analysis, the paper warns against just using the aggregated results – but rather recommends that the full scorecard of the 32 parameters be reported so that relationships between parameters can be explored. The paper also notes that while useful, these measures of physical change do not describe the nature or degree to which biologic patterns and processes may be degrade in response to the hydrologic alterations documented through this approach. Finally, the paper points to the potential effectiveness of this approach in designing restoration strategies for water bodies that have been altered hydrologies.

The paper then demonstrates the use of the IHA method on the Roanoke River in North Carolina.

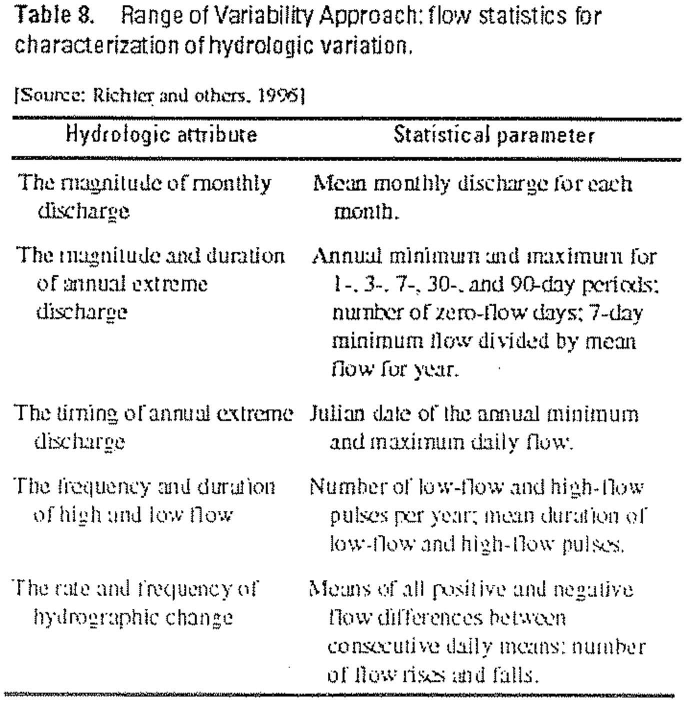


Table 8. Range of Variability Approach: flow statistics for characterization of hydrologic variation.

[Source: Richter and others, 1996]

Hydrologic attribute	Statistical parameter
The magnitude of monthly discharge	Mean monthly discharge for each month.
The magnitude and duration of annual extreme discharge	Annual minimum and maximum for 1-, 3-, 7-, 30-, and 90-day periods; number of zero-flow days; 7-day minimum flow divided by mean flow for year.
The timing of annual extreme discharge	Julian date of the annual minimum and maximum daily flow.
The frequency and duration of high and low flow	Number of low-flow and high-flow pulses per year; mean duration of low-flow and high-flow pulses.
The rate and frequency of hydrographic change	Means of all positive and negative flow differences between consecutive daily means; number of flow rises and falls.

Table 8 *from: Armstrong, D.S., Parker, G.W., Richards, T.A., 2003, Evaluation of Streamflow Requirements for Habitat Protection by Comparison to Streamflow Characteristics at Index Streamflow-Gaging Stations in Southern New England: U.S. Geological Survey Water-Resources Investigations Report 03-4332, 108 p*

Summarized by Mark P. Smith, The Nature Conservancy
April 5, 2004 --- Language from the article was excerpted for parts of this summary.

Turning Instream Flow Water Rights Upside Down

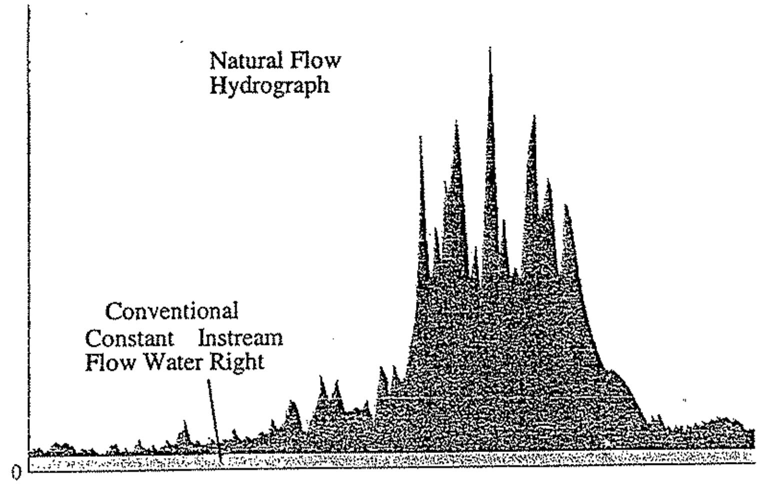
Nicole Silk, Jack McDonald, Robert Wigington

Rivers, Volume 7, No. 4 2000

Abstract: Conventional approaches to instream flow protection protect instream flows by protecting a specified level of flow to be left in a stream and indirectly allocate the remaining flow for water development. Such flows have been quantified with constant year-around or monthly values that bear little resemblance to a river's natural pattern of flow and may maximize the reservation of water for development. This paper proposed to turn this model "upside down" by specifying a level of water for development and protect remaining flows for the stream. The paper also examines a number of examples under state and federal law where this approach is used and makes the legal argument for recognition of upside down instream flow rights and suggests such rights be used when seeking to protect complex and not easily predictable flow patterns.

Summary: The paper begins with a description of the importance of natural flows to riverine systems. "The natural ecosystem of any river is the product of millions of years of adaptation and evolution, which have created a myriad of variables and subtleties more complex than we can imagine. With each additional habitat type or species to be protected, determining how much should be left in the stream to meet ecological needs is compounded and confounded."

The paper discusses conventional instream flow water rights. In particular it looks at western water law of 'prior appropriation' and how it grants rights to those who use water in the order in time and amount in which they use it. In most cases states have the ability to appropriate water for instream flows, but often this right is looked at as minimum flow and is often stated as a constant flow year round. Variations on this approach include monthly flows, or year round flows with one differential flows – e.g. a specific high flow period in the spring.



As an alternative to this approach the paper proposes a different approach – to first define the demands for water development and then allocate the rest of the water in the stream to serve ecosystem needs. By defining specific water needed for development the approach leaves a

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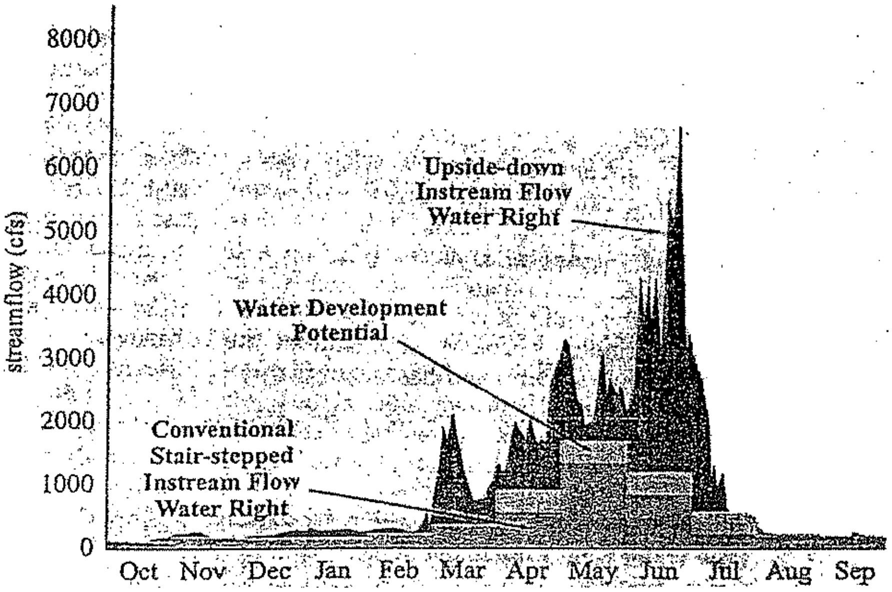
naturally variable amount in the river or stream that supports the ecosystem. The paper suggests this could be determined by examining the critical thresholds within flow characteristics and then, through modeling and experimentation, determining an increment of water available for development that does not demonstrably impair the river's ability to perform its ecological services. To address the potential of this water allocated for development taking all the water available at low flows; the paper suggests a conventional minimum or maintenance flow can be used in addition to the "upside-down" water rights.



The paper then examines a number of cases where this concept of upside down water rights (the National Park Service has called this approach using a "departure analysis") has been used and discusses how such water rights can be used under federally reserved water rights and can be used as appropriations under state water laws.:

Specific examples described include:
National Park Service, including Glacier and Yellowstone national parks, Big Hole National Battlefield, the Big Horn Canyon National Recreation Area and the Little Big Horn Battlefield National Monument, Rocky Mountain National Park, Zion Natural Park, **Bureau of Land Management** – upper Missouri River, Cache la Poudre River, Colorado, three Idahoe wilderness areas, **Colorado Water Conservation Board** – Hanging Lake and **Endangered Fish Recovery** - Upper Colorado River Basin and 15 Mile Ranch

Among the papers conclusions are:

- Upside down water rights may be most applicable on relatively undeveloped rivers.
- Upside down water rights can be hedged by combining with a conventional instream flo rights. This approach can protect the top and bottom of the hydrograph and still leave room for water development.
- Upside down water rights should err on the side of the river ecosystem
- Upside down water rights can only work if the amount reserved for developmen large as to undercut the river's ecosystem health.

Summarized by Mark P. Smith, The Nature Conservancy
April 5, 2004 --- Language from the article was excerpted for parts of this summ
Graphs © 2000 S.E.L. & Associates

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Large Rivers Vol. **12**, No. 2–4
Arch. Hydrobiol. Suppl. 135/2–4, p. 239–268, Februar 2001

CPC 107

Physical habitat modelling for fish – a developing approach

P. Parasiewicz[1] and M. J. Dunbar[2]

With 7 figures and 1 table in the text

Abstract: Quantitative physical habitat modelling is a river management methodology that has been developed to aid the assessment of the impacts of altered river discharge on freshwater aquatic communities. In this paper we outline the potential value of habitat modelling in advancing the study of fish (particularly 0+ fish) habitat use, and also issues surrounding the inclusion of young fish in environmental impact assessments. Young fish have often been used as target species during such assessments, due to their perceived sensitivity to environmental changes, particularly associated with altered river discharge. However in the past, the paucity of information on young life stages, combined with the general difficulty in quantifying their habitat requirements, has limited the use of habitat models for this purpose. Firstly we describe the context within which habitat modelling has been applied traditionally: the development of water resources, and the predictive assessment of associated environmental problems. Alternative approaches to habitat modelling are briefly mentioned. Overall, these techniques, which combine physical and biological data, offer a broad perspective for the ecological management of degraded rivers, and can assist in developing our understanding of the processes that influence aquatic organisms in running waters. In the 20 or so years since its inception, habitat modelling has undergone considerable improvement. However, there has not been a recent review of such advances. Therefore in the main text, we describe the current state of habitat modelling, emphasizing recent developments. Many of these offer possibilities for the advancement of our knowledge of 0+ fish.

Keywords: rivers, physical habitat, habitat hydraulics, habitat modelling, quantitative methods, review, fish, assessment, multivariate statistics, bioenergetics.

1. Introduction

1.1 River regulation

River regulation, designed to meet human needs for water, power, land use, transport and flood protection, has been undertaken for centuries. Demands for water

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0945-3784/01/0135-0239 $ 7.50

have grown rapidly in the last hundred years, causing increased pressure on running water resources (Petts 1984). Although there were some early attempts to consider environmental requirements when developing water resource schemes (e. g. Baxter 1961; Stalnaker & Arnette 1976), it was not until the 1970s that significant progress was made in addressing discharge-related environmental concerns in a formal fashion. Evidence of significant damage to riverine ecosystems has finally awoken some public concern (International Rivers Network 1997). This has led, for example, to explicit acceptance that water remaining within a river (the 'instream flow') can simultaneously perform multiple useful functions. Some functions (such as fisheries) may have direct commercial value, while others (such as maintenance of river ecosystem processes) are more difficult to value. The necessity for economically-based trade-offs between in- and out-of-stream water use led to development of quantitative habitat modelling techniques (Stalnaker 1995).

1.2 Development of the habitat modelling approach

Research has shown that the combination of streamflow variability and river morphology (along with other factors such as water quality, energy inputs and biotic interactions) is a primary control on the processes that determine the composition and dynamics of stream ecosystems (Karr et al. 1986; Statzner et al. 1988; Minshall 1988; Hildrew & Townsend 1994; Poff & Ward 1989), and that both long term low flows (Armitage & Petts 1992) and shorter term fluctuations (Bain et al. 1988; Cowx & Gould 1989; Parasiewicz et al. 1998; Valentin et al. 1996) can have a negative effect on fish and invertebrate populations. Hence, multifunctional management of running waters requires appropriate tools for assessment of these impacts.

Although in some cases, models of direct linkages between flows and populations have been obtained (e. g. Cunjak & Therrien 1996), frequently insufficient biological data (spatial and temporal) are available to demonstrate direct relationships between population changes and artificial changes in streamflow on individual river systems. Further difficulties arise due to the problems inherent in statistical analysis of datasets which are affected by multiple, time-varying human impacts on top of natural environmental variation. One route around these problems takes account of the fact that aquatic organisms do not respond to primary 'flow' per se, but to secondary and tertiary aspects of it, arising from water depths and velocities, shear stresses and sediment movement. This route has led to assessment techniques that indirectly model impacts on river biota through modelling of their habitats.

Following the development of the ecological niche theory (Hutchinson 1957), it became clear that living organisms can be affected by the variability of their whole environment. The observation that the aquatic biota respond to specific physical patterns in a stream, both at the population level over long periods of time and directly to patterns of physical habitat over a shorter timeframe, has provided the background for development of physical habitat models. Although physical variables are clearly not the only factors affecting abundance and health of organisms in rivers (KARR et al. 1986), they provide effective assessment criteria due to their history of anthropogenic impact, predictability and ease of measurement (STALNAKER 1995).

The selection of the variables used in physical habitat models arose from empirical studies which demonstrated the association of fish (and invertebrates) with particular physical and chemical aspects of their available habitat (BINNS & EISERMANN 1979; JUNGWIRTH 1988; MILNER et al. 1985; RABENI & JACOBSON 1993; WRIGHT et al. 1993). Although these general studies have proved successful in overall habitat description, their use within water allocation frameworks required by water supply undertakings (public or private businesses) proved difficult. In this context, inherently incremental techniques are required. Of key interest to water managers is a model with directly predictive capacity, enabling evaluation of both the environmental and economic impacts of particular changes in the timings, magnitudes and durations of river discharge events. Thus, the step was taken to link simple physical habitat use/description models to hydraulic models capable of predicting the variation of the key habitat variables in an incremental fashion (BOVEE 1982; GORE & NESTLER 1988). This allowed simulation of the relationship between stream discharge and an aggregate physical habitat quantity for life stages of a target aquatic species (e.g. fish). Thus, researchers simplified the analysis of anthropogenic changes (ORTH 1987) by modelling only the key habitat variables likely to change (which can also be measured relatively easily), and linking these with the preferences of aquatic species. Finally, this simplified quantification of trade-offs between water diversion and instream ecological water requirements, and gave biologists and water resource managers a common way of working together. It could then be used as a basis for discussion, allowing the stakeholders within a river basin to draw up a compromise solution to a resource management/ecological impact problem.

It should be noted at the outset that such approaches were designed to represent habitat potential not standing stocks; this has been a source of considerable misunderstanding in the past. However, clear population linkages have been demonstrated for major long-term studies in rivers, where physical habitat can at times be a key limiting variable (JOWETT 1992; RAILSBACK et al. 1993; NEHRING & ANDERSON 1993; PARASIEWICZ et al. 1997).

The last twenty years have involved the application and further improvement of such models, along with heated discussion as to their validity (for a review see GORE & NESTLER 1988). Since the elaboration of the original PHABSIM (Physical HABitat SIMulation) habitat modelling software (BOVEE 1982), there have been a number of important developments. Some of the numerous frameworks which have been applied are listed below (Table 1). In addition, there are a number of techni-

Table 1. Habitat modelling frameworks.

