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Environmental Impact Statement

Appendix 14

Integrated Turf Management Plan

The Belleayre Resort at Catskill Park

Integrated Turf Management Plan for the Big Indian Country Club and Highmont Golf Club at The Belleayre Resort at Catskill Park

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ERRATA

This document has been revised to incorporate comments/concerns raised during the original completeness review of the DEIS. In particular, revisions have been made as to what pesticides may be used and will not be used on the proposed golf courses. These changes are as follows.

- Cyproconazole was registered for use on turf in New York State at the time that the original DEIS was written. Cyproconazole is no longer registered for use in New York and is no longer proposed for use. All references to cyproconazole use on the proposed golf courses have been eliminated from the DEIS.

- Because of the Department's concern with mancozeb metabolites, particularly ETU, mancozeb is no longer proposed to be used on the proposed golf courses. The DEIS has been amended to reflect this.

- The fungicide trifloxystrobin has been added to the DEIS as a substitute for mancozeb. Trifloxystrobin was just recently recommended for use on commercial turfgrass in New York State (Cornell Cooperative Extension's *2002 Pest Management Guidelines for Commercial Turfgrass).* Trifloxystrobin has been evaluated using the same procedures used for the other active ingredients analyzed in the Fertilizer and Pesticide Risk Assessment (DEIS Appendix 15). For the five soil series profiles analyzed, there was zero trifloxystrobin leaching from three of the soil series. The maximum undiluted leachate concentration from the other two soil series profiles was 0.0068 mg/l. This undiluted concentration is almost 10 times less than an actual drinking water health standard of 0.050 mg/l. For the runoff portion of the analysis, when trifloxystrobin was present in runoff, it was at undiluted concentrations less than the LC_{50} values for rainbow trout and *Daphnia.* (LC_{50} = concentration that is lethal to 50% of test organisms in a toxicity test.) Undiluted concentrations of trifloxystrobin in runoff ranged from 0.0001 mg/l to 0.0026 mg/l. These are well below the LC_{50} values of 0.014 mg/l for rainbow trout and 0.025 mg/l for *Daphnia.* The DEIS has been amended to include the option of using trifloxystrobin to treat leaf spot, pink snow mold, and pythium.

- Very recently the manufacturer of products containing metalaxyl adjusted the chemical structure of metalaxyl to form a slightly different compound. The new stereoisomer of metalaxyl is known as mefenoxam, and mefenoxam is now the active ingredient in products that formerly contained metalaxyl. The *2002 Pest Management Guidelines for Commercial Turfgrass* published by Cornell University now includes mefenoxam, and no longer includes metalaxyl. Metalaxyl is no longer proposed for use on the golf courses and the DEIS has been amended to reflect this.

Because mefenoxam has a slightly different chemical structure than metalaxyl, mefenoxam also has slightly different characteristics that affect its potential to leach to groundwater. Mefenoxam has a slightly higher water solubility, but a much higher K_{oc} value than metalaxyl. The vapor pressure and soil half-life for the two compounds are similar. Mefenoxam is more efficient in controlling the target pythium fungus, so much so that mefenoxam label application rates are half of what they formerly were for metalaxyl products.

Behavior of mefenoxam on the proposed golf courses was modeled in the same way the other pesticides were modeled in the Fertilizer and Pesticide Risk Assessment (DEIS Appendix 15). At no time did the undiluted leachate concentration from any of the five soil profiles simulated come close to exceeding the MCL for an unspecified organic compound of 0.05 mg/l. The highest undiluted leachate concentration was 0.0234 mg/l. Mefenoxam can be used safely on the proposed golf courses.

In addition to mefenoxam, this ITM plan continues to recommend etridiazole and propamocarb for pythium treatment. Also, fosetyl-Al has been added to the list of pesticides to treat pythium. Fosetyl-Al did not have any use restrictions as a result of the Risk Analysis, and was recently added to potential pesticides recommended by Cornell to treat pythium.

The DEIS, including Appendix 15, Fertilizer and Pesticide Risk Assessment, and this Appendix 14 have been edited to remove metalaxyl from the list of potential products that could be used on the golf courses. Additionally, the DEIS has been edited to add mefenoxam and fosetyl-Al as products available to safely treat pythium.

- Isofenphos is no longer proposed to be used. Spinosad, acephate, ethoprop, and bendiocarb are still proposed to be used to treat insect pests. The Cornell Recommendations for Commercial Turfgrass was recently revised (2002 edition) for the pest spectrums for these four products. Ethoprop is now also recommended for cutworms. Ethoprop and bendiocarb are now recommended for webworms and bendiocarb is now also recommended for chinch bugs. The ITM plan has been amended to reflect these changes.

- Additionally, Cornell's *2002 Pest Management Guidelines for Commercial Turfgrass* includes three new pyrethrin insecticide active ingredients; bifenthrin, lambda-cyhalothrin, and deltamethrin. These three active ingredients were analyzed using the same analyses contained in the Fertilizer and Pesticide Risk Assessment (DEIS Appendix 15). Two of the new active ingredients, bifenthrin and lambda-cyhalothrin, did not leach through any of the modeled soils, nor did they appear in runoff from the simulated 18th fairway. Deltamethrin did not leach through any of the modeled soil profiles, but did appear in runoff from the simulated 18th fairway. When it did appear in runoff, deltamethrin concentrations ranged from 0.0001 mg/l to 0.0014 mg/l. The LC50 value for deltamethrin and rainbow trout is 0.001 mg/l to 0.010 mg/l. Deltamethrin is not proposed for use on the golf courses because its runoff concentration at times exceeded its LC50 for fish.

The Fertilizer and Pesticide Risk Assessment has been amended to include these findings. Additionally, this Integrated Turf Management Plan has been amended to include bifenthrin as another option for treating cutworms, sod webworms, and chinch bugs. Lambda cyhalothrin will likewise be added to the list of options available for treating cutworms and sod webworms.

- The Integrated Turf Management Plan (page 54) states that 2,4-DP could be used on the proposed golf courses as part of a "combination product" with other broadleaf herbicides. As an example, the product Super Trimec® (EPA registration number 00217-00758) contains 2,4-DP as one of its active ingredients, and is currently registered for use in New York according to the Department's listing of currently registered pesticides.

- DCPA is not listed in the recently issued *2002 Pest Management Guidelines for Commercial Turfgrass* issued by Cornell Cooperative Extension, and is no longer proposed for use on the proposed golf courses The DEIS has been amended to reflect this.

It is expected that the 2003 version of the Cornell Recommends will be issued some time in the Spring of 2003 and any changes in the status of pesticides proposed for use on the project golf courses will be reassessed at that time.

SECTION 1 INTRODUCTION: The Principles of Integrated Turf Management

Integrated Turf Management (ITM) is the application of the principles of integrated pest management (IPM) to the turfgrass environment. IPM has been defined by various authors in different contexts, and this has led to confusion about the exact meaning of the term as it relates to management of golf course turf. In 1994 the National Coalition on Integrated Pest Management, a group of agriculture, horticulture, and environmental groups, suggested the following as a standard definition for "integrated pest management". "Integrated Pest Management is a sustainable approach to managing pests by combining biological, cultural, physical, and chemical tools in a way that minimizes economic, health or environmental risks."

The definition of Integrated Turf Management can be expanded for proposed development to include not only principles of Integrated Pest Management, but other things such as performing a risk assessment in selection of pesticides and fertilizers, general Best Management Practices (BMPs) to be implemented, and a program for the safe storage and handling of pesticides and fertilizers.

The principles of IPM are not new, but were originally developed over a century ago. Many IPM techniques were practiced prior to the 1940's, before the introduction of wide-spectrum pesticides. Stern et al. (1959) are credited with systemizing the IPM concepts of chemical/cultural/biological control and economic thresholds. However, it was not until the mid-1970's that IPM was recognized as an economically and ecologically sound system for insect control in agriculture (Wearing, 1988).

Intensive use and overuse of pesticides, fertilizers and irrigation water in agricultural and turfgrass management were major factors in the rapid growth of interest in IPM (Leslie, 1989). The IPM concept seeks to minimize the disadvantages of nutrient, pesticide and water management and to maximize the advantages (Allen and Bath, 1980). Development of IPM systems offers one of the few comprehensive solutions for systematic control of environmental problems related to the management of biotic systems. IPM systems do not preclude the use of pesticides and inorganic fertilizers, but offer systematic options to maximize their efficiency and minimize the potential for adverse impacts.