Acronym	Description
IFIM (Instream flow incremental methodology)	A conceptual framework for integration of ecological demands into the water resources planning process. National adaptations (e.g. Spain, Austria) (BOVEE 1995).
PHABSIM (Physical habitat simulation system)	The original physical microhabitat simulation model. Freely available from the US National Biological Service (BOVEE 1982).
RHABSIM (Riverine habitat simulation)	RHABSIM, from Thomas Payne Associates is a commercial version of PHABSIM (PAYNE 1994).
RYHABSIM (River hydraulic and habitat simulation)	New Zealand microhabitat model developed around the same time as PHABSIM (JOWETT 1989).
CASIMIR (Computer aided simulation of habitat in regulated streams)	A reach-based shear-stress simulation model developed in Germany for hydropower impact assessment (JORDE 1996).
EVHA (Evaluation of Habitat)	French microhabitat model (GINOT 1995).
RSS (River System Simulator)	Norwegian microhabitat model (ALFREDSEN & KILLINGTVEIT 1996; KILLINGTVIET & HARBY 1994).
HABIOSIM/HYDREAU	Canadian microhabitat model (LAFLEUR & LECLERC 1997).
FRC (Fish Rule Curve)	Canadian method for the use of PHABSIM/physical habitat time series to develop minimum, average and optimum flows for instream physical habitat (LOCKE 1996).
AGIRE	GIS system developed by Electricité de France. Combines spatial and temporal data on a range of themes. Includes a model of fish-breeding habitat quality for brown trout.
RCHARC (Riverine Community Habitat Assessment and Restoration Concept)	Used to compare habitat hydraulics of a reference situation with alternative scenarios (NESTLER et al. 1996).

ques still at the research stage, which we further outline in the following sections. A key issue is whether to continue to use well-tested techniques, with very gradual minor improvements (providing stability, and a level playing field; SCRUTON & GIBSON 1993), or to adopt new approaches as the science develops. Both are the subject of this paper. These new methods we describe are far from being adopted as standards, but will certainly go some way to improve representation of physical and biological reality (GORE & NESTLER 1988), as well as aiding water resources managers, who naturally prefer simple, easy-to-implement techniques.

1.3 Alternative approaches for the determination of environmental flow requirements

Before entering into a more detailed discussion of the habitat modelling approach, it is worthwhile to review briefly some alternative approaches. They may be based on simple minimum hydrological indices, in which case the approach is known as 'standard setting' (JOWETT 1997). Such an index will commonly be related either to a proportion of the natural mean discharge (e.g. 10%, 30%; TENNANT 1976), or to an exceedance percentile on a natural flow duration curve. The methods may be indexed to annual, seasonal (90-day), monthly (MATTHEWS & BAO 1991), or special (e.g. months during which fish spawn) periods. An alternative standard-setting approach, based on reductions in invertebrate diversity, has been proposed by DOCAMPO & DE BIKUNA (1995). Such methods need considerable resources to set up initially, but once developed require a relatively low level of resources per site. Key issues include the methods by which flow indices are transferred to ungauged sites, and adequate biological justification for the choice of index. The values may be used for monitoring the state of a river, or for abstraction licensing, where they could be implemented as so called Hands-off Flows (HoFs), Maintained Flows (MFs) or flow bands (KITSON 1984). Furthermore, they can play an important monitoring and strategic role and provide interim objectives, where further investigation is justified. Such methods are unlikely to be suitable if there is likely to be conflict between different interest groups over the results of such determinations.

More detailed investigation may require reconstruction of the natural flow record. It may then be possible to apply standards for alteration from a natural flow regime (RICHTER et al. 1997). Where enough historical data are available, they may be related directly to historical impacts (PETTS 1996), although separation of flow-induced changes from changes arising from other factors is often problematic. Alternative approaches are to construct basic hydraulic models of key sites, and either relate directly to pre-determined standards (ESPEGREN & MERRIMAN 1995; GIPPEL & STEWARDSON 1996), or to use these data as part of a wider-ranging workshop, where participants determine instream flows using their expert knowledge, formulated in a structured manner (KING & THARME 1994; SWALES & HARRIS 1995). For more details see DUNBAR et al. (1998).

2. Physical habitat modelling

2.1 Structure of physical habitat simulation models

As presented in Fig. 1 (modified from HARDY 1994), modelling of riverine physical habitat consists of two major procedures that together lead to an assessment of the impacts of various management options. Biological sampling is applied to determine habitat use by selected fish and/or invertebrate species. Spatial measure-

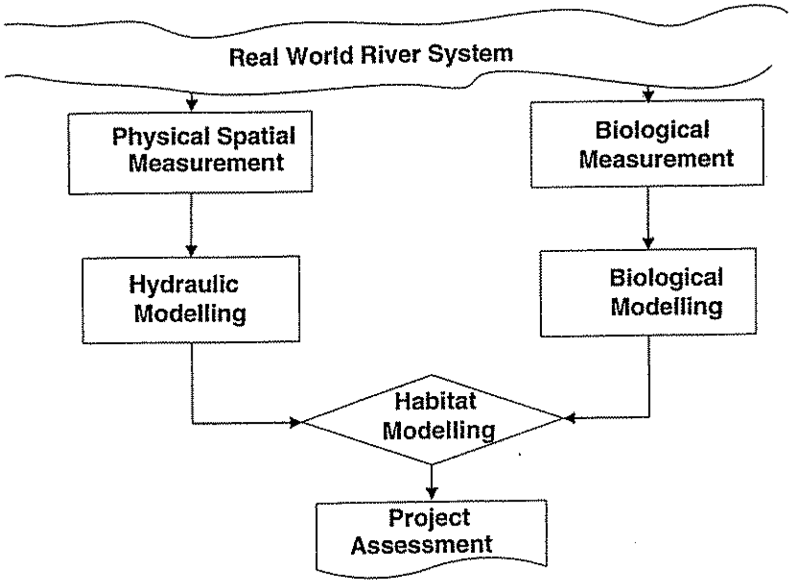


Fig. 1. General structure of a habitat modelling framework (modified from HARDY 1994).

ment provides a description of the morphologic/hydraulic habitat conditions in the studied water at a range of flows. Changes in these conditions with changing discharge can then be determined using mechanistic hydraulic models or statistical approaches, and variation in habitat suitability thus evaluated.

In the following sections we describe the various model components following Fig. 1, first from the perspective of the 'original' PHABSIM methodology and then in light of more recent developments.

2.2 Physical spatial representation

From macro to micro

Many habitat modelling frameworks use the stream segment as a basic unit. This is defined as relatively long sections between larger confluences with consistent geomorphology. The segment can be divided into reaches including a mosaic of meso- and microhabitats (Fig. 2). This provides a hierarchical framework by which the results of detailed measurements can be scaled to a unit appropriate for river management (BOVEE 1982; FRISSELL et al. 1996).

A segment is commonly described using either a critical reach (e.g. situated in habitat known to be limiting to population levels), representative reach (i.e. including all typical structures) or a mesohabitat typing ('habitat mapping') approach (MADDOCK & BIRD 1996; JOWETT 1993) (Fig. 3). Each of these approaches may be appropriate, depending on the situation. The first habitat mapping applications assumed transversal continuity between stream lengths assigned the same mesohabitat type. More recent research has examined the improvements arising

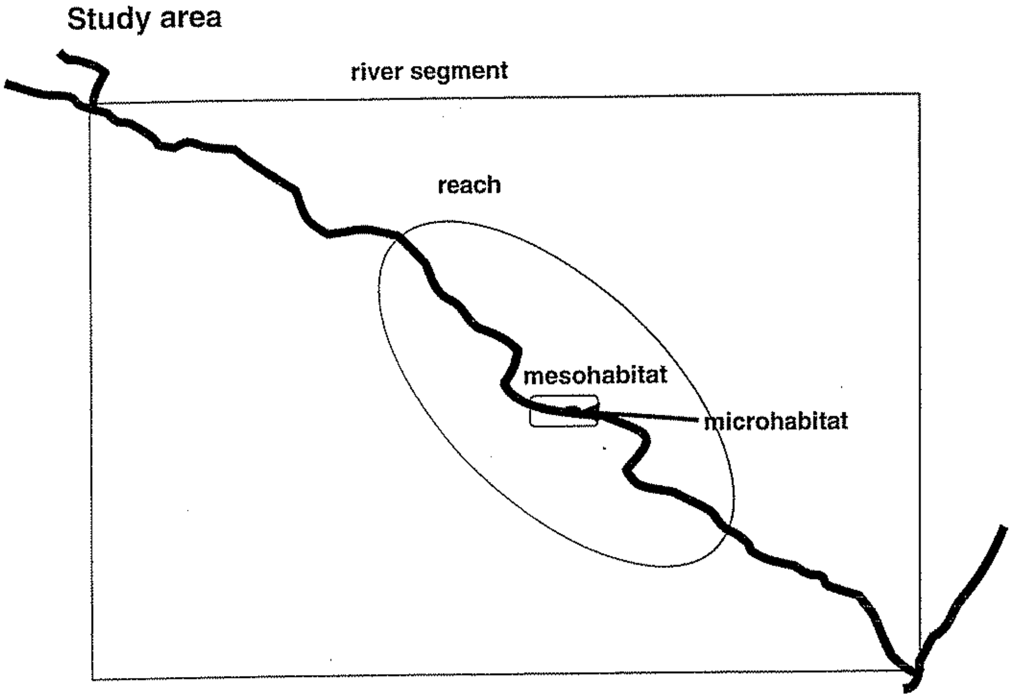
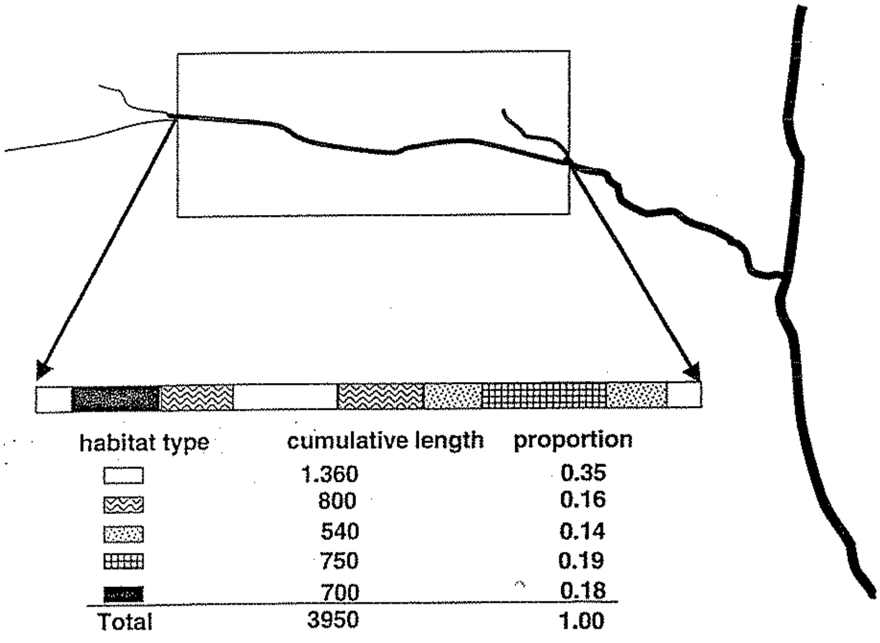


Fig. 2. Habitat classification scales.



habitat type	cumulative length	proportion
□	1.360	0.35
▨	800	0.16
░	540	0.14
▦	750	0.19
■	700	0.18
Total	3950	1.00

Fig. 3. Mesohabitat mapping (the mesohabitats are quantified over the segment length) (modified from Bovee 1994).

from transversal discontinuity of mesohabitats (Pouilly et al. 1996). Multispectral aerial videography in combination with ground truthing is another high-resolution technique that has enabled rapid mapping of distinct hydraulic habitats (Panja 1994).

Microhabitat sampling. Physical spatial measurement can be time and labour intensive, and can potentially take a considerable proportion of the resources of a project. Because of this, early sampling methods aimed to reduce this effort by using general assumptions, such as the ability of point measurements across transects to represent the spatial distribution of hydraulic variables in the whole reach.

Discrete cell representation

Fig. 4 presents how data collection procedures lead to 'discretization' or tessellation of a mosaic of "cells" used to represent the study area. In the original habitat modelling frameworks such as 'PHABSIM', the cells represent physical microhabitats and are defined using points spaced across a series of transects, placed to characterize the broader habitat types present along the river. This leads to the delineation of roughly rectangular cells. This approach allows some degree of easy stratification, it is also required for existing 1-dimensional hydraulic models. However, it may not allow the river to be described in sufficient detail. At each transect, the required physical variables (commonly water depth, velocity and substrate) are measured using verticals located in a systematic manner. The cell borders are commonly taken to be halfway between vertical sample points, and verticals are placed so that there are generally homogeneous conditions within each cell.

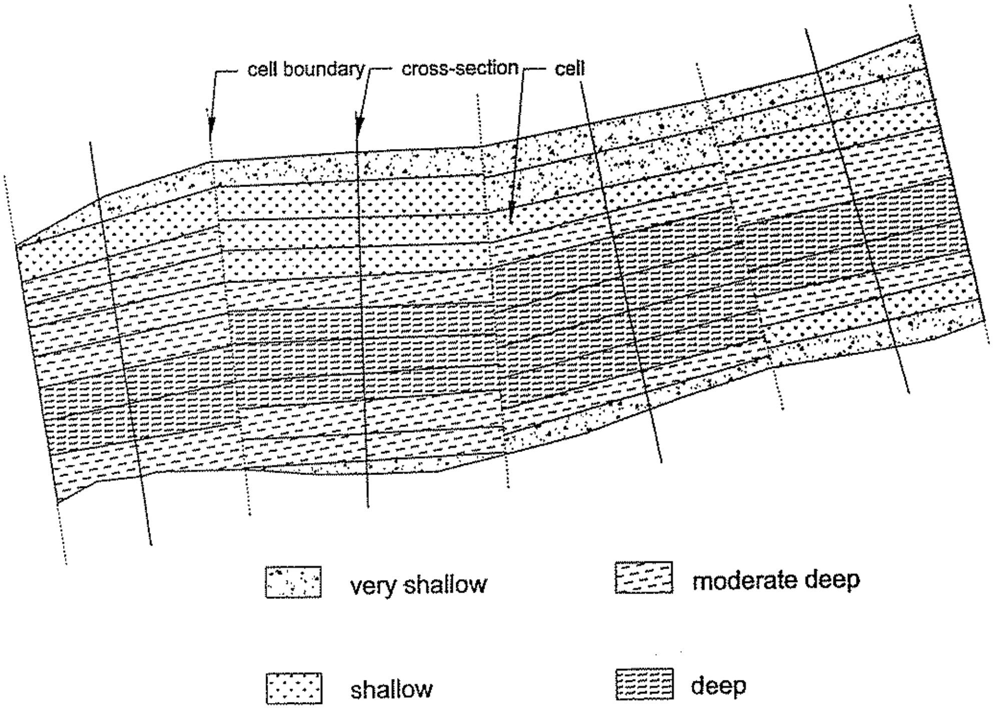


Fig. 4. Cell-based spatial representation of sampled river site (modified from BOVEE 1994).

Geodetic sampling and linear interpolation

More modern sampling methods have been supported by rapid technological development, and are based on geodetical principles of linear distribution of variables between measured verticals, adapting techniques from digital terrain modelling (Grossmann & Kahmen 1988). These are thought to give improved representation of real habitat conditions, and can reduce sampling effort (Parasiewicz 1996). Further reductions in effort may be achieved using measuring instruments capable of simultaneously measuring and logging multiple in-channel variables (e. g. position, depth, mean column and near-bed velocities). However, the development of such equipment is limited by the small market (Parasiewicz et al. 1999).

Random

Another method for measurement and description of microhabitat variables is random sampling. This method is, compared to other techniques, characterized by relatively low numbers of samples assuming that the sampled variables are evenly distributed in the mesohabitat unit. However, this approach may not be suitable for explicit spatial representation, which is becoming more and more important in habitat modelling (Bovee 1996).

Fractal geometry

Nestler & Stutton (in press) have proposed the use of fractal geometry for description of the properties of aquatic habitat. In this context, the fractal dimension describes the rate at which the habitat complexity changes with scale of observation. Thus, it may itself change at particular ‘breakpoints’ of scale, and is potentially able to deliver a habitat metric integrated over a range of scales. They also outline other related techniques more suited to the measurement of scale in river systems, such as the Angle Measurement Technique (AMT) and energy-area plots. These were applied to analyse habitat change on the Missouri River. It was demonstrated that the natural river morphology gave conditions approximating to a statistical fractal (i. e. with the same basic features repeated at increasingly smaller scales). However, the present-day channel exhibited limited distinct fractal scales, with a paucity of habitat structures at scales in between. This fact has a major consequence for spatial redistribution of energy in the cross-section at different discharges.

Although clearly still at the research stage, fractal geometry shows promise as an additional element in the ‘tool box’ of physical habitat analysis techniques. It could be relevant both for the evaluation of habitat restoration plans, and perhaps for the analysis of physical habitat for fish which are integrating stimuli at a range of scales, and which may vary their response to feature scale with growth. It is, however, not designed to replace the other techniques presented above.

2.3 Hydraulic modelling

Modelling variation in discharge with time

Once spatial data are collected, the key stages remaining are the modelling of how these variables vary with discharge, and the linking with habitat requirements of target species. In practice, prior choice of hydraulic modelling approach will greatly influence the data sampling strategy.

'Zero models'

By sampling many times over a range of flows, it would be possible to construct an empirical relationship between physical conditions and discharge. Habitat suitability is then calculated for measured conditions (see below) and values for other flows from considered range interpolated. Such a method does not require the investigator to accept any underlying requirements or assumptions of a particular hydraulic modelling technique. The predictability of this model is limited to the range of measured discharges, so it is usually restricted to low discharge situations. An example of this is the approach used in Austria and described in PARASIEWICZ et al. (1997).

Another method using this approach is the CASIMIR model (Computer Aided Simulation Model for Instream discharge Requirements in regulated streams). It was developed for assessment of impacts of river diversion for hydropower schemes. It is still under development, but will ultimately include a suite of models, currently the most developed of which is for variations in benthic shear stress (JORDE 1996). This works at a high spatial resolution, and is applied at the reach scale, measurements are taken at randomly selected points using STATZNER's 'FST' hemispheres (STATZNER & MÜLLER 1989) and repeated at multiple discharges.

The 'Wissey and Babingley methods' (PETTS & BICKERTON in prep.; PETTS 1996) functions in a similar manner, but with mean column velocity measurements. Transect-based physical habitat measurements are collected at representative sites in multiple segments and at multiple discharges as outlined above, and are related to site-specific habitat suitability criteria for invertebrates. This technique is particularly interesting in that the researchers have developed standard criteria for using the outputs to define a suite of benchmark river discharges (PETTS 1996) as: Threshold Ecological Flow (sustains refuges for biota; sustains a minimum level of refuge habitat within one reach in one sector), Acceptable Ecological Flow (sustaining some useable summer habitat for the target species within at least one reach type in each sector), Desirable Ecological Flow (sustaining some useable winter habitat for the target species in all reaches along the river), Optimum Ecological Flow (maximizing habitat area for target: this flow may occur infrequently but is important for sustaining long-term ecological integrity), Channel Maintenance Flow (the flow required to achieve a bankful discharge), and the Habitat Maintenance Flow (required for flushing of fine sediments).

Finally, surface flow 'biotopes' have been suggested as easy to measure habitat features, these currently require such a 'zero model' approach to map habitat changes with discharge. Using TWINSPAN analysis, it is possible to delineate invertebrate community associations with **functional habitats** (HARPER et al. 1998), defined from a list of **potential habitats** with distinct surface flow appearances (unbroken standing wave, rippled, smooth) (PADMORE 1995; RAVEN et al. 1995). The presence of such habitats can also be linked to levels of secondary production by selected invertebrate groups. By mapping in two dimensions (along and across the river) how the habitat types change with discharge (e. g. a reduction in area of riffle habitat with decreased discharge), it is possible to develop relationships between discharge and either a measure of community structure or secondary production (BUFFAGNI & COMIN in prep.).

One-dimensional models

Generally, in order to reduce effort to manageable levels, only a small number of discharges (commonly but not necessarily three) are sampled. Established 1-D hydraulic modelling techniques are used to interpolate and extrapolate predictions of the physical habitat variables. Such hydraulic models rely on transect based sampling, and solve standard equations (MANNING's equation, mass and energy balance) to simulate, over a range of discharges, water surface levels and mean velocity at each transect. Simulated water levels are combined with mean column velocity measurements for each 'cell' in each transect and then used to calculate how the velocity of each cell varies with discharge. Procedures also exist for simulating nose velocity, but within the PHABSIM framework, these are often not of sufficient accuracy (MADER pers. comm.). Similar alternative 1-D hydraulic models are used in other systems such as RHABSIM (PAYNE 1994), RHYHABSIM (JOWETT 1989), EVHA (GINOT 1995) and RSS (KILLINGTVIET & HARBY 1994). The modelled physical conditions will ultimately determine the habitat suitability of each cell.

NESTLER et al. (1996) have developed 1-D hydraulic techniques that aim to evaluate the cumulative impacts of river channelization and regulation, and how they might be mitigated. One of these techniques is a simulation framework called RCHARC. This aims to overcome two key problems inherent in applying the traditional PHABSIM type model approach to large warmwater systems with diverse fish communities. Firstly, development of habitat suitability criteria for non-existent habitat features (removed by previous channelization) is impossible. Secondly, the sheer numbers of species present would make species/life stage based analysis very time consuming. RCHARC uses hydraulics to compare multiple scenarios of flow regime and river morphology in terms of the frequency distributions of water depths and velocities. Each scenario may be assessed in terms of deviation of physical habitat diversity from a selected reference condition (such as unregulated, natural channel). This process has been used to evaluate how alternative flow regimes could partially mitigate some of the physical habitat diversity lost by historical habitat degradation.

Multidimensional hydraulic models

Multidimensional hydraulic computer models have recently experienced rapid development. Such models simulate physical conditions in two or three dimensions, applying the principles of conservation of mass and momentum in those dimensions. They also include some empirical representation of water turbulence at a scale finer than that of the model scale. They were developed for, and are commonly used in major flood investigations, and for studies of pollution diffusion and erosional processes.

Implementation of two-dimensional models (along and across river) for hydraulic description of physical habitat is currently being intensively evaluated. It has become a standard procedure in modelling systems such as RSS from Norway or HABIOSIM from Canada. Furthermore, the new version of the standard PHABSIM model includes 2-D hydraulics. Current models may still have problems simulating shallow river edge areas with high roughness, which may also dry and wet as river discharge changes.

Expansion of habitat modelling to the third dimension (explicit representation of how water velocity varies with depth) requires a further considerable jump in technology, but has been demonstrated in a research context. Accurate routines have been tested in Japan (TSJUMOTO 1996) and Norway (ALFREDSEN et al. 1997). These models require intensive computation, and they lack widespread validation for these purposes. However, it is hoped that future development will allow further reductions in velocity sampling effort, more detailed topographical survey and improvement of modelling accuracy. An important new development in three-dimensional modelling is the capacity of using a nested grid, i.e. different spatial resolution in the same model application. This will allow the use of fine grids in ecologically important areas, while coarser grids can be used in areas which do not require such resolution (OLSEN 1998).

Statistical hydraulic models

An alternative approach is to use statistically based models of river hydraulics. While empirical models of variation in broad morphometric channel variables have been in existence for many years, it is only recently that these techniques have been applied to model habitat hydraulics at the reach or mesohabitat scale. It has been suggested that at the reach scale, statistical hydraulic models can provide estimates of frequency distribution of hydraulic variables, when given simple inputs such as mean river velocity, depth and width (LAMOUROUX et al. 1995). Statistical techniques have shown that consistent patterns of such distributions appear among different streams. Based on power laws or multiple measurements, the depth-discharge and width-discharge relationships can be obtained, linking discharge to occurring hydraulic distribution patterns. Encouraging results have also been obtained from Australia (M. STEWARDSON pers. comm.). This method requires a wide range of input data from different streams in various catchment areas. Once a "library" of occurring patterns is established, the effort necessary for obtaining depth/width-discharge relations is relatively low. It should be also noted that current models are most suited to rivers with relative natural morphology. Their value lies in their ability to analyse broad trends in habitat hydraulics, rather than the specific description of a particular reach.

2.4 Biological sampling for suitability criteria

Sampling strategies

Sampling strategies will in part be governed by the general techniques that are proposed for the study. A key distinction is whether habitat preferences are considered relevant at the microhabitat level (BOVEE & ZUBOY 1988), the macrohabitat level (SCRUTON & GIBSON 1993), or the mesohabitat level (LAMOUROUX et al. 1998; BAIN & KNIGHT 1996). Generally, habitat variables to measure are chosen from previous autecological studies or preliminary multivariate analysis (e.g. BERREBI DIT THOMAS & BOET in prep.). Previous limitations of habitat models, in combining variables and handling categorical data, generally no longer apply.

For fish, occurrence of the investigated species in different habitat conditions is documented most commonly using electrofishing or underwater observation. Sonar technique is an alternative method applicable to deeper rivers. Electrofishing can be selective to species and life stage, can introduce location inaccuracies and is limited to relatively shallow areas (LAMBERT & HANSON 1989). Direct underwater observation is considered preferable but is limited by visibility, species size and activity. At low depths, fieldworkers generally switch to observation from above the water surface, which may introduce bias (HEGGENES 1990). Direct observations using videography can also be undertaken in laboratory conditions (FLORE & KECKEIS 1996). These have served to illustrate the detailed habitat choices that 0+ fish may make, however, it is not certain how information obtained in the laboratory may be applied to more complex riverine conditions. Both electrofishing and direct observation require a high number of random samples. Various sampling strategies have been developed for this purpose (BOVEE 1986; BIRD et al. 1995). At each sampled location, fish occurrence and the relevant physical variables are recorded. The substrate is either divided into site specific groups or most commonly described as the dominance or relative distribution of various particle sizes. This can result in complex coding systems. The **chotiotop** system (Austrian standard M6232) uses named classes of biologically relevant associations. It has been suggested that this is a more practical method for this purpose.

Cover coding can vary from simple presence-absence systems to relatively detailed descriptors of structural cover.

The obtained information is used for the development of habitat suitability criteria for the investigated species and life stages. The key issue is that habitat availability should receive special consideration as it can vary strongly between streams and sites, and it can be a major determining factor in fish habitat choice. Two rules of thumb are commonly applied, although in reality, this field has not received sufficient study (Bovee 1995):

a) If site-specific criteria cannot be developed, criteria should be transferred from streams with sufficient habitat diversity.

b) Criteria should be developed on river reaches not suffering from artificial flow alterations.

Univariate criteria

In this approach the measured variables are considered independently. Such suitability criteria can be of three categories:

Category I or "professional judgement" criteria are derived from life history studies in the literature and professional experience. Specifically collected field data are not required. Data may be collected from literature review. Other methods include the 'Delphi' technique (Crance 1987), and expert observation of river conditions (habitat recognition) (Chaveroche & Sabaton 1989).

Category II curves or "utilization curves" are curve-fitted frequency histograms, weighted over the measured range. The curves can have continuous, binary or conditional format. Care must be taken to view the utilization curves in the light of the available habitat in the streams where they were developed (Fig. 5).

Category III or "preference" curves attempt to factor out the influence of limited habitat availability. It was initially thought that these curves would be more 'transferable' between streams. Some attempts to use these curves have suggested that additional biases arising from incorporation of availability may make the curves of less use than originally thought (Slauson 1992; Bovee 1995) although others have suggested that they are more transferable (Beecher 1995).

Multivariate functions

Exponential polynomial functions were used in the first attempts to model multivariate habitat selection. This approach aims to account for interactions between the physical habitat variables, both in the physical domain, and also in the habitat choices made by the animal being studied. Drawbacks are that the data will always

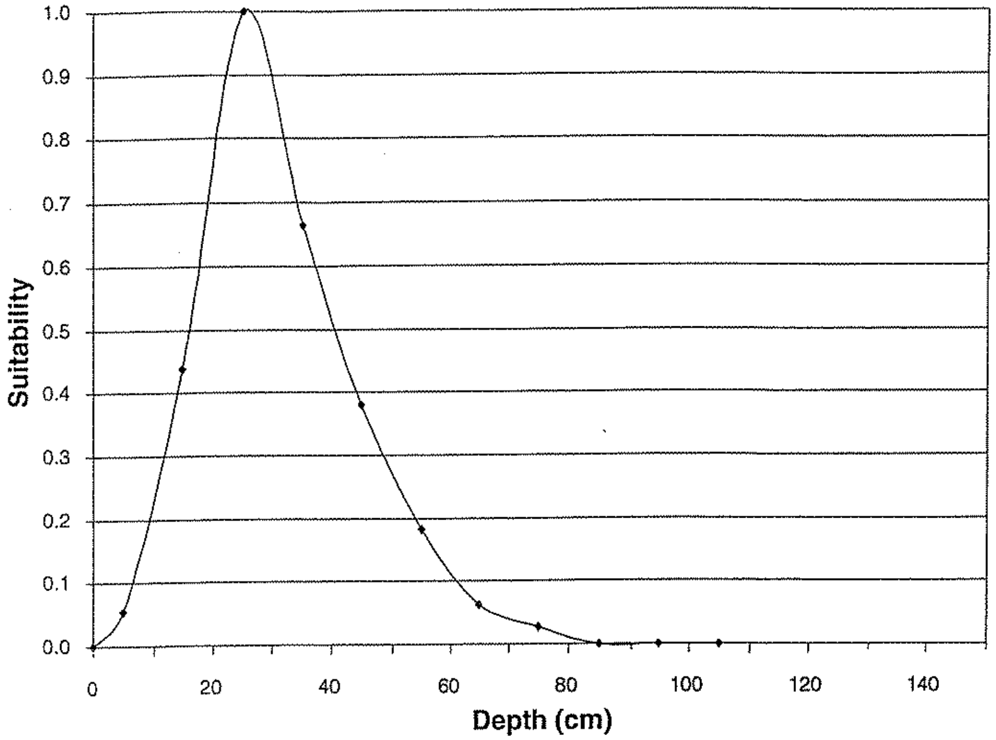


Fig. 5. Example of univariate suitability criteria.

be forced to fit the model to some extent (an increasing problem with more variables), the lack of visual control of result quality, and the additional skill and effort required to ensure meaningful results (LAMBERT & HANSON 1989).

Further multivariate approaches include:

Index weighting factors for each variable. These can be obtained by applying multivariate statistical techniques such as principal components analysis (PCA) (BOUDREAU et al. 1996), to develop weighting functions to be used with univariate curves. This approach still requires the variables to be combined using some a priori defined function, such as multiplication, and its application to categorial variables is limited.

Logistic regression. As habitat occupancy can be considered in terms of proportions of total available habitat occupied, it has been suggested that multivariate logistic regression may be applied for habitat preference calculation. This allows additional insights to be obtained with non-normally distributed frequency data as well as categorical data. Furthermore, it accounts for interaction and redundancy of input variables. The dependent variable is a dichotomous (binary) one describing the verticals occupied by the fish; the result is the function for fish occurrence probability as an integrative effect of physical factors. An example is provided in PARASIEWICZ et al. (1997).

Fish community analysis using combined MANOVA and PCA models. BAIN (1995) and BAIN & KNIGHT (1996) studied over 1500 samples taken on 10 lowland rivers in Alabama, USA. Based on multivariate analysis of 51 repeatedly captured species and physical habitat variables, five different habitat-use assemblages were identified, along with their microhabitat associations. This analysis suggested that the spatial extent of these key habitat types corresponds to the abundance and diversity of the fish species specialising on them.

The key habitat types identified in BAIN & KNIGHT (1996) could be used in current instream flow models. Variations in discharge can be evaluated by plotting the areas of stream that meet the criteria for each type of habitat under different flows. This assessment differs from standard physical habitat modelling in that the suitability is defined as occurrence and quantity of the defined assemblage habitat types.

Mesohabitat (reach unit approaches). Multivariate regression has been used to provide probability of fish occurrence for combinations of sampled variables in a mesohabitat based approach (LAMOUROUX et al. 1998). A river reach is divided up into habitat elements, based upon morphological properties. The frequency distribution of physical variables within each habitat element is obtained using around 10 stratified random measurements. Each measurement is thus associated with area or volume of represented strata and with one distribution class. The set of these area frequency distributions (one for each physical variable measured) is then assigned to every reach element. Frequency distributions for the whole reach are calculated summarizing distribution classes of each element weighted with element size. The fish population of the element is estimated by electrofishing. The biological (fish population) and physical (frequency pattern of variables) measurements are then analysed using mutivariate regression. Each element frequency class is than weighted by its regression coefficient and summarized (including the regression constant) in order to provide composite suitability index of reach element. The suitability indices at the reach element level are averaged to give an index at the reach level, which is assigned to reach distribution patterns.