IPM is not synonymous with the elimination of pesticides as a management tool. Reduction in the amounts of pesticides, fertilizers and irrigation water used is almost always an economic and environmental benefit derived from the implementation of an IPM program. "Pesticides are an important tool of an IPM program. IPM programs incorporate the use of pesticides and would continue to use them. ITM practitioners optimize the use of pesticides by increasing their knowledge base of turfgrass, turfgrass pests, monitoring, and timing of pesticide applications to maximize their efficiency and minimize off-target hazards." (Ferrentino, 1991). Monitoring pest levels, and basing the ITM decision to whether or not to use a pesticide on the actual levels of pests observed, results in the great majority of pesticide treatments to be curative treatments, and not preventative treatments intended to prevent the pest from occurring in the first place. Implementing this ITM plan on the Belleayre Resort golf courses means that there will be a curative approach to pesticide use rather than a preventative approach.

Development of economically feasible programs compatible with long-term environmental and societal goals is an essential ingredient for the success of IPM programs. The basic steps in development of IPM programs for turfgrass management have been outlined by Leslie (1989). The basic components of an ITM system are:

1. Define the roles of all people involved in the turfgrass management system to assure understanding and communication. Important individuals in development of ITM systems on golf courses are the superintendent, the golf professional, the golfers, and maintenance workers. During golf course design or improvements the golf course architect should be aware of site-specific conditions required for development of ITM systems.

2. Determine the cultural, water, nutrient, and pest management objectives for specific areas as the basis for establishing control methods and action thresholds. Management of tees and greens would require different control strategies compared to fairways and rough.

3. Establish action thresholds or economic thresholds based on regional research and prevailing economic conditions. Action thresholds are based on pest populations, turfgrass/soil nutrient tests, soil water conditions, soil and thatch physical properties, turfgrass playing conditions, or environmental conditions that indicate some action must be taken to maintain objectives for turfgrass quality. No action; chemical, physical, or cultural is taken until this point is reached. Actions are taken when the impact of pest populations or nutrient/water deficiency affect turfgrass quality sufficiently to threaten the biological and economic viability of the turfgrass as defined by management objectives.

4. Monitor the site environment, soil condition, pest populations, and turfgrass quality on a periodic and consistent basis to determine when the action threshold is reached. Monitoring also is used to determine whether a specific suite of practices has been successful.

5. Specific management practices to suppress pest populations, reduce nutrient/water deficiencies, or maintain turfgrass quality for playability should be selected from a range of options including physical, cultural, or chemical treatments. Habitat modification and understanding the relationship of nutrient, water, and climatic conditions is especially important for control and prevention of conditions conducive to pest infestations. Use of alternate nutrient and pesticide control options should always be considered.

6. When necessary, appropriate chemical (fertilizer or pesticide), irrigation, or cultural action should be taken. Preferred chemical practices would reduce movement of the applied chemical off the target site, provide maximum contact with the intended pest (pesticide) or root system (fertilizer) while presenting the least possible hazard to non-target organisms. Chemicals should be applied on the basis of need. Pesticides should be applied when the pest is in its most vulnerable life stage. Calendar, global broadcast, and preventative applications are not consistent with ITM economic, environmental quality, or societal goals.

7. Evaluation of the results of pest habitat alteration, pesticide application, use of alternate control options, fertilization, and water management (irrigation/drainage) should be conducted periodically to assess the success of the ITM program. The results of the evaluation are used to modify the initial conditions. Flexibility and economic feasibility ultimately determine the long-term success of ITM programs (Smith and Raupp, 1986; Wearing, 1988).

8. Maintaining written records of site management objectives, monitoring methods, data collection, management actions, and the results of management practices is essential for evaluation of ITM systems and development of future plans.

The proposed golf courses will be managed in accordance with these principles of integrated turf management. The overriding goal during the formulation of this management plan has been to provide guidelines by which high caliber golf courses can be managed with the sensitivity that would provide the desired quality of play while minimizing the potential for adverse environmental impacts.

This management plan takes into account the most recent advances in research and technology for turfgrass management. The potential for integration of golf course management and environmental protection for the proposed golf courses is quite real. However, for these golf courses to remain current with advances in golf course management technology and environmental protection, management strategies must remain flexible in order to accommodate improved technologies and products. To ensure the environmental compatibility of the new golf courses, new technologies considered for the courses would not be implemented unless they meet all pertinent promulgated regulations and are approved by proper regulatory agencies.

In this light, this document is submitted with the understanding that consideration has been given to all alternatives of turfgrass management strategies currently in practice. Recommendations are made based on the most recent advances in turfgrass agronomy. It should be realized that in this field, as in every other evolving scientific field, that procedures, processes, products, and strategies would change with time. Therefore, this document is not intended to be an ultimate management plan. Ideally, there would never be an ultimate management plan for any golf course. It is hoped that the wealth of new knowledge currently being developed in the turfgrass management field would be considered along with new technologies to constantly upgrade the quality of maintenance and environmental protection on the proposed golf courses.

SECTION 2. ITM IN THE GOLF COURSE PLANNING PHASE

The initial steps in the management of golf course pests actually begin before a golf course is constructed. Thorough and thoughtful planning allows for providing conditions most beneficial to successful turfgrass establishment and development while at the same time minimizing the suitability of the golf course for potential insect, weed, and fungal pests. Four areas which deserve particular attention during the planning process are (1) choosing the proper grass species for a particular site, (2) providing soil moisture and physical conditions suitable to turf growth but not proliferation of pests by surface grading and, if necessary, subsurface drainage, (3) confirming that adequate water would be available to meet irrigation needs and (4) analyzing site-specific conditions to determine if there is potential for negative environmental impacts associated with golf course pesticide and fertilizer use.

2.1 Grass Species Selection

Healthy plants are naturally more resistant to damage by pests and able to recuperate from pest invasion as compared to plants which are under stress due to ambient environmental conditions (temperature, moisture, etc.) or physical stresses (foot traffic, etc.) beyond which they are capable of withstanding. Selection of proper plant materials provides some "natural defense" against potential pests. Introduction of plant species to unsuitable or marginally suitable environments increases greatly the need for "health increasing" or preventative maintenance practices.

The property is located in the cool humid portion of the United States and provides conditions most suitable to those grass species grouped together as the cool-season grasses. The cool-season grasses are generally adapted to temperate and sub-arctic climates. Kentucky bluegrass, the bentgrasses, and fine fescues are widely used throughout much of the northern U.S. and Canada (Christians and Engelke, 1994). In contrast, tall fescue and perennial ryegrass are less winter hardy with their primary uses in the mid-central regions of the U.S. Cool-season grasses are well adapted to climates with ambient temperatures ranging from 60 to 72^{o} F.

<u>Site Suitability for Golf</u>

There has been contention by some in the earlier steps in the SEQRA process that the proposed project site, particularly the Belleayre Ridge portion of the site, is unsuitable for golf course turf due to its location and elevation. This contention is unfounded based upon local history, the geographic distribution of existing golf courses and ecological science.

Up until the 1960's a number of golf courses existed close to the project site. These included the 9-hole course at the Grande Hotel and nine hole golf courses such as the Takanasee in Fleischmanns and the nine hole golf course at the Shandaken Inn. The former golf course at the Grand Hotel was roughly at the same elevation as the Highmount Golf Club (1,900 – 2,200 feet). By comparison, the Big Indian Country Club golf course is between an elevation of 1,990 to 2,740 feet.

Thus there are portions of the Big Indian Country Club Golf Course that are up to approximately 550 feet higher than the former Grand Hotel golf course. On average temperatures in mountainous regions decrease about 0.5 degrees Celsius for every elevation increase of 100 meters (328 feet) (Darbenmire, 1974). Thus the temperature difference between the elevation of the former Grand Hotel Course and the proposed Big

Indian Country Club can be expected to be less than one degree Celsius. This difference certainly is not enough to make a difference in the successful establishment and growth of turf on the proposed golf course.