Artificial Neural Network techniques have also recently been applied to analyse fish occupancy of mesoscale habitat features (BARAN et al. 1996) and in the future these too may be linked to hydrological/hydraulic models.

Bioenergetic criteria

Another kind of biological model uses a mechanistic approach based on fish bioenergetics (ADDLEY 1993; HUGHES & DILL 1990; FAUSCH 1984; FLORE et al. in prep.). Such a model must still be coupled to a suitable hydraulic framework. This uses suitability criteria representing net energy income (NEI) of the studied species as a result of environmental circumstances. In general, the NEI is the difference of gross energy income provided by the prey and the cost necessary for obtaining it. This includes the swimming and digestion costs.

By their very nature, such models potentially require a considerable knowledge of bioenergetics and the behaviour of a target species/life stage. In most cases, long lists of input parameters must be obtained by laboratory experiments and direct observation studies. This has often led to many of the parameters being taken from previous studies. Existing models have turned out to be sensitive to only a few of these parameters; this has significantly simplified the modelling procedure (ADDLEY 1993).

2.5 Habitat models

The key procedure of habitat modelling is the combination of site-specific hydraulic data, and habitat suitability data, in order to assess the relationship between habitat quality and river discharge in the study reach.

The traditional approach

The first physical habitat models computed a composite habitat suitability index using univariate suitability criteria for velocity, depth and channel index (a composite of substrate and cover suitability). Most often simple un-weighted multiplication has been used, although the facility exists to model habitat using the geometric mean or the minimum of the univariate indices. A measure of available habitat **at each flow** is then obtained from the sum of area-weighted composite suitabilities. Physical habitat may be analysed at the reach level, although more and more often, analysis is also carried out at the mesohabitat or even the cell level. Facilities also exist for restricting analysis to habitat of a certain quality, to compare habitat for different species, to consider spatial habitat metrics, and to evaluate potential impacts of rapid changes of flow that arise from ramping of hydropower production.

Technically, these procedures are elementary, if repetitive, and could be implemented in a spreadsheet program. Generalization of the cover and substrate information, the lack of an index of the relative strengths of the variables, and the univariate nature of the curves themselves are features of the PHABSIM HABTAE habitat model.

Other habitat modelling frameworks (e.g. EVHA, RSS, HABIOSIM) function essentially in the same manner, providing simple methods of aggregation of individual cell suitabilities at different river flows. RSS and HABIOSIM may show the way forward in providing a flexible habitat modelling framework which can link to any type of hydraulic data (e.g. ALFREDSEN & KILLINGTVEIT 1996).

The multivariate approaches described before also use the same principles. The major difference is in the consideration of the effects of combinations of physical variables on habitat choice instead of artificial aggregation of univariate suitabilities. It is hoped that this should improve representation of actual habitat use.

Habitat models linked to statistical hydraulic models

LAMOUROUX et al. (1998) have extended statistical channel hydraulics studies to link with multivariate habitat suitability analysis (see 2.4.3). This may overcome the requirements for habitat suitability criteria to be combined using a priori functions such as multiplication, and may also provide improved relation of fish biomass to the direct physical environment. As mentioned above, statistical hydraulic models can provide the depth- and width-discharge relationship for studied reaches based on physical measurements of two discharges and a power law. This derived relationship allows interpolation of the distribution of physical variables at any intermediate discharge, and thus fish abundance, via the multivariate suitability indices. This method has been evaluated successfully for various species on the Rhone River. The applicability in other river basins has still to be tested.

Bioenergetic habitat models

Biological fish energetic models may of course be coupled with suitable physical models: in this case areas of high NEI are considered to be of high suitability, and fish might be expected to prefer these feeding positions to maximize their NEI. This coupling will be most profitable when using more sophisticated physical sampling and spatial representation techniques. These models have recently shown some promise, notably for drift-feeding salmonids. However, validation for younger life stages has been shown to be particularly problematic (ADDLEY 1993).

Such models could allow us to overcome problems with ontogenetic shifts in habitat requirements leading to similar shifts in habitat use, to overcome potential problems with the transfer of habitat suitability criteria between rivers and to understand better the mechanisms of habitat use and the reactions to temporal and spatial dynamics of the system.

This approach is potentially extremely powerful, and it is hoped that it could lead not only to more accurate habitat models, but also to a better understanding of habitat requirements and thus the overall life history strategies of fish. However, intensive life history research is necessary in order to make use of this type of model, and the models still require development and testing to evaluate the importance of factors such as competition and predation, and activities other than resting and feeding.

2.6 Use of models for impact assessment and river management

For the first uses of the PHABSIM model in the 1970s, the resultant relationship between physical habitat and discharge was the final key output used for negotiation by catchment stakeholders. In many cases, these relationships represent the starting point for any assessment of ecologically acceptable flows or impact assessment of a proposed project. Additional analyses may also be required for integration of such factors as trophic interactions, channel maintenance and flush-

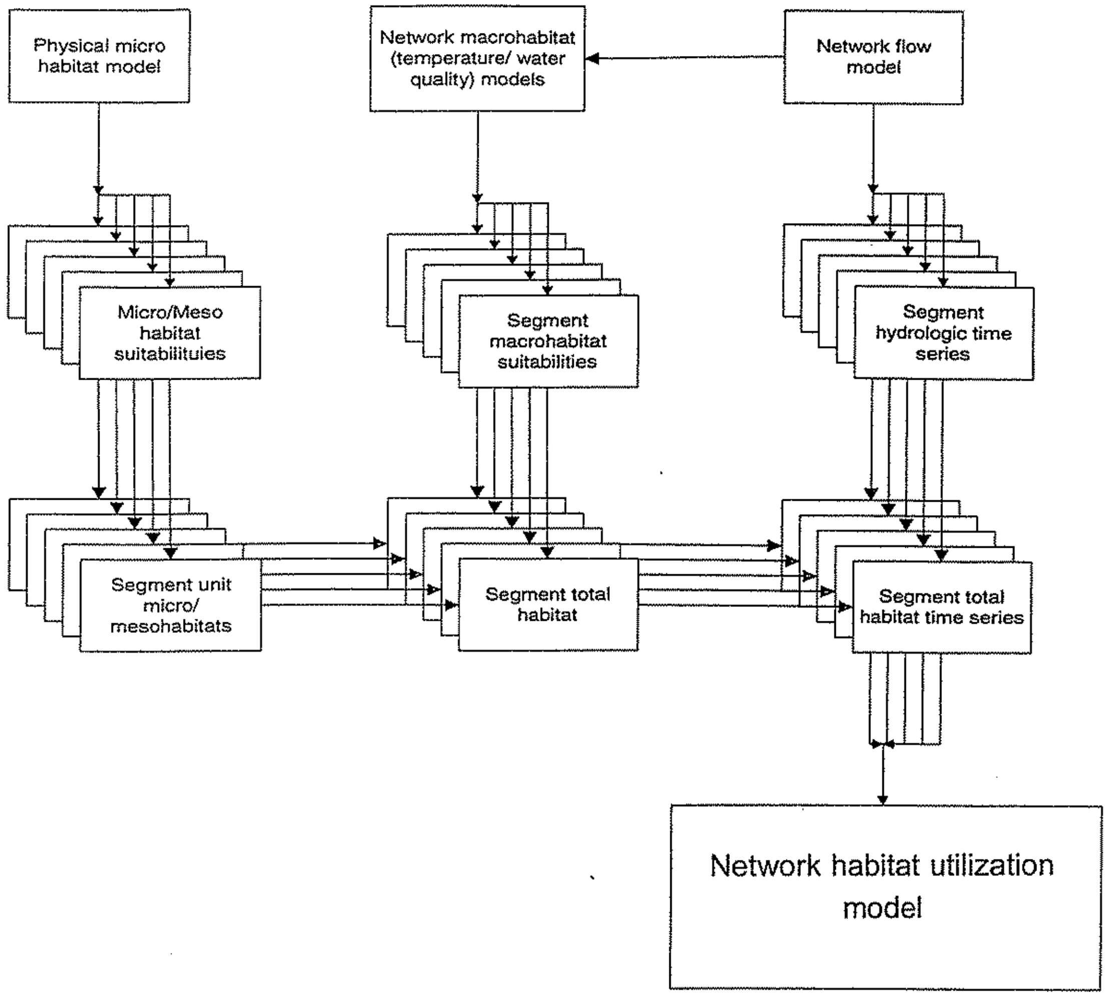


Fig. 6. Network habitat utilization model.

ing flows (Bleed 1987; Hill & Beschta 1991), riparian maintenance flows (using hydraulic data already collected), and/or water quality and temperature modelling.

In the 1980s, techniques were developed for analysis of physical habitat time series. Such analysis relies on the use of the derived habitat-flow relationships to show how alternative flow scenarios will alter physical habitat in a time and species sensitive manner. This time series could include the natural flow regime, the historical regime if already impacted, and suggested alternative regimes. Such alternatives can then be revised in the light of modelling results to produce a compromise that includes both economic and environmental factors. A framework for this is the **network habitat utilization model** (see Fig. 6), which is able to integrate physical habitat, water quality and temperature model data for multiple stream segments.

Structured approaches for time series analysis are not common, examples are illustrated in Geer (1987), Locke (1996) and Dunbar et al. (1996). These include the use of seasonal habitat duration curves (Gustard & Elliott 1997), and

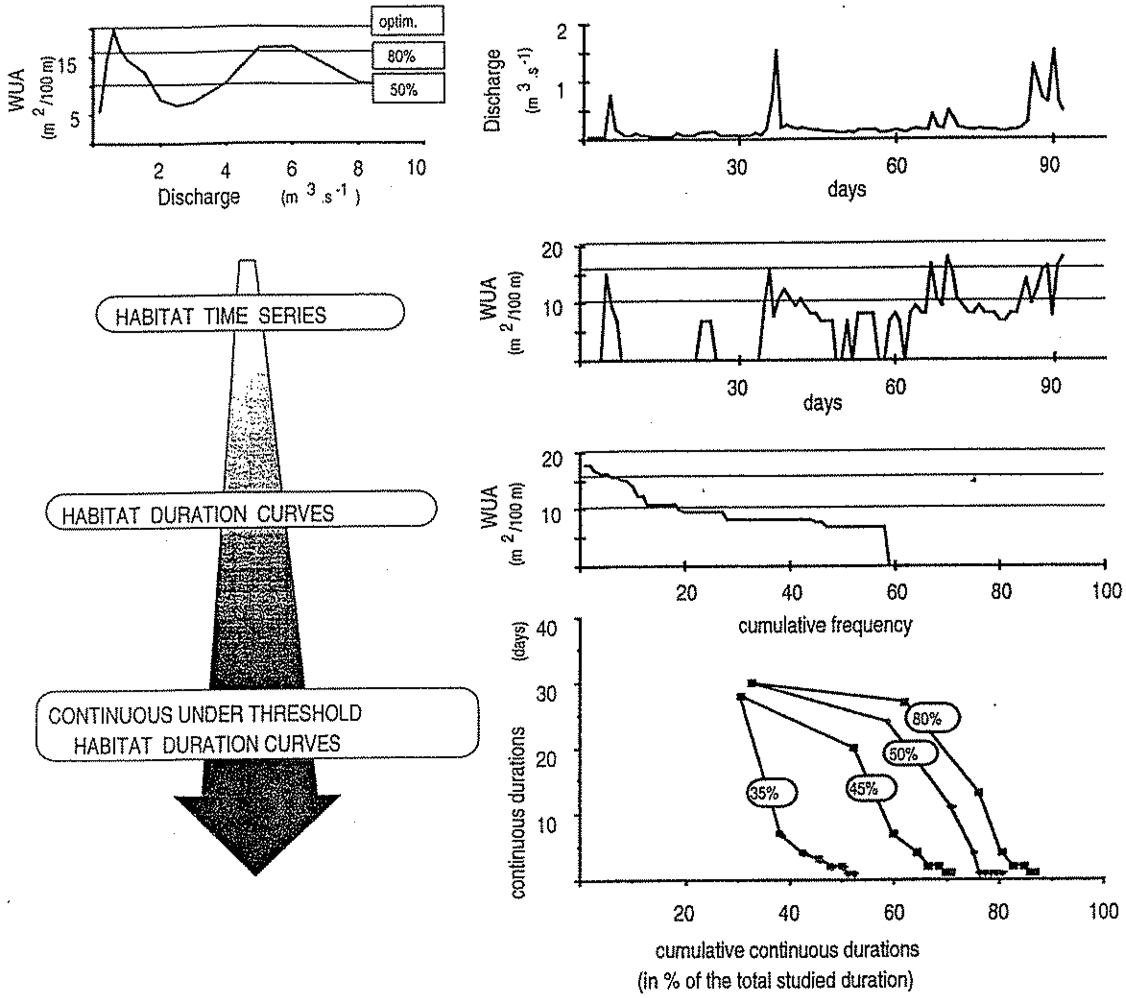


Fig. 7. Continuous under threshold analysis (Capra et al. 1995).

durations of habitat below threshold values (Capra et al. 1995). The latter, called CUT curves by Capra et al., involve calculating the frequency and length of continuous periods in each year that physical habitat drops below some predetermined value, usually defined as a percentage of the optimum (Fig. 7). These have been demonstrated as a simple yet biologically valid habitat index, and validated on several streams in France, where they were able to explain a greater amount of variance in year-to-year biomass than were any equivalent index derived from flow alone.

As mentioned above, physical habitat models were originally developed for the purpose of instream studies. It is only in the last few years that the value of this approach for other ecological studies dealing with river habitat rehabilitation has been realized. The first applications have demonstrated the clear value of linking hydrological-hydraulic models to habitat models, and the potential problems with adopting a building block approach to adjusting in-channel morphological elements (Elliott et al. 1996). Preliminary results (Dunbar et al. 1997) with existing one-dimensional hydraulic modelling techniques have shown that they are limited in their ability to model predictively the velocity conditions when river morphology is altered. It is hoped that the capabilities of multidimensional hydraulic models could improve hydraulic representation in this area. Despite this, comparison with actual post-scheme field data has shown that it would be of benefit to use such techniques at the design stage to improve the environmental standard of river engineering works.

In an impact assessment or ecological management project, exact procedures will depend on the scope of the study; it will still require discussion to decide what is acceptable given overall management goals. Consideration of timings, magnitudes, durations and frequencies of habitat and their relation to impact or benefit will be a key tool in enabling this informed decision to be made.

3. Discussion

This paper has outlined the following points:

1. The principles behind habitat modelling, and why such techniques came to be developed.
2. The new approaches that are being developed in order to develop more biologically realistic and useable habitat models.

We believe that when applied in a research context, the coupling of physical and biological habitat models can lead to valuable insights into biological processes. Habitat modelling is becoming more and more powerful, allowing better understanding of internal processes and functions of ecosystems. Clearly, fry and juvenile fish offer particular challenges for the habitat modeller. Their inclusion in habitat models is of considerable importance, both within an environmental assessment framework and also in the research domain. We have shown in this paper that many of the traditional limitations of habitat modelling no longer exist. Furthermore, a range of new techniques are being developed which are able to model riverine physical habitat in a manner which can be more biologically relevant and easier to generalize. However, we suggest that habitat modelling of 0+ fish still presents particular challenges. Further issues to consider are outlined below:

a) Accuracy and intensity of spatial sampling: several studies have emphasized the fine scale at which habitat choices are made. In many cases, fish have habitat requirements that are beyond the limits of existing measurement technology and model precision.
b) The relevance of habitat features existing at a range of scales: the study of alternative more spatially explicit habitat metrics has been begun by NESTLER & SUTTON (in press), BAIN & KNIGHT (1996), and LAMOUROUX et al. (1998).
c) A general lack of sufficient life history information: it is hoped that as our

biological understanding increases, the relevance of these discoveries to applied environmental assessment will be recognized and followed through.

d) Further biological interactions such as inter- and intra-species interactions (e.g. predation and competition), food availability and species migration, and the applicability of habitat modelling to their study.