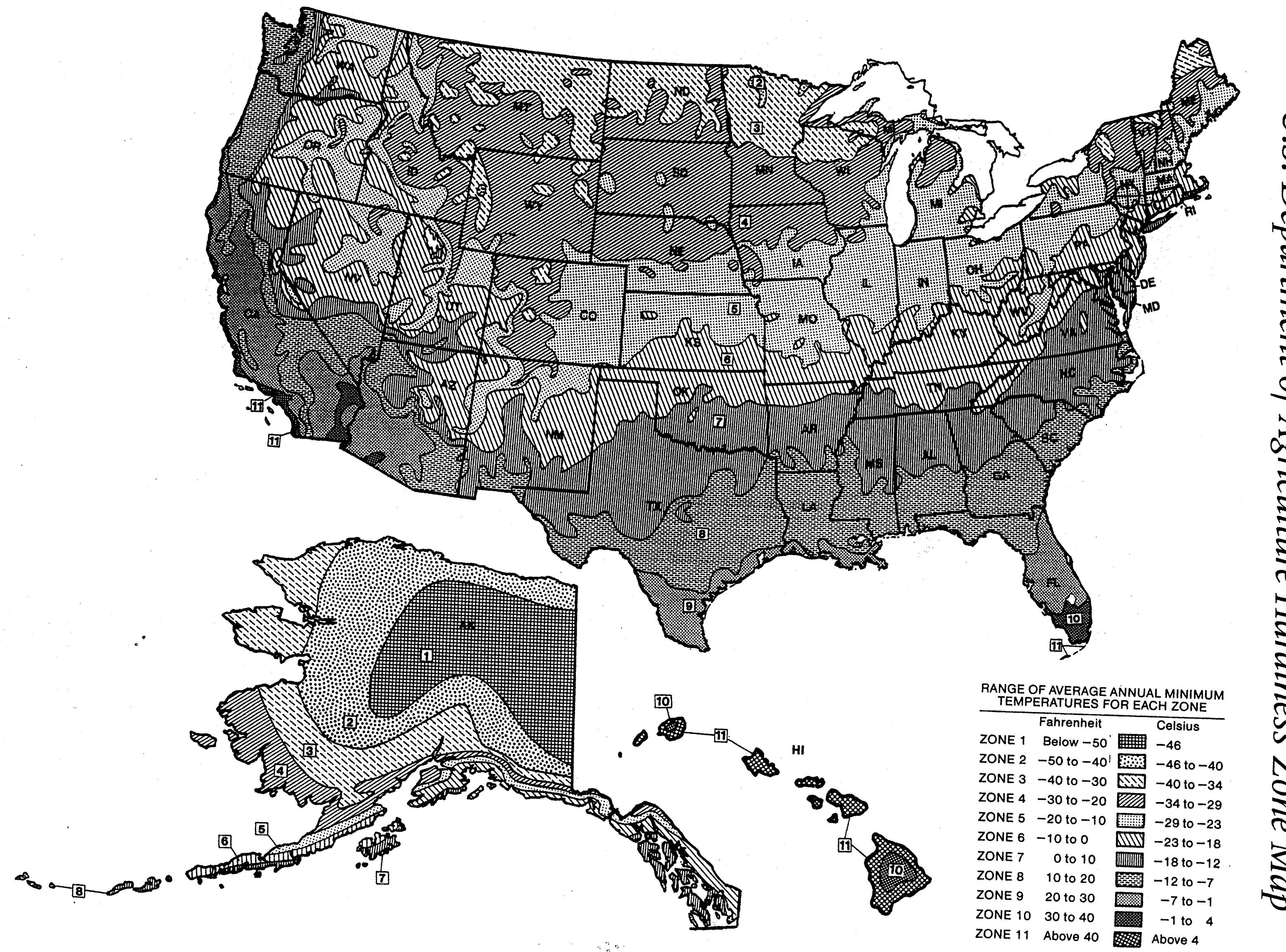
When constructing new trails at the Ski Center, portions of which are at higher elevations than the proposed golf courses, up to 3,300 feet, a seed mix is used that contains some of the same grasses proposed to be used at the proposed golf courses. The Blue Seal Feeds Conservation Mix is composed of more than 33% fine fescue and almost 10% Kentucky Bluegrass. These are the two grass species proposed for the fairways of both golf courses.

Temperature regimes and the ability to grow and maintain golf course turf will vary not only with altitude but also with latitude. More northerly climates will have generally have colder temperature regimes and shorter growing seasons. However, unlike the altitudinal and temperature (climatological) relationship described above, there is not a precise correlation of temperature changes with latitude. (Dr. Susan L. Woodward personal communication, July 7, 2000) (Dr. Woodward has extensive experience with altitudinal zonation, including just having finished research in eastern Brazil.)

In New York State there are a number of golf courses in the Adirondack Region of New York that are at altitudes comparable to the proposed Big Indian Country Club Golf Course. There are two golf courses at elevations over 1,900 feet located approximately 160 miles to the north in the Lake Placid area (latitude 44 degrees 15 minutes, versus 42 degrees 7 minutes for the Big Indian Country Club). At about the same latitude as the Lake Placid golf course there is a golf resort in Michigan called Crystal Mountain Resort. The golf course superintendent at this course reports excellent playing conditions on the 18 hole course, including a successful grow-in during 1997. Seeded in August of 1997, this golf course was ready for play in June of the following year.

One can even go much further north than Lake Placid or Michigan to find successful golf courses. The Anchorage Golf Course, an 18-hole, 6,616 yard, par 72 golf course was constructed in 1987 and offers play between May 15 and October 1st. Another example is Mountain Acres Golf Club in Sainte-Agathe Quebec Canada. Located in a "picturesque mountain setting" (Golffacts, 1995) this 18 hole, par 70 course requires reservations one week in advance in order to play, a testimony to its high quality.

Also substantiating the site's suitability for growing golf course turf is the US Department of Agriculture's Hardiness Zone Map for plants in the United States. As illustrated in Figure 1, "Hardiness Zone Map", the country is divided into a number of zones corresponding to different ranges in average annual minimum temperatures for each zone. The project site occurs in zone five, with a minimum of average temperature of –20 to –10 degrees Fahrenheit. By comparison, the Lake Placid region and the locations for the Anchorage Golf Course and Crystal Mountain Resort in Michigan are all within zone four with average annual minimum temperature of –30 to –20 degrees Fahrenheit. It is recognized that these zones are mapped on a large scale and there can be some local variability. However, an analysis of actual minimum daily temperature as an indicator of annual conditions reported at Slide Mountain and Lake Placid climatological monitoring station for a five year period (1989-1993) confirms the hardiness zone mapping. During this period minimum daily temperature at Slide Mountain averaged –10 degrees Fahrenheit (-10, -9, -9, -9, -13 degrees), while the minimum daily temperature average at Lake Placid was –24.8 degrees Fahrenheit (-29, -15, -27, -22, -31 degrees).



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Integrated Turf Management Plan

Proposed Belleayre Resort
At The Catskill Park

Hardiness Zone Map

Figure 1

At this time, it is anticipated that the tees, greens and the approaches to greens will be planted with creeping bentgrass. Fairways and roughs will be planted to a mix of Kentucky bluegrass and fine fescues.

Creeping bentgrass is, by far, the most commonly used grass species on golf courses in the northeast (Emmons, 1984). The widespread use of creeping bentgrass is a reflection of its tolerance of low mowing heights even as low as the heights required on putting greens. Even at mowing heights less than 1/4 inch creeping bentgrass can still form a stand with extremely high shoot density. However, there are some disadvantages associated with creeping bentgrass. Creeping bentgrass has the highest fertility requirements of the cool season turfgrasses. Creeping bentgrass is also the most susceptible to fungal diseases of the cool season turfgrasses. By limiting creeping bentgrass to the greens, tees and approaches, where the low cutting height necessitates their use, the amounts of fertilizer and fungicide required to maintain the golf course can be significantly reduced. For example, it is known that one local golf course with bentgrass fairways has in the past applied 65 gallons of fungicide per year on fairways. By not using bentgrass on the fairways, this amount could likely be reduced by as much as 90%.

Kentucky bluegrasses and fine fescues are lower maintenance grasses commonly used in the northeast in athletic fields, home lawns, and golf courses. These grasses perform well at the higher cutting heights in golf course roughs. Recent advances in breeding of different varieties of bluegrass and fine fescues have produced varieties that perform well under the lower cutting heights used on golf course fairways.

Low maintenance rough areas such as mowed roughs would also be planted to a mix of Kentucky bluegrass and fine fescue. Fescues would comprise a larger portion of the grass mix in the outer roughs that would not be maintained except for an annual mowing to keep out woody species. Hard fescue and chewings fescue are both considered to be "fine fescues", as opposed to tall fescue, which is considered a coarse fescue. The fine fescues as a group have the lowest fertilization requirements of the cool-season grasses. Fine fescues also have a high shade tolerance that enhances their suitability in areas closer to the edges of fairways where shading is more likely to occur. A high drought tolerance also makes the fine fescues a good choice for rough areas that are not irrigated.

Each grass species has a number of different types, or cultivars, that are commercially available. Cultivars have their own strengths and weaknesses and through regular national field testing, the National Turfgrass Evaluation Program (NTEP) ranks cultivars on their performances. Characteristics such as color, density, mowing quality, drought resistance, and resistance to various diseases is rated. The most recent field test results and recommendations by Cornell University will be consulted when formulating the construction specification for the different seed blends to be used on the golf courses. Preference would be given to those cultivars that show the ability to naturally resist potential pests. For example, past NTEP results compiled by Cornell University ranks the Kentucky Bluegrass cultivar "Coventry" as having Moderate to Very Good disease Tolerance for five different diseases. The same NTEP results have the cultivar "Princteon" as having Very Good to Excellent resistance to the same five fungal diseases. From a disease resistance standpoint, Princeton would be the preferred cultivar.

2.2 Grading and Erosion Control Plans

The plans prepared for the golf courses show how most of the holes on the courses would be graded so that surface drainage is directed to low points outside of the area of concentrated play but still within the golf corridor. Positive surface drainage would be provided in order to prevent soil saturation or standing water, both of which are detrimental to turf health. Grading in this matter also provides a mechanism where any potential pollutants carried in runoff can be filtered out during infiltration.

Between the time when golf holes have been cleared of existing vegetation and the time turf is established, erosion potential would be highest, particularly in areas with steeper slopes. Erosion control measures need to be implemented to prevent degradation of surface water quality both on and off the site. During the planning stage, erosion-prone areas have been identified and the plans prepared for the project identify these areas and also show the proposed location for erosion control measures, such as the installation of settling basins, silt fences, hay bales, and areas that are to be sodded. A draft version of a Construction Stormwater Pollution Prevention Plan (DEIS Appendix 11) has also been prepared for the construction phase of this project, and this report describes the measures that would be implemented to prevent erosion. This plan would be finalized with the assistance of NYSDEC and NYSDEP prior to construction.

2.3 Irrigation Water Supply

A water source should be adequate to provide sufficient quantities of irrigation water during the growing season. The three principal sources commonly used for golf course irrigation water are groundwater from wells, stationary surface waters (lakes and ponds) and flowing surface waters (rivers and streams). A fourth source of growing importance, more so in more arid regions of the U.S., is the use of effluent water from municipal treatment facilities.

Irrigation water for the proposed Big Indian Country Club golf course will be withdrawn from a groundwater bedrock well located on the project site near Friendship Road. This well has a yield of approximately 77 gallons per minute (gpm). Irrigation water will be pumped to irrigation water storage ponds located near the proposed golf clubhouse. The ponds have been designed so that they have a storage volume of approximately 7.4 million gallons.

A study of the Village of Fleischmanns municipal water supply has indicated that their system has sufficient amounts of water to serve the Wildacres Resort and Highmount Estates portions of the proposed project. The Village of Fleischmanns has indicated that they are interested in supplying water to the project. Treated wastewater from the Wildacres Resort and Highmount Estates will be used to irrigate the proposed Highmont Golf Club. After advanced treatment effluent will be pumped to a storage pond with a 7.3 million gallons storage capacity. Effluent irrigation has been successfully used at other high elevation golf courses in New York State such as the Lake Placid Resort Club in Lake Placid, New York.

Effluent irrigation has been successfully used on other high elevation golf courses in environmentally sensitive areas in New York State such as the Lake Placid Resort Club in Lake Placid New York. For over three years, the Village of Lake Placid has used treated wastewater effluent as a source of irrigation water for two local golf courses. Lake Placid operates a 30-year old municipal sewage treatment plant that currently uses floating aerators to treat municipal wastewater prior to discharge to a surface water within the phosphorus restricted Lake Champlain Basin. The plant is in the process of an upgrade to a yet to be determined Best Available Technology, however, the use of the wastewater effluent for golf course irrigation has been a success even with the antiquated treatment process.

For the period covering June to September of 1998, Lake Placid supplied 14 million gallons of treated wastewater for irrigation at an 18-hole golf course. The success of the 1998 irrigation led to an increase to 31 million gallons supplied in 1999 and an expansion in the months for irrigation to include the period between April 15th and November 15th. During winter months, the wastewater facility discharges to a surface water. In the year 2000, Lake Placid continued to irrigate the original pilot golf course, with the addition of discharge to a second course located nearby.

The SPDES permit for the irrigation project was issued by a permit administrator in the DEC Main Office in Albany. The permit includes flow limits, nitrate limit of 20 mg/L, chlorine limit of 2 mg/L, BOD of 30 mg/L, Total Suspended Solids (TSS) of 45 mg/L and Total P (monitor only) of 0.8 mg/L. Fecal coliform is 200 mg/L average day/400 mg/L maximum day and total coliform is 2400 mg/L average day/5000 mg/L maximum day.

Operationally, the system functioned within parameters expected and exceeded expectations in terms of the benefits to the soil and turf. Initial concerns about the plugging of the sprinkler heads due to solids loadings proved unfounded. A holding pond was successfully employed to provide dechlorination and storage. The golf course management lobbied successfully for the ability to irrigate at night, as is common practice to avoid conflicts with play and to reduce loss due to evaporation and transpiration. DEC initially monitored the night irrigation carefully to watch for over application (sheeting), however, once the practice was fully established, monitoring was decreased.

Unlike courses in the southwestern US where treated wastewater is used for irrigation, the course in Lake Placid encountered no problems with salts or other byproducts of the treatment process. In the southwestern US, salts have been an issue with the use of wastewater effluent for golf course irrigation due to evaporation and concentration of byproducts and minerals due to mandated continuous water recycling without dilution. In fact, the levels of nitrogen and phosphorous have acted as fertilizer in Lake Placid resulting in improved soil conditions.

The use of treated wastewater from the Lake Placid wastewater treatment plant for irrigation of an 18-hole golf course is considered a success by regulators, the local community, and the course management. The course owner increased greens fees to compensate for the increased maintenance and mowing of the greens due to the "lushness" of the turf. Lake Placid is considering the potential of using the treated wastewater for snow making during the winter months.

The Lake Placid treated wastewater golf course irrigation pilot has been the focus of review by NYSDEC as the permitting agency, NYSERDA as the provider of the funding for a two year study, the Adirondack Park Agency (APA), the Lake Champlain Management Conference as the agency charged with maintaining the quality of water within the watershed, and the Ag School at Cornell University where scientific analysis has been conducted.

The Lake Placid project has successfully withstood rigorous regulatory scrutiny. The parameters under which the SPDES permit were issued in Lake Placid are far less stringent than those required under the NYC Watershed Rules and Regulations. The NYC DEP has held discussions regarding the use of treated wastewater for irrigation in the NYC Watershed and has endorsed the concept for applications in Delhi and other potential locations.

Gray water (treated wastewater) is used for irrigation across the United States. A number of states have enacted mandatory water recycling or water reuse. Appendix 12 contains a list of some of the many guidance documents available for the design and permitting of gray water reuse and golf course irrigation. In addition, the Appendix contains selected examples of the successful use of gray water for irrigation.

2.4 Modeling Site-Specific Pesticide and Fertilizer Behavior

Mathematical modeling was used to predict the environmental fate of chemicals (fertilizers and pesticides) which could be applied to the proposed golf courses as part of an integrated turf management program. Modeling was performed in order to determine what products could be used to control golf course pests without posing risks to groundwater and surface water quality, human health, and non-target fish and wildlife. Results and discussion of the modeling effort, "Fertilizer and Pesticide Risk Assessment", is included as Appendix 15of this DEIS.

Assessment of water, pesticide and fertilizer practices prior to their use provides an excellent opportunity for cost-effective and environmentally sensitive soil and water management. Computer simulation models provide a logical mechanism to integrate the complex factors influencing water quality, fate, and persistence of chemicals, and the environmental effects of different management practices (Donigan and Rao, 1986). Simulation models can be used to identify agricultural or turfgrass management practices with potentially favorable or adverse effects on the environment. Computer simulation is used to (1) evaluate alternate management practices, (2) select alternate compounds for pest and nutrient control and, (3) design optimum water, cultural, and chemical management strategies to meet turfgrass and environmental quality goals.

Specific results of the Risk Assessment are summarized in Appendix 15.