Recent developments are already addressing the above issues, and future research should lead to improved ecological management of rivers. Better measurement and representation at the micro-scale, combined with more sophisticated modelling techniques, can improve our representation of biological reality at a scale relevant to 0+ fish. In parallel, statistical analysis of riverine biological communities at a broader scale offers additional insights into the key factors that structure them, and offer future hope for the reduction of sampling effort.

Perhaps some time in the future, it will be possible to link data and models at a range of scales, using three-dimensional microhabitat evaluation where required, but also measurements and models acting at a meso- or segment-scale where possible, in order to reduce data requirements and maximize generality.

In this paper it was not our intention to provide solutions, but rather to review existing habitat modelling techniques with all their advantages and disadvantages in order to allow a specialist to judge the capabilities of this "toolbox" of techniques. We hope that this paper has both helped improve the knowledge of habitat modelling and stimulated further discussion on this topic.

4. Summary

Instream physical habitat modelling was conceived more than twenty years ago as a flexible tool for the integration of biological information into the water resources planning process. However, it continues to undergo considerable development and modification. The aim of this paper is to describe the techniques that are being used world-wide, from an operational point of view.

Physical habitat modelling combines the results of biological and physical observations in order to define physical habitat conditions and in this way indirectly assess human influence on aquatic biota. Using the original 'PHABSIM' philosophy, several new models have been introduced world-wide. Many of the improvements concentrated mostly on computing techniques with little change to the original approach. Methods like EVHA, RHABSIM or RSS were the result. Others have tried to improve the simulation procedure itself. The application of more sophisticated hydraulic models has been applied in several research studies. Various techniques for incorporating greater biological content into the models have been suggested, but there is clearly still some way to go. In particular, univariate suitability indices have come under strong criticism due to the inherent physical complexity of aquatic systems. Some multivariate techniques have been

successfully implemented. Alternative modelling techniques are to construct a habitat model for fish based on a mechanistic/bioenergetics approach or statistical hydraulic model.

In general, the application of physical habitat modelling for the assessment of habitat conditions for 0+ fish requires development of specific techniques oriented on the requirements of the target life stage. Considerable integrated study must be undertaken to ascertain the utility of using 0+ fish as indicator species within physical habitat simulation.

Zusammenfassung

Die Methode der Habitatmodellierung wurde vor mehr als zwei Dekaden als Prognoseinstrument zur Einbindung biologischer Aspekte in wasserwirtschaftliche Planungsprozesse entwickelt. Seither wurden ständig Weiterentwicklungen vorgenommen. Basierend auf weltweiten Recherchen sind diese im vorliegenden Artikel dargestellt.

Habitatmodellierung verbindet Ergebnisse biologischer und physikalischer Beobachtungen und beschreibt darauf aufbauend die unmittelbaren physikalischen Lebensbedingungen. Auf diese Weise werden die Auswirkungen anthropogener Eingriffe auf die aquatischen Biozönosen indirekt beurteilt und quantitativ bewertet. Ausgehend von der Philosophie des „Urmodels“ PHABSIM (Physical HABitat SIMulation System) wurde in den letzten Jahren eine Reihe von Verfahren und Adaptationen entwickelt, welche sowohl programmiertechnische Verbesserungen (z. B. EVHA, RHABSIM, RSS) als auch Modifizierung der Simulationsprozeduren zum Ziel hatten. Einsatz von mehrdimensionaler Hydraulik sowie multivariater Analyse zur Einbindung der biologischen Aspekte waren dabei die Schwerpunkte. Außerdem entstanden auch alternative Modelle, welche auf Prinzipien statistischer hydraulischer Modellierung, Bioenergetik oder der fraktalen Geometrie aufbauen.

Diese Instrumente stellen ein wertvolles Werkzeug dar, welches bessere Einblicke in die funktionellen Zusammenhänge der aquatischen Ökosysteme erlaubt. Die Anwendung für die Erforschung der Juvenilfische als Indikatororganismen ist einerseits vielversprechend und stellt andererseits eine Herausforderung dar. Es bedarf methodischer Entwicklung, die auf die Spezifika dieser Fragestellung wie z. B. Skalierung, temporäre Veränderung oder limitierende Faktoren eingeht.

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These views are those of the authors rather than their respective institutes.

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Strategy for Sustainable Management of the Upper Delaware River Basin

Prepared by Piotr Parasiewicz
For Trout Unlimited

> "The forests and their deep duff, with topsoil intact, covered surrounding mountains like deep sponge. Even the heaviest rain seldom raised the river's level appreciably or even clouded its waters. Flash floods were practically unknown. If they did occur, it was only in the late winter or very early spring, with the break up of river ice or when frozen ground couldn't absorb snowmelt. The river was narrower because the banks were squared and closer together, not eroded by floods. They were well defined, sharp and steep, not lensing gradually up the valley sides. The Delaware was a classic example of a freestone river, its bottom filled with glacial boulders, graded stones, and gravel. (...) Silt was unheard of. The water was cooler. Dense conifer forests interspersed with hardwoods kept tributary streams cool and helped keep water temperatures low in the main stream. Even the main river was better sheltered, because trees grew down to the banks and overhung the river. Brook trout prospered."
>
> Nick Karas "Brook Trout"

Summary

The Upper Delaware River represents a valuable ecological resource of New York and Pennsylvania. Recognized as one of the most scenic rivers in the country, it is highly appreciated for high quality trout fisheries and outdoor experience. The river also serves as a water supply for local communities and New York City. The three New York City water supply reservoirs (Cannonsville, Pepacton and Neversink) are designed to withdraw more than 70% of the average annual volume available at the top of the basin at three stems of the Delaware: West Branch, East Branch and Neversink River). The severe flow reductions, together with channel alterations and landscape modification, result in dramatic changes of water temperature in the river. As a consequence of these alterations to water flow and temperature, Delaware aquatic fauna is strongly impaired.

The complex ecological impact caused by unnatural flow conditions and past environmental degradation conflict with local and regional development and necessitates a well-defined management scheme to optimize use of the river as a resource and secure its long-term sustainability. Detailed hydrologic and biological information is needed to determine factors that control the functioning of the system and help to define a long-term management plan. However, the highly degraded fishery requires immediate action. Consequently, a two-phase program is proposed to address the problems. In the first phase acute deficits will be addressed by prescribing permanent increases of base flow, and reducing ramping rates and peak amplitudes. These measures are expected to stop further damage and are compatible with current water withdrawals. In the second phase, a broad multidisciplinary study will provide a solid base for type specific restoration options and an integrative, long-term management plan for the whole basin.

Introduction

With 22 million inhabitants and numerous industrial enterprises, the Delaware River Basin is an example of an intensively used resource with conflicting demands. The sparsely populated upper portion of the basin represents a valuable ecological resource for both New York and Pennsylvania. Heralded as one of the most scenic rivers in the country and highly regarded for its fisheries and outdoor experience, the river serves as a local and regional (New York City) water supply. Multiple withdrawals of water for domestic supplies dramatically alter the flow of the river and consequently the river character. Three New York City reservoirs (Cannonsville, Pepacton and Neversink) are designed to withdraw more than 70% of the average available annual volume at the top of the basin. The effects of flow manipulation can be observed throughout the West Branch, East Branch and Neversink watersheds and the main stem (Sheppard 1983, Hulbert 1987). Negative consequences like thermal fish kills are evident, but many are rarely or hardly recognized. Information pertaining to the consequences of water withdrawals, such as alteration of fauna composition, sediment transport, surface-ground water interaction, thalweg elevation and substrate composition are commonly available for other watersheds, but sparse data exist for this area. Furthermore, limited knowledge of this ecosystem in its pristine form hampers the process of assessing human induced alterations. Hence, a deficit analysis can only be inferred from empirical knowledge of the system and theoretical assumptions. In the long run, a comprehensive multidisciplinary study is needed to establish an explicit management plan with long-term objectives.

Ecological perspective - Anticipated natural conditions

The Upper Delaware (West Branch, East Branch, and Neversink) is an alluvial upland river system of straightened-confined meandering character (B according to Rosgen 1985) with a pluvio-nivial flow regime (i.e. high flows related to rain and snow melt in the fall and spring, and low flow in the summer (Parde 1968)). The gradient is relatively low compared to headwater rivers, and multiple wetlands accompany its course. The river flows over unstable glacial deposits in a U-shaped valley that was heavily forested in pre-colonial times. The high capacity of the forest and wetlands to store water suggests that the historical hydrological regime of East and West Branch differed from the present by having lower fall and spring peaks, and higher summer flows. Consequently, thermal conditions would have been more stable in the past due to higher summer flows (i.e. increased thermal capacity), shading, and high groundwater input (i.e. spring discharges). Historical evidence of coldwater fish species in the upper Delaware also suggests lower summer temperatures and/or wide availability of thermal refuges in the main stem or tributaries (Karas 1997, Van Put 1996).

The estimated native fish community can be classified as either a cold or mixed cold and warm water assemblage. Early nineteenth century evidence suggests only an abundance of large brook trout year-round and American shad seasonally (Karas 1997). NY DEC records show the presence of fallfish, pickerel, golden shiner, pumpkinseed, minnow and sculpin (Elliot pers. comm.) after the river was already heavily modified. The comprehensive list of fauna composition from pre-colonial times does not exist and could only be reconstructed from river morphological characteristics.

Management perspective – economic potential

As a resource, the Upper Delaware offers high quality potable water for local communities and for export to New York City. The groundwater body provides higher quality and a more stable source of potable water because Catskill forests have a high water storage capacity.

Commercial use of the river is also important. Numerous industries can make use of the water resources, including the tourism and recreation industries. The scenic, mountainous landscape is rich with flora and fauna and offers extraordinary recreational opportunities for nearby urban populations like the New York City metropolitan area. The world famous brown and rainbow trout fishery is a traditional attraction and plays a vital economic role in the region.

Large trout rivers on the east coast are rare. Large rivers like the Delaware with high abundance of brook trout were rare even in the past. This exquisite fishing is now limited to a few northern, unsettled regions like Labrador or Manitoba. While restoration of the native brook trout fishery that once existed faces numerous obstacles, it is still a potential option that could open a highly exclusive fisheries resource.

Deficit analysis

Ecological deficits

The river's current condition is the result of two hundred years of human alterations to the original system, not merely the construction of the three upper-basin reservoirs. As a result of massive deforestation in the nineteenth century, the hydrological regime has been modified in the entire basin. Runoff was destabilized, changing annual amplitudes of flow. Average spring and winter flows increased, and summer/early fall flows decreased. With the loss of retention capacity, fluctuations of flow became more frequent and intense. An unstable riverbed was altered by a higher occurrence of flushing flows and massive logging operations, resulting in a wider and shallower channel. These morphological changes, together with reduced canopy cover and lowered ground water discharges, modified annual fluctuations of water temperature, leading to much warmer summer flows. Increased catchment sediment yield and bank erosion changed substrate composition in the river and covered spawning grounds and hyporheic refugia with silt. In response to all these factors, the faunal composition has shifted from a coldwater community towards a more generalist and warm water assemblage. Heavy angling pressure as well as stocking of domesticated brook trout and exotic species also share the blame for loss of a regional treasure: native, long living brook trout (Karas 1997). Tanneries and acid factories contributed to the complete destruction of the aquatic community. These industries vacated the Catskills in early twentieth century, but the physical damages remained.

In the more recent past, the construction of Neversink, Pepacton and Cannonsville water reservoirs for New York City has also contributed to various deficits in the Delaware River system.

- ➢ With regard to flow:
  - ✓ **Reduction of average annual volume by 50%** (from nearly 400 Billion Gallons per Year (BGY) to 200 BGY). The highest flow decreases have occurred on the East Branch and Neversink (70% and 80%, respectively). As a result, chronic low flows occur throughout the year and water flow is severely curtailed in the lower portions of the rivers. Critical physical attributes (velocity, depth etc.) are altered making habitat unsuitable to the original fish community, as well as nonnative cold-water fish including brown and rainbow trout, promoting a generalist and lentic assemblage.
  - ✓ **Change of seasonal and spatial flow pattern.** The magnitude of high flows is only a fraction of the pre-dam peaks (Figure 1). Average discharges over the winter and

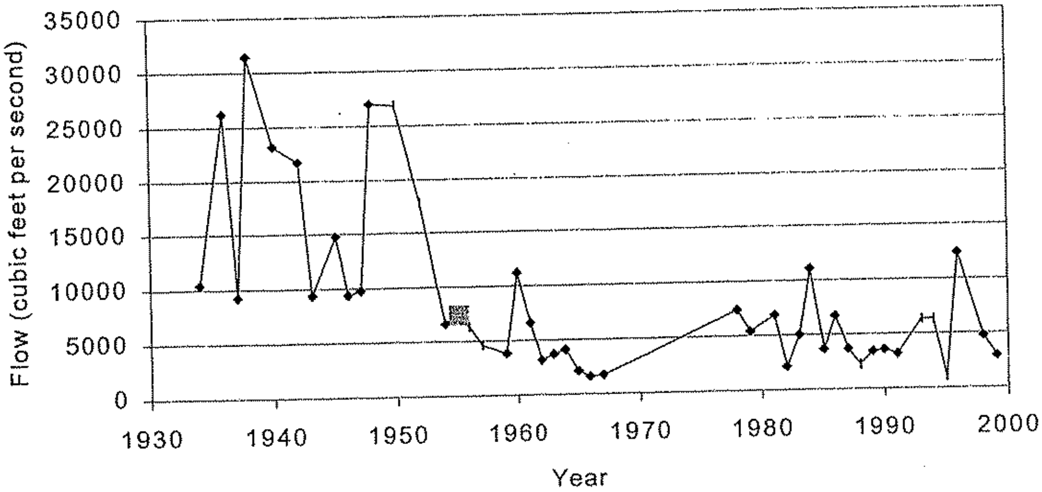

Figure 1: Historical annual peak flows at East Branch of the Delaware River, Harvard gage. The red square indicate the time of construction of Pepacton reservoir (courtesy of Nat Gilespie)

spring periods are dramatically reduced (Figure 2). Summer flows in the West Branch are unusually high, but in contrast are very low in the East Branch and Neversink. Frequently droughts occur in fall instead of summer as a result of sudden increase of reservoir storage (Elliot pers. comm.).

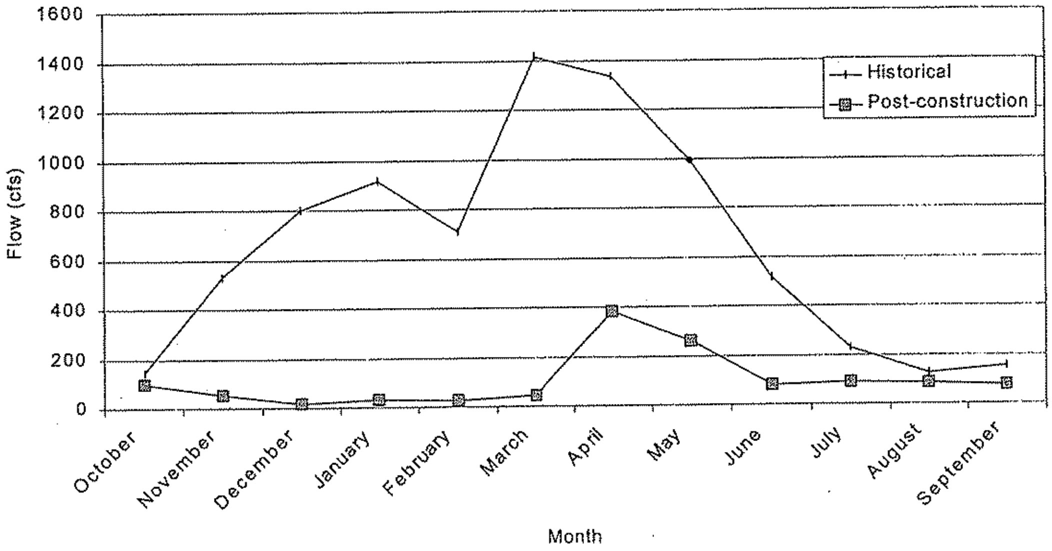

Figure 2: Median monthly flows at East Branch of Delaware River, Downsville NY

- ✓ **Modification of daily flow pattern** (increase of amplitude and ramping rate).[1] Figure 3 compares the Walton (above Cannonsville reservoir) and Stilesvile (right below the dam) hydrographs. In the tailwater, rapid flow changes occur more frequently and with higher intensity. Such frequent spates can result in the impoverishment of aquatic biota (Parasiewicz 1998). Contrary to natural systems, the artificial flow increases are not associated with increased ground water levels that have been identified as "warning signals" for benthic fauna in alluvial rivers (Bretschko and

Moog 1990). Also, the falling limb of the hydrograph fundamentally differs from a natural scenario. Such conditions can lead to the stranding of organisms and increased deposition of fine particles within the channel instead of on adjacent floodplain areas.