Results of the Risk Assessment demonstrated that golf fertilization of the golf courses would not negatively impact local groundwater quality. At no time did a simulated golf course fertilizer program produce undiluted leachate that contravened drinking water standards for nitrate nitrogen. Nitrate is the component of fertilizer that has the highest tendency to leach and for which drinking water standards have been established. This lack of impact was demonstrated even with the incorporation of a number of worst case factors into the analysis including a high fertilizer application rate, not considering groundwater dilution of leachate, high precipitation amounts, etc. Results demonstrated that **undiluted** drainage from fertilized golf areas could be used as a potable water supply and meet State and Federal drinking water standards for nitrate.

In terms of potential groundwater impacts from pesticide use, the Risk Assessment demonstrated that each potential turf pest that could occur on the golf courses could be treated with suitable pesticide(s) without impacting groundwater quality. Like the nitrate leaching analysis, conservative factors were incorporated into the analysis of potential pesticide leaching for pesticide active ingredients. Those pesticides that could not meet the rigorous standards of the Risk Assessment leaching analysis will not be used on the proposed golf courses.

Undiluted pesticide leachate concentrations were compared with drinking water standards. All potential pests that could occur on the proposed golf courses could be treated with a suitable New York State registered turf pesticide without having undiluted leachate exceeding State or Federal drinking water standards. Many of the products produced no leaching whatsoever and these pesticides should be given preference for use when it is determined that chemical control is warranted.

Undiluted pesticide runoff concentrations were used in conjunction with published aquatic toxicology valves to assess risk. Modeling predicted various levels of runoff for the 53 pesticides analyzed. Use restrictions are proposed for certain pesticides based on the runoff potential and toxicology values.

Analysis of fertilizer runoff found that nutrient runoff could increase over existing conditions, but limiting fertilizer phosphorus use will mitigate potential impacts to surface waters.

2.5 Safe Handling and Storage of Fertilizers and Pesticides

All pesticides will be mixed, loaded and stored in a chemical handling/storage building equipped as follows; a mixing and loading area complete with a closed recycling system for rinse water at the washdown area, and a controlled pesticide storage area. Also included within this building will be a pesticide mixing and recycling area. The area consists of an exterior concrete pad that slopes to the center where there is a grate over a concrete sump. The concrete pad is covered by a roof. The sump contains a pump that is piped to two 500-gallon above ground storage tanks inside the building. Rinse water from cleaning pesticide application equipment will be captured, pumped to the tanks, and stored and reused when future pesticide solutions need to be made. Any mixing and filling of pesticide application equipment would be made on the same concrete pad. Should any material be released during mixing it will be captured and recycled similar to rinse water. The recycle water holding tanks will be housed within a building on a concrete pad and sufficient containment will be provided in the event of tank leakage. Pesticides will be stored in this building in a separate locked and fireproof area with a "curbed" floor to provide containment of any accidentally spilled materials.

Access to the building will be by the golf course superintendent, assistant superintendent and trained applicators under the direct supervision of the superintendent. The building will contain heat detectors, fire extinguisher, first aid kit, two stage ventilation (low level at all times and three times ventilation volume increase when someone enters the building), explosion proof fixtures, emergency shower/eyewash station, and personal protection gear. Hazard communication signage will be placed inside and outside the building. Material Safety Data Sheets on all pesticides stored in the building will be readily available. All personnel using the facility will be trained in safe handling and operation of application equipment and emergency response procedures and contacts.

Any release in the building will be readily contained by dry sorbent materials and safely stored until disposed of by a licensed hauler. Only the amount needed will be loaded in the application equipment. All rinsate material from containers and from the spray equipment will be captured in the system, recycled and reused in the next spray. All pesticides will be stored, handled and applied according to their label instructions. All personal protective measures will be followed.

The building will be constructed of non-combustible walls with a combustible roof. With explosion-proof fixtures, fire is unlikely. If fire does occur, the building will vent heat and smoke through the roof and spraying water on the fire will not be encouraged. The use of a limited amount of fire fighting water is encouraged to mitigate environmental damage from a large volume of water and to reduce the amount of contaminated water that will need disposal.

It is anticipated that only small quantities of pesticides will be stored in the building. A general contact fungicide or a specialized fungicide will be stored in case of an outbreak of a disease posing an imminent threat to the golf course that requires immediate action. For insect and weed control, insecticides and herbicides will be purchased and used on an as-needed basis. All empty pesticide containers will be handled and disposed of by a licensed hauler. Like pesticides, only small amounts of fertilizers will be stored at any one time. Fertilizers will be ordered so that their delivery coincides with the time they are applied to the golf course.

Both pesticides and fertilizers will be stored in walled of sections of the maintenance facility. The floors will be sealed and will not contain a floor drain. The concrete for the floor and the lowest one foot of the walls will be poured at the same time without joints so as not to allow water in or out of the storage area.

SECTION 3. ITM IN THE GOLF COURSE OPERATION PHASE

The majority of true ITM tactics would be implemented during the day-to-day maintenance of the proposed golf course turf. Operational phase activities would consist of providing the best environment for turf growth, while at the same time providing an unsuitable pest environment via cultural practices, monitoring pest levels and documenting their occurrences, and remediating pest problems when pest threshold levels are exceeded.

3.1 Primary Cultural Practices

Mowing, irrigation, and fertilization are the primary turfgrass cultural operations needed to sustain turfgrass quality. These practices are intimately related.

3.1.1 Mowing

Mowing is the most basic of all turfgrass cultural practices and is performed regularly for both aesthetic and functional reasons. From a purely botanical standpoint, mowing is detrimental to turfgrass. It causes temporary cessation of root growth, reduces carbohydrate production and storage, creates ports of entry for disease-causing organisms, temporarily increases water loss from cut leaf ends, and reduces water absorption by the roots (Turgeon, 1991). From a practical standpoint, regular mowing is necessary to provide a playable surface on golf course greens, tees, and fairways and reduce encroachment of many weedy plants.

Mowing has an influence on pest problems as well (Emmons, 1984). Mowing decreases weed populations because of increased turf density and the continued removal of the terminal growth portion of turf weeds. Disease problems, however, often increase because of mowing. When shoot tissue is cut-off, an open wound remains. Fungi that cause turfgrass diseases can gain entrance into the leaf through the wound before it heals. Insect pest damage would be promoted by practices such as cutting too low (scalping), too infrequently, using a dull blade, or any other practice which decreases turfgrass vigor.

Cutting heights vary with grass species and turf use. At the proposed golf courses the turf would be maintained in "mowing units" including, greens, approaches to greens, tees, fairways, and roughs. The bentgrass greens would be mowed to a height of 0.12 to 0.20 inches to provide a desirable putting surface. Bentgrass is the grass species of choice for putting greens because of this ability to tolerate low mowing heights. The bentgrass approaches would also be mowed at a lower height but higher than the greens, at a height of approximately 0.25 inches. It is anticipated that tees would be mowed at a height of approximately 0.25 to 0.33 inches. The fairways at the proposed golf courses would be mowed higher than either the tees or greens for play and aesthetic reasons. The low heights of tees and greens are not required for the fairways but a relatively low height should be maintained so that a golf ball in the fairway would "sit up" on the turf rather than lie within the turf leaves like a ball would in the rough. Mowing height of the fairways would be somewhere around ½ to 9/16 inches. Only portions of the rough areas would be mowed, portions would remain unmowed. Mowing height in the mowed portions of the rough would be 1 ½ to two inches to three inches.

The frequency of mowing which would be required to maintain these heights would vary between mowing units for the moderately to intensively cultured turfs such as those proposed for the golf courses. A generally accepted guide has been to remove no more than one third of vertical shoot growth per mowing; otherwise, an imbalance between aerial shoots and roots may retard growth (Turgeon, 1991). Cool-season turf growth rates vary through the year as illustrated in Figure 2, "Growth Pattern of Cool Season Turfgrasses". Thus, mowing intervals would change depending on growth rates. On average, golf course greens would be mowed five to seven times a week, tees four to six times a week, fairways two to four times a week, and roughs once every seven to fourteen days during the maintenance season.

A long-standing concern in lawn culture is whether to catch clippings during mowing. Arguments offered in support of clipping removal include reduced thatching tendency, reduced disease incidence, reduced injury from heavy deposits of clippings, and generally improved turfgrass quality (Turgeon, 1991). Additionally, today's problems of decreasing landfill capacities and disposal abilities have added another compounding factor to the clipping removal debate. Clippings would be removed from the greens at the proposed golf courses. On greens, clippings interfere with play and should be removed (Emmons, 1984). Clippings from the greens would be spread in the rough areas of the golf courses. On intensely cultured golf course fairways the removal of clippings during mowing (along with conversion to lightweight mowers) has resulted in improved turf quality (Turgeon, 1991). However, it is not anticipated that clippings normally would be removed from the proposed golf course fairways due to the volume of clippings that would be generated. Clipping removal from tees would be left to the discretion of the golf course superintendents. Clippings would not be collected in the mowed portions of the roughs. No clippings will be placed within 100 feet of any watercourse or wetland.

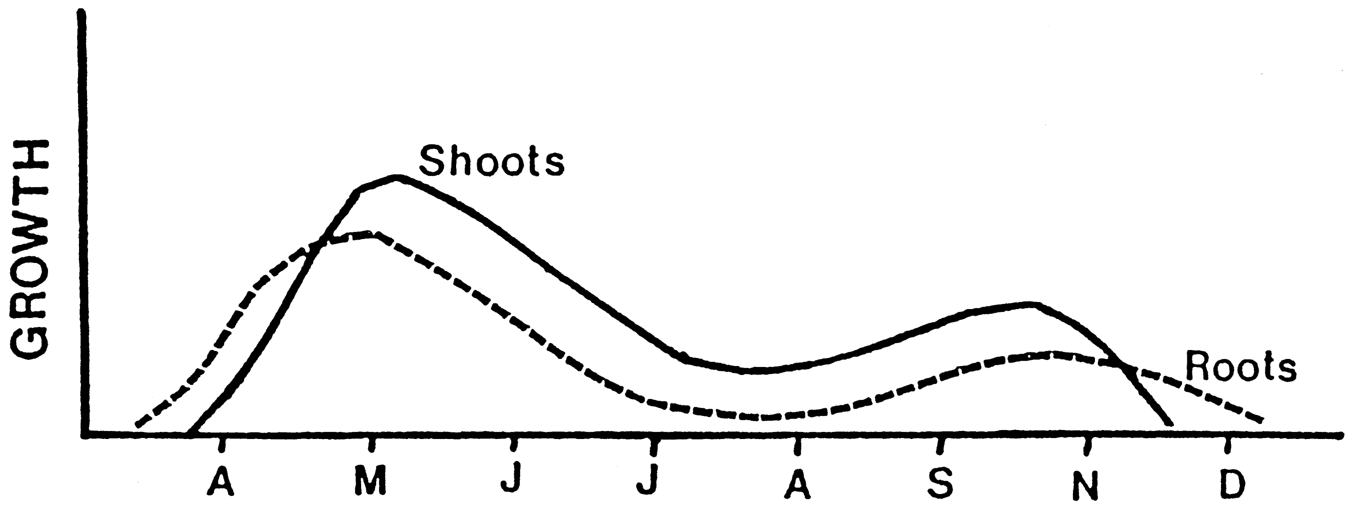
3.1.2 Fertilization

Growth of turfgrass requires an adequate supply of all essential plant nutrients, in addition to many other cultural and edaphic factors (Davis, 1969; Beard, 1982). Of the 16 elements essential for plant growth and development, nitrogen, phosphorus, and potassium are generally the most important with respect to turfgrass fertilization (Hughes and Henson, 1965; Matches, 1979). Use of fertilizers and nutrient requirements of turfgrass systems has been reviewed by Beard (1973, 1982), Davis (1969), Murray and Powell (1979), Petrovic (1990), and Wilkinson and Mays (1979). Use of nitrogen and phosphorus is a concern from a water quality and environmental impact perspective (Petrovic, 1990; Schuler, 1987; Kenna and Snow, 2000).

A. Nitrogen

In general, turfgrass is most responsive to nitrogen fertilization (Beard, 1982). Nitrogen is the essential element considered controlling growth when other elements are maintained at adequate levels. Nitrogen can be added or withheld to regulate both growth and color of turfgrass (Street, 1988). Nitrogen is very dynamic in the soil system. Its concentration is constantly changing, usually decreasing, and therefore, must be routinely added to maintain a soil level sufficient for turfgrass growth (Wilkinson and Mays, 1979). Nitrogen deficiency occurs frequently and is characterized by stunting of shoot growth in the initial stages of deficiency, followed by a yellowish chlorosis across the entire leaf blade in intermediate stages. In the advanced stages of nitrogen deficiency, necrosis of the leaves occurs (Beard, 1982). This condition is exacerbated on coarse, sandy soils and on soils subject to leaching from intensive rainfall or irrigation (Beard, 1982).

Nitrogen fertilizer carriers can be divided into two groups; quickly available and slow release. Quickly available or soluble forms include the inorganic salts (ammonium nitrate, ammonium sulfate, ammonium phosphate, and potassium nitrate) and some organic carriers of which urea is an example. Characteristics associated with quickly available nitrogen carriers include high water solubility, rapid but short-term turfgrass



(Cornell Cooperative Extention Turf Management Handbook)

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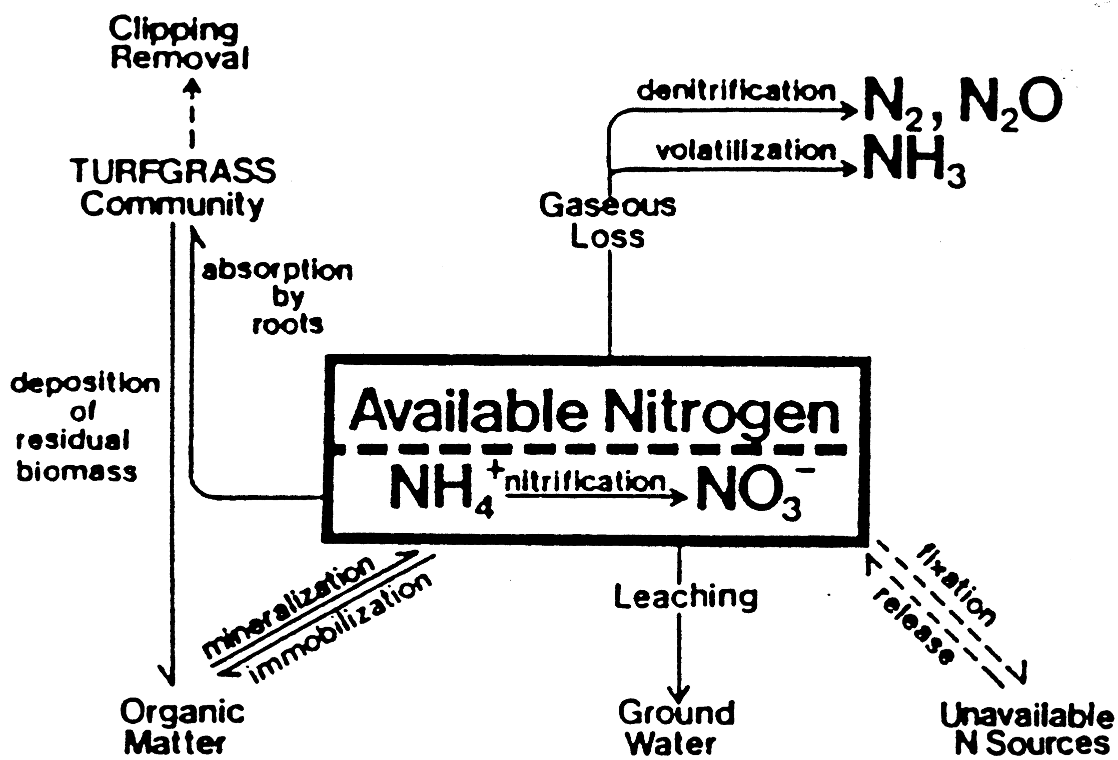
Integrated Turf Management Plan

Proposed Belleayre Resort
At The Catskill Park

Growth Pattern of Cool-Season Turfgrass

Figure 2



(Turgeon, 1990)

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The Fate of Nitrogen In Turf

Figure 3

response, minimal temperature dependency, high burn potential, and low cost per unit of nitrogen.

Slowly available forms of nitrogen include slowly soluble urea formaldehyde (UF), isobutylidene diurea (IBDU), slow release sulfur and polymer coated urea (SCU), and natural organic (activated sewage sludge) types. Characteristics of slowly available nitrogen carriers include slow initial but long-term turfgrass response, low (IBDU, SCU) to high (UF) temperature dependency, generally low burn potential, and moderate to high cost per unit of nitrogen. An advantage gained with the use of slowly available nitrogen carriers is the reduced loss of nitrogen from leaching and, possibly, gaseous loss due to volatilization and denitrification (Turgeon, 1991). In many commercial turfgrass fertilizers, quickly available and slowly available nitrogen carriers are mixed to combine the advantages and reduce the disadvantages associated with each.