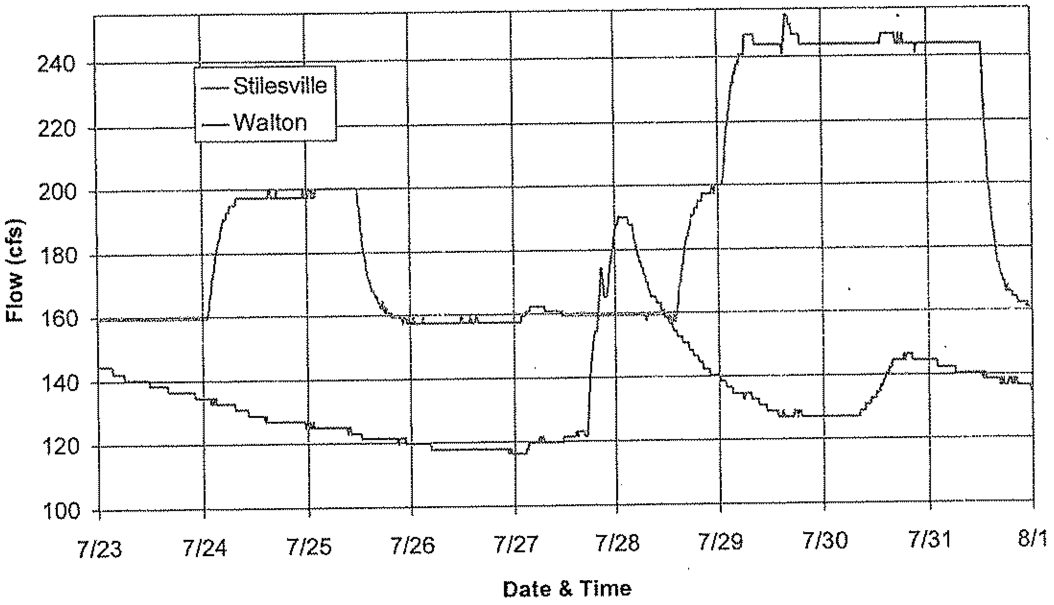

Figure 3: Comparison of daily hydrograph on the West Branch in Walton and Stylesville between 23-31 of July 2000.

✓ **Critically low flows during drought and winter seasons.** During droughts, releases are reduced to almost nothing, reducing habitat and thermal refugia in both seasons. In winter higher volumes needed for over-wintering habitat (most frequently deep pools for adult fish and riffles for juvenile fish and fry) do not exist. These periods are detrimental to fish.

- The thermal regime is also dramatically altered:

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[1] Rate of change during flow increase or decrease

- ✓ **Higher annual amplitudes of temperature**. Low flows, widened riverbeds, and reduced ground water discharge lead to high water temperatures in the summer and cold temperatures in the winter that did not occur in the past. The summer "warm ups" have already caused multiple fish kills in the Delaware River. The increased formation of ice cover with lowered water temperatures in winter (Figure 4) reduces habitat availability in the most critical stage of the annual life cycle, and particularly impacts the survival of young fish. Anchor ice in riffle areas may damage the riverbed and impact juvenile fish and benthic fauna (Gillespie pers. comm.).

Figure 4: Ice on the West Branch of Delaware River at Hancock on 21 January 2001

- ✓ **Extreme daily fluctuations and thermal plunges.** Shallow water bodies are susceptible to highly variable water temperatures even under normal weather conditions (Figure 5). Water temperature can change by many degrees centigrade during hot summer days. Drastic changes in release of water Cannonsville (e.g. 200 cfs to 1200 cfs) regularly introduce a coldwater plume that causes thermal shock to downstream fauna.

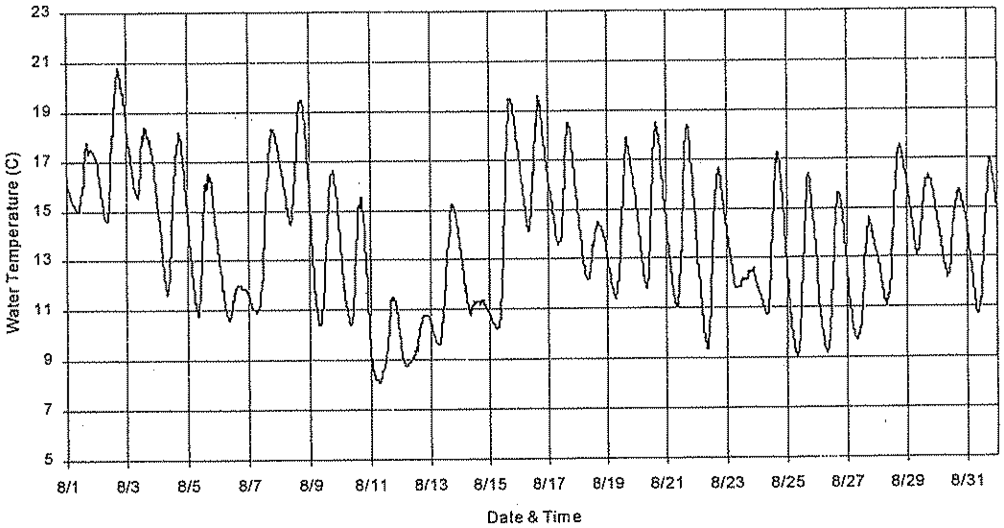

Figure 5: Water temperature on the West Branch of Delaware at Hale Eddy during August. 2000 (cold and wet summer).

- ✓ **Thermal discontinuity.** The temperature continuum along the river course is disrupted by the reservoirs compared to the original system. A natural distribution of the flora and fauna assemblages (as described in River Continuum Concept, Vannote et al. 1980) is disrupted.

- ➢ Longitudinal connectivity is affected by a lack of fish passage facilities at the dams. The resulting habitat fragmentation impairs the migratory cycle of species and limits the access to upstream thermal refugia.

- Substrate recruitment is disrupted by the impoundments and could possibly lead to the downcutting of the riverbed in the tailwaters.

- Channel modifications that took place due to logging and construction of roads, bank stabilization, levees and floodwalls are much more evident than potential morphological changes caused by the alteration of flow regime and substrate deficits. Armoring of the riverbed together with sedimentation of hyporheic zone could reduce vertical connectivity and affect benthic organisms. Potential downcutting might have an influence on longitudinal and lateral connectivity of the ecosystem, affecting life cycles of dependent organisms (e.g. access to spawning grounds).

Other ecological deficits exist that are not attributable entirely or in part to New York City reservoirs and water withdrawals:

- In the Upper Delaware little is known regarding the discharge from the aquifer to the river (USGS pers. comm.). Loss of wetlands and floodplains, increased paved surfaces, and infiltration limited by road surfaces together with low river flows could significantly reduce ground water contributions. Changes in water table levels could have a strong influence on the flow and temperature of the river as well as riparian areas.

- Exotic fish species have been introduced, but their influence on the native population is not clearly known. Brown and rainbow trout compete very successfully with native brook trout. Many unlikely species (e.g. small mouth bass, carp, and walleye) are also abundant. Additionally, many exotic plants compete with native flora.

Resource use deficits

In many cases the different resource uses have opposing interests:

- The water supply industry must deal with increased pressure from local communities and a requirement for water in the stream. On the other hand, water suppliers need to be prepared for an increased frequency of droughts and a growing demand for potable water (see also UNEP report on Global Warming, January 2001).

- Sustained reductions in the recharge of water to groundwater aquifers might cause serious problems for the region in the future. This issue needs to be studied more intensively. The resource has not been used very actively at present, but demands could increase significantly in the near future.

- Non-point source pollution threatens water quality and potable water supplies. Current farming practices (e.g. diaries in the flood plain) are not compatible with a catchment that is intensively used as a drinking water supply. Specifically, the Cannonsville reservoir has been often used to maintain River-Master-prescribed target flow levels due to its low water quality caused by poor upstream land-use practices.

- Recent flood damage made clear that current flood protection measures are not effective or sustainable. More extensive flood damages can be expected because of loss of wetlands and floodplains, expanding storm drainage and road systems, and increased urbanization. Comprehensive, long-term flood protection solutions are needed.

- The tourism and trout fishing industry require high quality instream and riparian habitat. Present flows and thermal conditions are not satisfying and lead to a reduction of fish populations. There is a widespread belief shared by fisheries managers, guides, and other river users that the trout fishery is not achieving its full potential due to flow management. The trout fisheries can be maintained only with the help of cold water releases. The large releases from the Cannonsville reservoir are intended to fulfill flow targets and help to alleviate the need for cold water. However, the East Branch and the Neversink are apparently sacrificed for the sake of the West Branch.

- ➢ A tremendous recreational resource is largely under-utilized. The region is economically depressed, but the unrealized potential of recreational activities of natural resources represents a possibly vast commercial resource.

Objectives for sustainable management

The ultimate goal of basin wide management could be to optimize resource use while maintaining sustainability by implementing the following multidisciplinary objectives:

- Preserve the original character of the river (as a coldwater system) to maintain a dynamic equilibrium and consequently long-term sustainability.

- Maintain ecological integrity (allow only slight changes in species composition and abundance from the type specific communities).

- Focus on the recreational industry and traditional trout fisheries.

- Preserve a potable water supply for present and future generations.

- Allocate water for industry and local uses in the lower part of the basin.

- Provide appropriate flood protection for communities in the upper and lower river basin.

Proposed target system

To fulfill management objectives the following characteristics can be envisioned as a management target:

- To allow for water withdrawals and maintain ecological integrity, the characteristics of the tailwaters of all three reservoirs should correspond to those of the natural system (but on a smaller scale). With some restrictions, higher-quality "reference" streams can be found in the Catskill Mountains (for example the West Branch of Delaware above Walton).

- The flow and temperature regime (timing, frequencies, amplitude, ramping rate) of the Delaware should correspond with the reference conditions (e.g. Walton hydrograph corrected for land cover)..To mitigate the impact of increased thermal uptake (a consequence of reduced water body and increased surface area) the temperature should continue to be lowered by releases of cold bottom waters from reservoirs.

- The high ground water level should be maintained by increased infiltration and storage (wetlands, backwaters etc.).

- Riparian vegetation should offer extensive shading and a source of woody debris, which in turn improves channel diversity.

- The substrate deficits should be controlled and minimized by adequate flow management.

- Ice damages should be of little significance and controlled by additional releases and higher ground water levels.

- The habitat diversity and connectivity should be restored.

- To support cold water fisheries low temperatures should maintained, but only to the extent that the tolerance of accompanying fauna is not exceeded.

- Within the limits of ecosystem resilience and sustainability, the water withdrawals can be continued at the same level and the efficiency of water use is maximized.

- Flood protection should assured on long-term basis.

Proposed measures

Implementation of the described target system will take time and additional research without conclusive historical records. However, immediate action is required to rescue the fishery and the ecosystem. Frequent thermal stress causes long-lasting damages to the fish fauna despite mitigation efforts utilizing a thermal stress bank. Unpredictability of weather conditions and a time lag of flow over long distances make precise temperature control difficult (just one catastrophic event could undo a multi-year effort). The damages to the West Branch are the most obvious. Trout are relatively abundant (a result of higher flow release practices), but lethal temperatures lead to fish kills, creating a fishery that is very inconsistent from year-to-year. Low winter flows and anchor ice create a long-term habitat bottleneck for fish and benthic fauna. The situation of the East Branch is also severe, with very low flows and consequent rapid warming. Although the water released from Pepacton reservoir is cold, the channel is wide and shallow, and the volume of warm water entering from the Beaverkill (also warmed due to an unnaturally wide and shallow channel), largely exceeds the downstream thermal capacity. The Neversink as a whole seems to be more resilient, probably due to a dense canopy cover and higher morphological diversity. The present flow regime in the Neversink and East Branch makes flow deficits during winter periods particularly apparent (see

Figure 2). Low flows and ice cover limit fish fauna in both rivers. On all three branches, rapid flow changes may cause serious damage to the fauna (through stranding, drift, thermal shock, and sedimentation).

For these reasons a two-step approach is proposed. First, preliminary measures should be undertaken to solve the most urgent problems and avoid further damages. The deficits that must be addressed in the short term are:

1. Chronic low flows on the East Branch and the Neversink Rivers.

2. Reduction of peak flows in the annual hydrograph with associated impacts. While it has been speculated that the East Branch and Neversink Rivers may suffer from the lack of higher flows since reservoir establishment, more data are needed concerning substrate composition, embeddedness and channel morphology.

3. Temperature bottlenecks in summer resulting from low flow releases.

4. Winter habitat bottlenecks and anchor ice damage resulting from low winter releases.

Second, a long-term management plan should be developed following a focused, multidisciplinary study of the entire system.

Immediate measures

<u>The simplest and most assured way to solve the issues listed above is to provide a constant and adequate base flow in all three branches</u>. It is necessary to prescribe minimum flows based on the general scientific and empirical knowledge of ecosystem mechanisms while adding an adequate margin of safety. As we gain a better understanding of the complex ecosystem, the flow regime can be optimized.

The following factors are integrated to develop a potential flow regime:

- New York City's ability to withdraw the same total amount of water for water supply needs.
- Present and historical flow regime at the reservoir locations.
- Need for reduction of temperature amplitude.
- Need for riparian succession to improve the channel.
- Coldwater fisheries.

Analyses of the water budget over the period of record (early twentieth century until now) have shown that since construction of the reservoirs on average 50% of the annual volume has been withdrawn from the Upper Delaware basin. Consequently, the other 50% of water flowing into reservoirs could be used for impact mitigation without affecting current supply. The key question is how to distribute it across the year most efficiently.

As mentioned before, the upper portion of the West Branch is a good template. The monthly mean flow at Walton or the historical monthly means at stations directly below the reservoirs can be used to determine minimum flow distributions (Figure 6 red and purple line). To accommodate water withdrawals the monthly values need to be reduced by 50% (Figure 6 dashed line). In order to provide the necessary thermal regime, it is proposed to redistribute the available spring and fall volume across the summer and winter months. Reduction of high flows would allow for more succession of riparian vegetation and, in the long run, decrease thermal amplitudes. Figure 6 shows how during an average flow year the flow releases could possibly be distributed on all three tributaries (green line) to meet the short-term management goals.

Furthermore, it should be realized that the flow releases from Cannonsville reservoir more effectively reduce the temperature of the main stem because the distance to the confluence is shorter and the temperature of the East Branch is elevated by inflowing Beaverkill waters. For this reason and also to accommodate the trout fisheries (mostly utilizing the West Branch and the main stem), an alternative approach would be to increase the Cannonsville releases to 300 cfs in winter and 600 cfs in summer. A small portion of 50% of the East Branch mean annual flow would therefore be transferred to the West Branch from November through May. Compared to the scheme presented above it requires only a slight reduction of the minimum flows in the East Branch (Figure 6 blue line). This pragmatic solution would also simplify the operation of reservoirs and compliance control. The proposed releases are summarized in Table 1.

Table 1: Proposed flow releases in cfs.

	oct	nov	dec	jan	feb	mar	apr	may	jun	jul	aug	sep
West Branch	300	300	300	300	300	300	300	425	600	600	600	450
East Branch	150	200	250	250	200	200	300	400	500	500	500	400
Neversink	70	100	150	150	150	200	228	200	150	100	100	100
Total	520	600	700	700	650	700	828	1025	1250	1200	1200	950

Because of the high vulnerability of the system to sudden temperature increase at low flows, the releases during the drought periods should be reduced to a ratio lower than for the other users and never go below 50% of the identified minimum flows.