Figure 3, "The Fate of Nitrogen in Turf" is a simplified, but convenient, description of the potential sources, sinks, pathways and transformation of nitrogen in the turf environment. The goal of the turf manger is to supply the correct amount and formulation of fertilizer to maximize turf uptake and minimize losses to other pathways including leaching to groundwater and runoff to surface water.

DEIS Appendix 15, “Fertilizer and Pesticide Risk Assessment,” contains a discussion of nitrate leaching and the factors that promote nitrate leaching to groundwater.

B. Phosphorus

Phosphorus usually enhances the rate of turfgrass establishment from seed or vegetative plantings and enhances root growth. Phosphorus deficiency does not occur as commonly as nitrogen or potassium deficiencies. Reduced levels of phosphorus is usually related to low soil levels or to soil pHs that are either too low (acid) or too high (alkaline) (Beard, 1982). Deficiency symptoms include a darkening of leaves followed by the appearance of blue green or purplish coloration followed by leaf tip withering and necrosis.

Most phosphorus fertilizers used in the United States are derived from rock phosphate ores and processed principally into superphosphate (calcium phosphate and gypsum) and treble superphosphate. As phosphates are relatively immobile in soil, they do not leech readily from the turfgrass root zone (Turgeon, 1991). Phosphorus is rapidly retained as insoluble inorganic compounds and sorbed to soil surfaces, therefore soluble losses of phosphorus in subsurface flow and runoff tend to be quite low.

DEIS Appendix 15, “Fertilizer and Pesticide Risk Assessment” contains a detailed description of phosphorus runoff and measures to mitigate potential impacts.

C. Potassium

Turfgrass needs potassium in relatively large amounts, second only to nitrogen (Wilkinson and Mays, 1979). On low potassium soils, addition of potassium may be necessary. Recent research has demonstrated that increasing potassium levels result in improved root growth, an enhancement of heat, cold, and drought tolerance and reduced incidence of disease (Street, 1988). Potassium deficiency in turfgrass systems occurs less frequently than nitrogen.

Most of the potassium used for turfgrass fertilization comes from potassium salt deposits that are mixed and processed to make muriate of potash (KCl). Potassium chloride is also converted to commonly used potassium sulfate and potassium nitrate fertilizer formulations (Turgeon, 1991). Potassium salts are readily soluble in water and thus are susceptible to leaching.. Plant-available potassium occurs slowly as minerals stabilize and some fixed potassium is released; but in low levels in most soils. Because of "luxury consumption" (plants absorb more potassium than that needed for normal growth as more is applied) potassium applications should be made several times in small amounts rather than just once in large amounts during the growing season.

D. Secondary Nutrients and Micronutrients

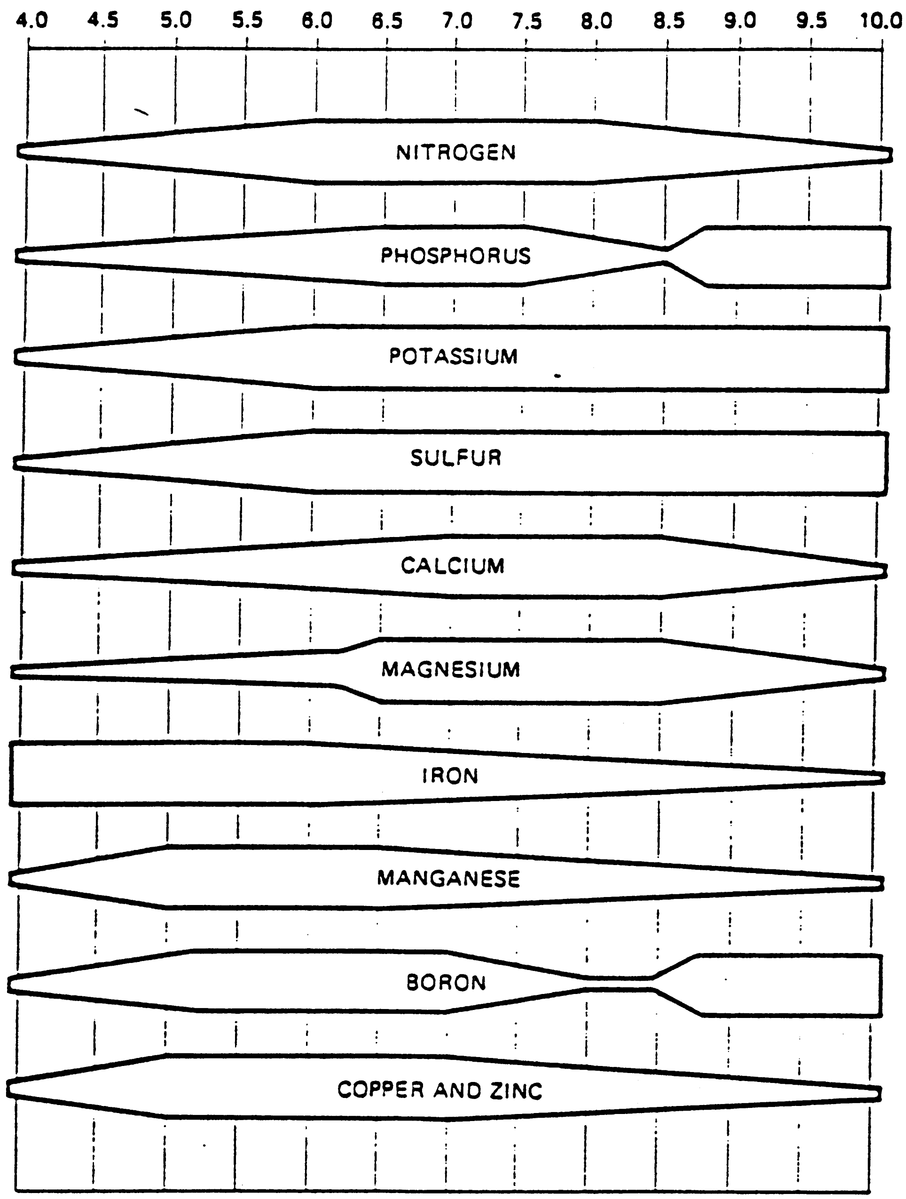
Other essential elements of importance to turfgrass systems include sulfur, calcium, magnesium and micronutrients. Sulfur deficiency occurs at a frequency similar to potassium. Deficiency of sulfur is characterized by loss of green color from older leaves in the initial stages. Sulfur deficiency has been noted to occur on coarse sandy soil, low in organic matter, and subject to intensive leaching. Calcium and magnesium deficiencies are extremely rare, but are more likely to occur in coarse, acid soils. However, acidic soils can be easily corrected by the addition of lime (see the following section). Micronutrient levels are usually adequate in most soils. In addition, micronutrients are needed in very small quantities and are often supplied as impurities in commonly used fertilizers, liming materials, top dressing, certain pesticides, and irrigation water. Sandiness increases the possibility for micronutrient deficiency. However, most sands used for soil modification are not pure and are usually modified to some extent with soil or organic matter. In general, micronutrient deficiencies are most likely to occur in alkaline soils. They are further aggravated by high soil phosphorus and high soil levels of other micronutrients (Beard, 1982).

The secondary nutrients; calcium, magnesium, and sulfur are absorbed by turfgrasses at levels equal to or just below those of phosphorus (Turgeon, 1991). The necessary amounts of secondary nutrients are usually supplied as by products of impurities of typical N-P-K turf fertilizer products.

Micronutrients or trace elements' principal importance lies in their role as catalysts in enzymatic reactions. Deficiencies are usually associated with conditions that limit the availability of soluble nutrient concentrations. For example, micronutrients (with the exception of molybdenum and chloride) become highly insoluble in alkaline soils, while, under conditions of excessive soil acidity, solubilities may be so high that they are naturally toxic to turfgrasses. Figure 3, "Availability of Nutrients vs. pH", illustrates the influence of pH on nutrient solubilities. Other conditions that promote micronutrient deficiencies include high soil phosphate levels, high concentrations of soil organic matter, excessive thatch accumulation, and poor drainage. Maintaining adequate pH is usually sufficient for maintaining suitable levels of micronutrient availability.