Another important issue is to avoid sudden flow and thermal fluctuations due to excessive ramping rates. The maximum amplitude of changes should be identified based on the Walton hydrograph. Ideally, the ramping rate should be more gradual than extreme values occurring at the Walton gage. The shape of the Walton hydrograph is narrowed due to the location of the gage higher up in the drainage and because the watershed suffers from lack of forest cover. For a

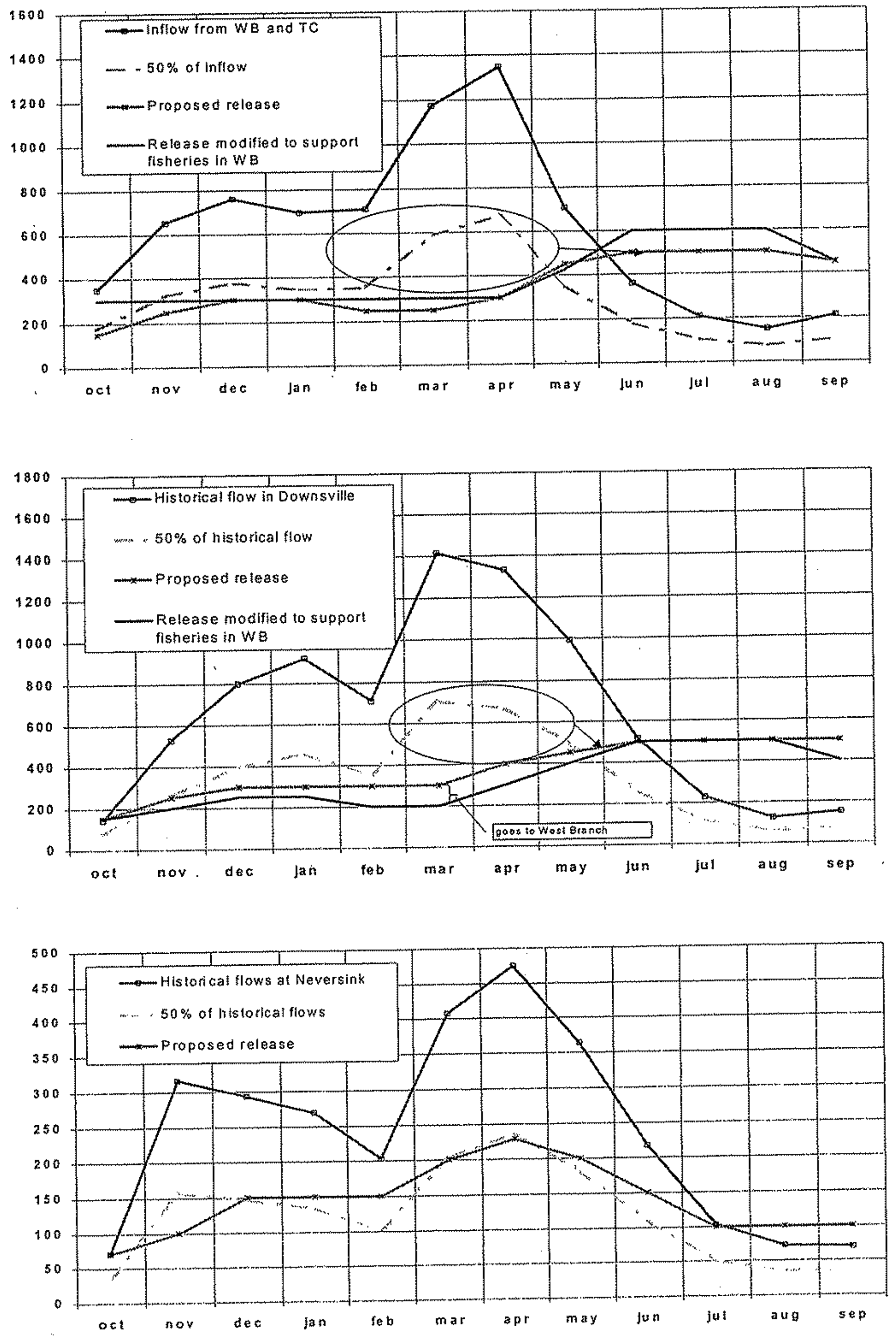

Figure 6: Calculation process of proposed flow releases based on historical flow regime for West Branch (up), East Branch (middle) and Neversink (down).

variety of biologic and geomorphic reasons mentioned earlier in the text, flow reductions should mimic the recessional limb illustrated in Figure 3, rather than being reduced at its current rate. Hence, special attention should be drawn to slow reductions of flow peaks.

Long term measures

This preliminary flow regime is still very artificial and needs to be intensively monitored to identify potential shortcomings. The monitoring results will support the planning process and help to define the most economically and ecologically effective measures. It should be conducted as part of a long-term management and research program. Intensive investigation by a multidisciplinary team of scientists and managers will provide an ecologically based foundation. Predictive models of hydrological and thermal regimes, ground water flow, sediment transport and target-fish-community habitat should be developed for the whole Upper Delaware, using a reference river for calibration and validation of measures. Based on comprehensive deficit analysis and model predictions, the dynamic flow management scheme can be determined. This and other measures, such as restored connectivity, improved channel diversity, or enhanced water quality in Cannonsville reservoir through reduction of non-point source pollution should be integrated to maximize ecological benefits of flow releases.

Conclusion

The Upper Delaware River Basin has a high potential to be an extraordinary example of applied sustainable management. We have an unprecedented opportunity to show that a devastated river system such as the Delaware can “bounce back” and create a definitive example for the entire country and world.

There are enough resources available to achieve this goal and allow for the coexistence of intensive human uses and an intact ecosystem. The costs of these measures are not high when compared to the long-lasting benefits for the users in and outside of the region. Even the short-term measures can be achieved at very low cost and are mostly flow management issues. Assuming that reservoirs are big enough to store adequate water volume, **the proposed flow scenario can be achieved without changing the volume of water withdrawn for New York City**. Moreover, the goals of uses could go hand in hand with restoration objectives (e.g. reduction of high flows).

These immediate measures are not optimal and even with them the system will remain heavily impacted. Therefore, in the long run it requires a well defined, scientifically sound, long term management concept that will consider the basin in its entirety. The intensive study to quantify limiting ecosystem factors, to better understand groundwater and surface water interactions, and to determine restoration options is a foundation of such plan. The majority of the necessary information is available, although it is widely distributed among research institutions. The "pieces of the puzzle" need to be collectively analysed and advanced through additional investigations and modelling exercises as prescribed in this study.

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CPC Exh 107

Instream Habitat Program
University of Massachusetts, Amherst

Main Menu

Stony Clove Creek

Scope of work
Application of MesoHABSIM on Stony Clove - PHASE I.

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Introduction

Many communities in the northeast presently face problems in river management (for example, hydrological alterations, impaired aquatic fauna and fisheries, and dramatic seasonal reductions or fluctuations in flow) resulting from three centuries of industrial and urban development, imprecise planning and poor knowledge of ecosystem processes. Many streams in New York State (NYS), especially those in urbanized areas, have been modified to some extent, (e.g. straightened, widened, dredged, impounded). The US Environmental Protection Agency (EPA) has recognized hydrological and habitat modification as major contributors to non-point source pollution. It is a strategy of the NYS Non-point Source Management Plan (page V-45) to improve water quality and restore instream and riparian habitat as a part of the maintenance and operation of existing modified channels [1]. The New York City Department of Environmental Protection (DEP), in partnership with the County Soil and Water Conservation Districts, is restoring stream channel stability in priority sub-basins in order to improve water quality in city reservoirs. The majority of methods used for instream and riparian habitat restoration [2] are limited in their ability to quantitatively assess biological responses to pollution, water withdrawals, channel modifications, and dam removals. River conservation efforts are therefore often limited to replacement and mitigation actions, which have improvement potentials that are largely unknown. Resource managers lack adequate tools for determining the most beneficial allocation of limited funds. Currently, they must apply multiple, and often intensive, assessment techniques in order to prioritize restoration and management efforts. Local and regional management agencies are thus in need of watershed management tools with the capacity of predicting the biological consequences of hydro-modification and applied restoration measures, while optimizing the level of required technical resources.

Nature and Scope of the project

Our overall goal is to assist communities in building more sophisticated environmental resource protection programs, and to enable these communities to see beyond single issues and consider the total ecological health of their landscape. Here we propose a project that would demonstrate the application of a newly developed instream habitat modeling technique (MesoHABSIM [3]) as a means of integrating aquatic habitat management, flood protection and water quality protection. In this process of transferring expertise to local governments and state agencies, we will help to provide a base of instream habitat knowledge, whereby ecological goals for the integrated management concept of the given watershed could be established.

The New York City DEP has expressed interest in integrating the above methodology with the presently used geomorphic approach to develop a Stream Management Plan for the Stony Clove watershed in Greene and Ulster Counties. In the first phase of proposed project, MesoHABSIM and the Target Community Approach will be incorporated into the habitat assessment work performed by the Greene County Soil and Water Conservation District. In the second phase, we will extend the application of the above methods to incorporate temporal and spatial habitat variability, simulate and evaluate restoration scenarios, and focus on the methodological merging of MesoHABSIM and geomorphological assessments.

Project goals

1. Demonstrate the application of MesoHABSIM and Target-Fish-Community-based habitat assessment approach for the Stream Management Plan.
2. Compare and combine this technique with geomorphological and fish-biological studies. These goals should be achieved through the following objectives:
    1. Establish a target fish community for the Stony Clove.
    2. Quantify physical habitat conditions for the fish community in management units.
    3. Conduct predictive modeling of restoration scenarios and quantitative evaluation of restoration measures.
    4. Superimpose the above results over geomorphological and fish (and invertebrate)-based biological assessments of the Stony Clove, compare the results and perform integrative analysis of fish habitat (see. Quinebaug Interim Report).
    5. Define a concept for most effective combination of all three approaches for the assessment of fisheries habitat.
    6. Extend methodological findings to other streams and establish interfaces between mentioned approaches.

Tasks to be performed:

PHASE I

1. Perform a literature search and establish a comprehensive list of potentially occurring fish species.
2. Consult with local and state government agencies and citizen groups to obtain information about naturally occurring fish species; select representative data sets.
3. Define the target fish community and compute a model of target community structure. Submit these definitions to the NYS DEC Region 3 and 4 fisheries biology staff and secure their comment and concurrence with the definition of the target fish community and model of target community structure.
4. Demonstrate the habitat mapping approach to agency staff members in two special courses.
5. Compute a habitat model for selected species and life stages.
6. Assess habitat conditions for the target fish community in each management unit over a range of low flows.
7. Report on steady-state habitat conditions in management units for the Stream Management Plan

8. Present and discuss Phase I findings with involved agencies and citizens groups.

PHASE II (preliminary)

9. Establish multi-seasonal, multi-life stage habitat selection criteria.
10. Conduct a habitat time series analysis for the fish community (habitat duration, persistence etc.).
11. Simulate and evaluate various restoration scenarios.
12. Perform a post-construction evaluation of applied restoration measures.
13. Integrate habitat modeling results with geomorphological and fish biological studies.
14. Evaluate developed approach on two other streams.
15. Discuss findings with NYSDEC, NYCDEP and other involved agencies.
16. Conduct a comparative analysis of the implemented approaches; develop recommendations for future applications.

Stony Clove Final Report

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[1] Nonpoint Source Management Plan, October 2000, New York State Department of Environmental Conservation, Division of Water, Bureau of Watershed Management
[2] http://www.epa.gov/owow/nps/MMGI/Chapter6/ch6-2b.html
[3] Parasiewicz, P. 2001. MesoHABSIM: A concept for application of instream flow models in river restoration planning. Fisheries 26:6-13.

Photo Archives

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INSTREAM FLOW REGIMENS FOR FISH, WILDLIF RECREATION AND RELATED ENVIRONMENTAL RESOURCES

Donald Leroy Tennant

ABSTRACT

A quick, easy methodology is described for determining flows to protect the aquatic resources in both warmwater and coldwat streams, based on their average flow. Biologists do their analysis with aid of hydrological data provided by the U.S. Geological Survi (USGS). Detailed field studies were conducted on 11 streams in 3 states between 1964 and 1974, testing the "Montana Method." Th work involved physical, chemical, and biological analyses of 38 different flows at 58 cross-sections on 196 stream-miles, affecting bo coldwater and warmwater fisheries. The studies, all planned, conducted, and analyzed with the help of state fisheries biologists, reve that the condition of the aquatic habitat is remarkably similar on most of the streams carrying the same portion of the average flov Similar analyses of hundreds of additional flow regimens near USGS gages in 21 different states during the past 17 years substantiate this correlation on a wide variety of streams. Ten percent of the average flow is a minimum instantaneous flow recommended to sustai short-term survival habitat for most aquatic life forms. Thirty percent is recommended as a base flow to sustain good survival condition for most aquatic life forms and general recreation. Sixty percent provides excellent to outstanding habitat for most aquatic life form during their primary periods of growth and for the majority of recreational uses.

Introduction

Natural, free-flowing streams are one of the world's most beautiful and valuable resources. Before the coming of Christ, the Roman Emperor Justinian said: "By the law of nature certain things are common property: for example, the air, running water, and the sea." America's late Senator Norris from Nebraska said: "The streams that are flowing downhill were given us by a creator. They do not belong to any special interest or to any individual. They belong to the people and ought to be utilized for the benefit of all of them."

Few streams in the United States have escaped degradation from land use practices or altered flows by some kind of man-made "water development" project. Some recognition is finally being given to instream flow regimens to protect the natural environment. Scientists from many disciplines are seeking reliable, practical methods for determining streamflow requirements to protect fishes, waterfowl, furbearers, reptiles, amphibians, molluses, other aquatic invertebrates, and related life forms from all the various people competing for our Nation's water.

With the help of several hydrologists and many State and Federal biologists, this quick, easy method was developed for determining flows to protect the aquatic resources in both warmwater and coldwater streams. This methodology evolved over the past 17 years from work on hundreds of streams in the states north of the Mason-Dixon Line between the Atlantic Ocean and the Rocky Mountains. This work has been cited in a score of publications and is best known as the "Montana Method."

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Method

The Montana Method is so brief it can be typed on a 3" x 5" card. It can be applied rapidly to many segments of thousands of streams by referring to Table 1 of this paper and surface water records of the USGS.

Table 1. Instream flow regimens for fish, wildlife, recreation, and related environmental resources.

Narrative description of flows *	Recommended base flow regimens Oct.-Mar.	 Apr.-Sept.
Flushing or maximum	200% of the average flow	
Optimum range	60%-100% of the average flow	
Outstanding	40%	60%
Excellent	30%	50%
Good	20%	40%
Fair or degrading	10%	30%
Poor or minimum	10%	10%
Severe degradation	10% of average flow to zero flow	

* Most appropriate description of the general condition of the stream flow for all parameters listed in the title of this paper.

The following intensive use of this method will produce a factual, conclusive streamflow study on any stream. First, determine the average annual flow of the stream at the location(s) of interest (listed as AVERAGE DISCHARGE by USGS and hereinafter called *average flow*). If the average flow is not published by the USGS, it can quickly be calculated for you. Visit the stream and observe, photograph, sample, and study flow regimens approximating 10%, 30%, and 60% of the average flow. Other flows can be studied, but these three regimens will cover a flow range from about the minimum to near the maximum that can normally be justified and recommended to protect the natural environment on most streams.

The average flow of a stream (or any given portion or percent of the average flow) is a composite manifestation of the size of the drainage area, geomorphology, climate, vegetation, and land use. These relationships have been evaluated and reported also by other biologists and hydrologists. (Rantz 1964; Tennant 1957, 1975).

For uncontrolled streams, study USGS records for daily, monthly, and annual flow patterns; then go to the field and check their gages until you can view and study natural flows approximating 10%, 30%, and 60% of the average flow.

If flows are controlled, begin by having the highest flow you wish to study released first; then regulate so that each succeeding lower flow will begin the following midnight. Photos taken early the next morning will reveal the difference in exposed substrate or wetted perimeter (Fig. 1). This is photographic "regression analysis." An interval of 8-10 hours will normally be sufficient to negate any appreciable differences in flow levels due to bank storage.

Figure 1. Missouri River below Holter Dam, Montana, showing differences between flows of 3,000 cfs (55% of the average flow) and 2,000 cfs (37% of the average flow). The vertical drop was 7 inches. Flows reduced about midnight will clearly reveal differences in wetted substrate when photographed the next morning (photographic "regression analysis").

Pictures may be the best data you will collect for selling your recommendations to the general public, administrators of construction agencies managing water development projects, and judges or juries adjudicating water laws. Black and white photographs and 35 mm slides of key habitat types (e.g., riffles, runs, pools, islands and bars) from elevated vantage points like bridges and high stream banks will give results superior to ground level shots or photos from aircraft high above the stream. Record appropriate, vital information on all photographs and slides as soon as they are received.

USGS monthly measurements of width, depth, and velocity cover a variety of flows at most of their stream gage or cable crossings. Obtain cross-sectional data on width, depth, and velocity measurements from the local USGS field office for flow regimens under study. Use this information to plot and compare water widths, depths, and velocities to known requirements for aquatic resources. As manpower and money permit, USGS will make specific cross-sectional measurements of width, depth, and velocity for government agencies at any point on any stream. It requires proper experience, equipment, and plenty of time for others to make the necessary cross-sectional measurements. Study average daily, monthly, and annual stream-flow regimen tables and previous historic low-flow data published by USGS to learn the base flow patterns of the climatic year and help determine flows that mimic nature and justify your final recommendations. Recommend the most appropriate and reasonable flow(s) that can be justified to provide protection and habitat for all aquatic resources.

Results

Detailed field studies were conducted on 11 streams in 3 states between 1964 and 1974 testing the Montana Method (Table 2). This work involved physical, chemical, and biological analyses of 38 different flows at 58 cross-sections on 196 stream miles, affecting both coldwater and warmwater fisheries. Reports or publications on 6 study streams are available as indicated in

Table 2. Detailed studies of instream flow regimens using the Montana Method.

Name Stream	State	Date	Miles Studied	Number of Stations	Different Flows	Parameters Studied[a]	Type of Fishery[b]	Reference
Republican R.	Nebraska	1964	40	3	4	W,D,V,S,B,C,T,F	WW	25
Wind-Bighorn R.	Wyoming	1968	50	10	3	W,D,S,B,C,T,F	CW & WW	24
Marias R.	Montana	1968	67	9	3	W,D,V,S,B,C,T,F	CW & WW	
Missouri R.	Montana	1970	15	8	4	W,D,V,S,B,C,I,F	CW & WW	
Blacks Fork R.	Wyoming	1971	16	4	3	W,D,V,S,C,I	CW	31
Shoshone Creek	Wyoming	1971	1	2	9	W,D,V,S,B,C,F	CW	
Ruby R.	Montana	1971	1	4	3	W,D,V,S,B,C,F	CW	10
W. Fk. Bitterroot	Montana	1971	1	5	3	W,D,V,S,B,C,F	CW	10
W. Rosebud R.	Montana	1971	3	3	4	W,D,V,S,B,C,F	CW	10
N. Platte R.	Wyoming	1974	2	10	2	W,D,V,S,B,C,F	CW & WW	
Total			196	58	38			

[a] Parameters Studied: W, Width; D, Depth; V, Velocity; S, Substrate & Sidechannels; B, Bars & Islands; C, Cover; M, Migration; T, Temperature; I, Invertebrates; F, Fishing & Floating; E, Esthetics & Natural Beauty.
[b] Type Fishery: WW, Warmwater; CW, Coldwater.

Table 2. Numerous black and white photos and 35 mm slides were taken of all the flow stages studied at each cross-section. The studies, all planned, conducted, and analyzed with the help of state fisheries biologists, reveal that the condition of the aquatic habitat is remarkably similar on most streams carrying the same portion of the average flow.

Width, depth, and velocity are physical instream flow parameters vital to the well-being of aquatic organisms and their habitat. Sixteen hundred measurements of these parameters for 48 different flows on 10 of the streams cited in Table 2 show that they all increase with flow, and that changes are much greater at the lower levels of flow (Fig. 2). Width, depth, and velocity all changed more rapidly from no flow to a flow of 10% of the average than in any range thereafter.

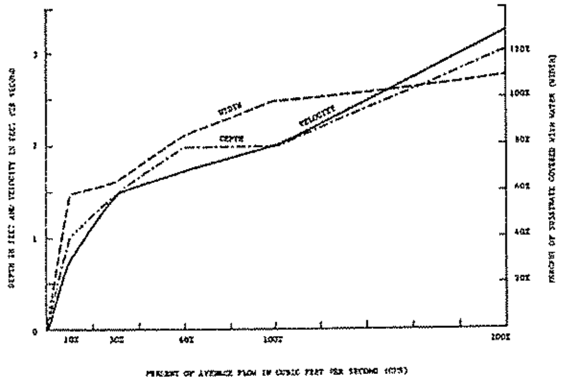

Figure 2. Average width, depth, and velocity from ten field tests of instream flow regimens using the Montana Method and the USGS hydrology data.

Ten percent of the average flow covered 60% of the substrates, depths averaged 1 foot, and velocities averaged 0.75 foot per second. Studies show that these are critical points or the lower limits for the well-being of many aquatic organisms, particularly fishes. This substantiates the conclusion that this is the area of most severe degradation or that 10% is a minimum short-term survival flow at best. Flows from 30% to 100% of average result in a gain of 40% for wetted substrate, average depth increases from 1.5 to 2 feet, and average velocities rise from 1.5 to 2 feet per second. These are within good to optimum ranges for aquatic organisms; however, it requires 3 to 10 times the amount of water needed for a short-term minimum or good base flow, and gains or benefit/cost ratios may become questionable. Increasing flow frim 100% of average to 200% of average (doubled) only increases average wetted substrate by 10%, average depth increases from 2 to 3 feet, and average velocity rises from 2 to 3.5 feet per second. Velocities averaging 3.5 feet per second are probably too high for the general well-being of most aquatic organisms but good for moving sidiment, bedload, and white water boating. In all 11 field tests of the Montana Method, water depth appeared adequate for aquatic organisms whenever velocities were satisfactory.

Analyses of hundreds of additional flow regimens near USGS gages in 21 different states during the past 17 years substantiate these correlations between similar flows on a wide variety of streams. Running waters studied ranged from small precipitous brooks high in the Rocky Mountains, to large, low-gradient rivers out on the prairies of mid-America and streams along the coastal plains. This phenomenon of nature is dicumented with hundreds of black and white photographs and 35 mm slides that are registered and filed with the U.S. Fish and Wildlife Service (FWS) in Billings, Montana; Grand Island, Nebraska; and Denver, Colorado.

Application of the Montana Method

Using the Montana Method it is easy to adjust to above or below water years and maintain stream flows that are appropriate portions of monthly, quarterly, or annual instream supplies of water. This helps fish, wildlife, and aquatic resources share surpluses and shortages of water equitably with other users.

With the Montana Method, USGS measures the hydraulic characteristics of the stream, and biologists interpret the biological responses. This saves considerable precious time that biologists can use on a more complete ecological analysis of streamflow needs.

There is significant hydrological and biological evidence that the Montana Method can be used successfully on streams throughout the United States and in other parts of the world (Rantz 1964; Whelan and Wood 1962). USGS data from cross-sectional measurements is subject to computer analysis with predicted flow parameters for width, depth, velocity, hydraulic radius, etc. at any desired water stage between zero and historic peak discharge.

USGS is considering the revision of stream flow data programs for most of the states (U.S. Department of Interior). The majority of existing gages may be discontinued under its future program. Techniques like measuring channel geometry, interpolation from a known flow to an unknown flow, and correlations with adjacent streams will be used to provide stream flow information at any point on any stream. Simple channel geometry measurements have produced average flow data as accurate as 10 years of continuous gage records (Hedman and Kastner 1974). The standard errors were lowest for mountain regions and in competition with 5 to 10 years of gaged records for the plains region. There is very little variation when results are compared between channel width and average flow (Fig. 3).

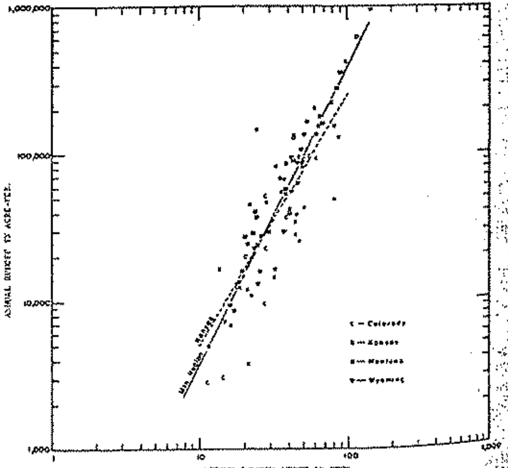

Figure 3. Correlation between average flow and channel width for streams in the mountain and plains regions of Colorado, Kansas, Montana, and Wyoming. Used with the permission of E.R. Hedman.

Mean annual discharge is one of the few criteria that will be routinely provided by this future program. Therefore, the Montana Method can still be used with this new program, since it is based primarily on knowledge of the mean annual discharge or average flow. The ability to provide the average flow at any point on any stream at any time would actually facilitate the use of the Montana Method in the future.

Adopting the metric system would not require conversion tables or other problems since this method is based on percentages of the average flow however it is expressed.

Conclusions

Ten percent of the average flow: This is a minimum instantaneous flow recommended to sustain short-term survival habitat for most aquatic life forms. Channel widths, depths, and velocities will all be significantly reduced and the aquatic habitat degraded (Figs. 2, 1). The stream substrate or wetted perimeter will be about half exposed, except in wide, shallow riffle or shoal areas where exposure could be higher. Side channels will be severely or totally dewatered. Gravel bars will be substantially dewatered, and islands will usually no longer function as wildlife nesting, denning, nursery, and refuge habitat. Streambank cover for fish and fur animal denning habitat will be severely diminished. Many wetted areas will be so shallow they no longer will serve as cover, and fish will be crowded into the deepest pools. Riparian vegetation may suffer from lack of water. Large fish will have difficulty migrating upstream over riffle areas. Water temperature often becomes a limiting factor, especially in the lower reaches of streams in July and August. Invertebrate life will be severly reduced. Fishing will often be bery good in the deeper pools and runs since fish will be concentrated. Many fishermen prefer this level of flow. However, fish may be vulnerable to overharvest. Floating is difficult even in a canoe or rubber raft. Natural beauty and stream esthetics are badly degraded. Most streams carry less than 10% of the average flow at times, so even this low level of flow will occasionally provide some enhancement over a natural flow regimen.

Figure 1. Republican River below Hardy Bridge, Nebraska, showing a flow of 12 cfs (10% of the average flow). Water depths were adequate to provide some fish cover, living space, movement, and fishing. Temperatures were within tolerable limits. This is a *minimum* instantaneous flow recommended to sustain short-term survival habitat for most aquatic life forms.

Thirty percent of the average flow: This is a base flow recommended to sustain good survival habitat for most aquatic life forms. Widths, depths, and velocities will generally be satisfactory (Figs. 2, 5). The majority of the substrate will be covered with water, except for very wide, shallow riffle or shoal areas. Most side channels will carry some water. Gravel bars will be partially covered with water and many islands will provide wildlife nesting, denning, nursery, and refuge habitat. Streambanks will provide cover for fish and wildlife denning habitat in many reaches. Many runs and most pools will be deep enough to serve as cover for fishes. Riparian vegetation will not suffer from lack of water. Large fish can move over riffle areas. Water temperatures are not expected to become limiting in most stream segments. Invertebrate life is reduced but not expected to become a limiting factor in fish production. Water quality and quantity should be good for fishing, floating, and general recreation, especially with canoes, rubber rafts, and smaller shallow draft boats. Stream esthetics and natural beauty will generally be satisfactory.

Figure 5. Bighorn River below Boysen Dam, Wyoming, showing a flow of 100 cfs (30% of the average flow). Water depth was adequate for trout movement, spawning, incubation, and winter survival in most run and pool areas for a distance of 15 car miles downstream. This is a base flow recommended to sustain *good* survival habitat for most aquatic life forms.

Sixty percent of the average flow: This is a base flow recommended to provide excellent to outstanding habitat for most aquatic life forms during their primary periods of growth and for the majority of recreational uses. Channel widths, depths, and velocities will provide excellent aquatic habitat (Figs. 2, 6). Most of the normal channel substrate will be covered with water, including many shallow riffle and shoal areas. Side channels that normally carry water will have adequate flows. Few gravel bars will be exposed, and the majority of islands will serve as wildlife nesting, denning, nursery, and refuge habitat. The majority of streambanks will provide cover for fish and safe denning areas for wildlife. Pools, runs, and riffles will be ade-

Donald L. Tennant

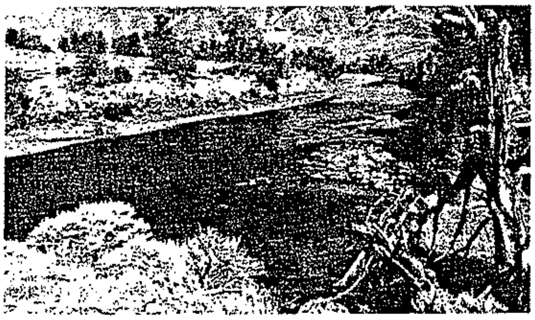

Figure 6. North Fork Shoshone River near Wapiti, Wyoming, showing a flow of 156 cfs (approximately 60% of the average flow). Water widths, depths, and velocities very good for fish and fishing in all riffles, runs and pools. This is a base flow recommended to provide *excellent* to *outstanding* habitat for most aquatic life forms during their primary periods of growth and for the majority of recreational uses.

quately covered with water and provide excellent feeding and nursery habitat for fishes. Riparian vegetation will have plenty of water. Fish migration is no problem in any riffle areas. Water temperatures are not expected to become limiting in any reach of the stream. Invertebrate life forms should be varied and abundant. Water quality and quantity is excellent for fishing and floating canoes, rafts, and larger boats, and for general recreation. Stream esthetics and natural beauty will be excellent to outstanding.

A flow of two to three times the average flow is often best for kayaks and whitewater canoeing. A flow of this magnitude is also preferable for larger boats with inboard or outboard motors, like those many people use on the annual Missouri and Yellowstone River floats held in June and July in Montana.

Recommendations

1. Request "instantaneous flows" to prevent flow releases from dams and diversion structures that are averaged over a day, month, or year, which permits erratic releases or even no flow at times.
2. Recommend that dual or multiple outlets to all dams be designed and constructed so that minimum flows of an appropriate temperature and quality to protect the aquatic environment can be by-passed at all times, including during drawdowns for safety inspections and emergency repairs.
3. Insist that costs for providing of instream flows to protect the aquatic environment downstream below dams be project costs, including costs for unforeseen emergency repairs and routine maintenance over the life of the project.
4. Justify only that portion of a stream flow required to fulfill specific instream needs. If fish need a flow of 100 cfs in a segment of stream where there are already legal requirements of 25 cfs for municipal water, 15 cfs for irrigation water transport, and 10 cfs for a U.S. Environmental Protection Agency water quality requirement, you logically and legally should have to justify a flow of only 50 cfs. Planners of water development projects may ask you to justify and apply benefit/cost ratios for fish to the 100 c flow because this makes their "project purpose" look mo favorable on a comparable benefit/cost basis.
5. Stipulate that the downstream flow will not be less than tl inflow to impoundments, whenever operators of wat development projects cannot provide specific flow r quirements. Make this an integral part of every flow regim recommendation, preferably part of the same sentence.
6. Reduced releases to a stream should not exceed a vertic drop of 6 inches in 6 hours. Fluctuations greater than th may significantly degrade aquatic resources.
7. Request that maximum flows released from dams not exce twice the average flow. Prolonged releases of clear wat greater than this will cause severe bank erosion and degra the downstream aquatic environment.
8. Use "undepleted" USGS hydrology data for flow recomme dations that relate to the stream in its pristine conditio (e.g., before dams, diversion, pumps, etc.). Otherwis recommendations from the Montana Method may relate depleted stream conditions and result in less than ide flows.
9. Avoid recommending minimum instantaneous stream flc regimens less than 10% of the average flow since they w result in catastrophic degradation to fish and wildli resources and harm both the aquatic and riparian e vironments. Encourage lawmakers to pass legislation th would prevent diversions or regulation at dams, whenever would reduce streamflow below this level. If water develo ment projects cannot make it on 90% of the water carried l a stream, use of the remaining 10% probably won't justi their projects. Philosophically, it is a crime against nature rob a stream of that last portion of water so vital to the li forms of the aquatic environment that developed there ov eons of time.

Note: Complete copies of this report can be obtained free by writing U.S. Fish and Wildlife Service, Federal Building, Billings, Montana 59101.

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