E. Soil Reaction Amendments

Although pH adjustment products are not used themselves as fertilizers, their use can improve efficiency of fertilizer uptake and metabolism. Turfgrass species are adapted to a wide range of soil pHs, however, optimum growing conditions usually exist where the pH is neutral to slightly acid (6.0-7.0) (Turgeon, 1991). The major reason that 6.0 - 7.0 is the preferred pH range is that all of the essential elements are in available chemical forms in this range. Significant amounts of each nutrient are available for plant use where the soil pH is around 6.5 (Emmons, 1984). When soil is maintained at the ideal pH plants obtain nutrients they need and growth is increased. Figure 4, "Nutrient Availability vs. pH", illustrates this relationship. If the soil pH is too acidic or alkaline, plants may experience nutrient deficiencies. In such cases, the soil may contain abundant quantities of these essential elements, but they are locked up in complex, insoluble compounds and



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Nutrient Availability vs. pH

Figure 4

are unavailable to plants. Soils on the proposed golf course sites are acidic and will require lime to maximize plant health.

Correcting acidified soils can be accomplished by the addition of lime materials containing calcium or magnesium, most commonly calcium carbonate ($CaCO_3$). The need for liming and the effectiveness of previous lime applications in reducing soil pH can be measured by simple on-site soil tests.

It is unlikely that the soils of the proposed golf courses would require treatment for reducing alkalinity due to the nature of the native on-site soils. However, if pH is ever found to be 7.5 - 8.5, alkalinity may be corrected by applying sulfur (Emmons, 1984). Elemental sulfur is commonly used. Aluminum sulfate is also effective, but is toxic to grass if improperly applied. Fertilizers containing acidifying chemicals such as ammonium sulfate and iron sulfate help to lower pH.

F. Fertilizer Program

A fertilizer program which meets the need of the turfgrass proposed for the golf courses was formulated and analyzed for nitrate leaching and phosphorus runoff using computer modeling of on-site conditions (see Appendix 15, Fertilizer and Pesticide Risk Assessment", for details). The fertilizer program contains specific amounts and proportion of slow release and fast-release nitrogen sources as well as phosphorus and also represents a typical fertilizer program for the region and the turf species proposed for the proposed golf courses. The program that is implemented by the superintendents of the proposed golf courses would not differ significantly from the program proposed and analyzed, in terms of the total amount of nitrogen and phosphorus applied.

The fertilizer programs analyzed would consist of application of up to a total of two to four pounds of nitrogen per 1,000 ft^2 distributed over either 5 or 10 applications per year. This program is for tees, green, and fairways which on most golf courses only comprises 20 to 30% of the total golf course area. The remaining 70 to 80%, the roughs, will be fertilized at one to two pounds of nitrogen per thousand square feet per year, half the amount applied to tees, greens and fairways. Lesser amounts of slow release N are applied during the periods of most active growth and N uptake such as early spring. Overall nitrogen fertilizing is when the grasses are hardening off (becoming cold tolerant) before winter dormancy (end of October - November).

3.1.3 Irrigation

Irrigation systems are employed on golf courses to supplement water supplied by natural precipitation, water fertilizers and some pesticides into the soil following their application, maintain sufficient surface moisture to promote germination of interseeded turfgrasses, and modify surface plant tissue temperatures (Turgeon, 1991).

Following precipitation or irrigation, water is lost from the turfgrass root zone by evaporation and transpiration processes, collectively called evapotranspiration (ET), and by drainage from soil macropores. Some moisture is obtainable from lower soil depths as water moves upward (capillary flow) to replace moisture lost through evapotranspiration. Often times capillary flows may not occur fast enough to supply turfgrass requirements. Thus, without timely irrigation, turfgrasses may die or become dormant. Efficiency of irrigation programs in producing a healthy turf is determined by the integration of irrigation frequency, timing, rate, and intensity in relation to natural precipitation.

Substantial evidence exists that suggests that too frequent irrigation is detrimental to turf. High disease incidence, reduced wear tolerance, low vigor, and high susceptibility to injury from climatic stresses are more apparent in frequently irrigated turfs (Turgeon, 1991). As irrigation frequency is reduced, turfgrasses typically improve until inadequate moisture limits growth. Determining the need for irrigation can be done either by estimating consumptive water use by evapotranspiration or by measuring soil moisture directly via devices such as tensiometers.

The trend toward daily irrigation of turf on golf courses had been rationalized based on increased traffic density, closer mowing requirements and demands for higher turfgrass quality and softer turf. With this approach, the following cycle of events often develops: daily irrigation renders the soil more susceptible to the compacting effects of traffic; increased soil compaction limits root growth; reduced rooting results in higher wilting tendency and, therefore, necessitates more frequent irrigation (Turgeon, 1991).

Irrigation can be performed at any time of the day or night, however, midday irrigation should be avoided. Standing water may cause scald injury to the turf during hot sunny days. Also, irrigation efficiency would be decreased during midday irrigations due to increased evaporative losses.

Irrigating at night has become standard for most golf courses where automatic irrigation systems are used. Irrigating at night does not interrupt play or maintenance activities on the course. Nighttime irrigation also allows for proper drainage to take place before traffic may cause unwanted compaction. A traditional concern over nighttime irrigation has been the presumed higher incidence of diseases caused by prolonged surface moisture on turfgrass leaves (Turgeon, 1991). Although there is some field evidence to support this principle, other considerations often outweigh disease concern and strongly support irrigating at night (Turgeon, 1991). Irrigating closer to morning may decrease the period of prolonged surface moisture because of more wind and sunlight and actually reduce disease potential.

The precipitation rate of irrigation will be below the infiltrative capacity of the soil to prevent puddling and/or surface runoff. Where infiltration is restricted due to soil type, slope, compaction, etc. multiple cycling (several short irrigation events in succession rather than one period of continuous application) may be used to deliver the desired water volume and maximize plant water availability. Infiltrative capacity would vary over a large area such as a golf course, so rates of delivery should be adjusted accordingly across the course in order to maximize the efficiency of water use.

Syringing, the application of small irrigation amount to turfgrass shoots, is often employed to prevent midday wilt during hot periods especially on closely mowed bentgrass. Syringing is also commonly practiced in early morning hours to remove dew and gutation water. Removal of dew and plant exudance by a brief irrigation actually promotes the drying of turf shoots and leaves so that subsequent mowing quality is improved and disease proneness is reduced (Turgeon, 1991).

Central computer processing units that would direct irrigation frequency, timing and amount would control irrigation of the proposed golf courses. During set-up of the irrigation system the computer would be programmed to deliver water at proper times and in the proper amounts to all areas of the courses based on soil type, slopes, sun and wind exposure, and type of turf (green, tee, fairway). During early stages of operations, modifications to delivery amount, rates and frequency would be made by the course superintendents to correct any areas where turf is receiving inadequate or excessive water. Irrigation, not including syringing, would be programmed to be delivered at replacement rates. Evapotranspirational loss of soil water will be computed based on data collected on-site, and this amount would be delivered to turf by the irrigation system. The frequency of irrigation events would be dependent on meteorological conditions and would be variable. During extremely hot, dry weather it is possible that the courses would receive irrigation four times in a week. On the other hand, irrigation may not be required for a period of weeks because of sufficient precipitation and low evapotranspiration rate. Irrigation events would be performed during non-play periods and as close to morning hours as practical to reduce the potential for disease activity. Delivery timing, rate, and intensity would be monitored on a course-wide basis and modified by maintenance personnel to meet localized water needs, thus maximizing turf water uptake, and minimizing losses via evaporation, runoff, and leaching.

Irrigation water supply was discussed previously in this appendix in Section 2.3, "Irrigation Water Supply" as well as in Section 2.2.5 of the main volume of the DEIS.

3.2 Supplemental Cultural Practices

It is sometimes necessary to supplement primary cultural practices with additional operations to sustain turf at a desired level of quality. Supplementary cultural practices become necessary when problems arise, or are anticipated because of unfavorable developments in the turf (Turgeon, 1991).

Excessive thatch development, soil compaction, grain, and convolutions in the turf's surface are conditions that can often be remedied by cultivation, topdressing, rolling and other practices other than primary culture. There is no easy substitute for proper site preparation prior to planting turfgrass, however, surface problems can be sufficiently reduced by timely and properly implemented practices described in this section.

3.2.1 Cultivation

Cultivation refers to mechanical methods of selective tillage that modify physical and possibly other characteristics of a turf (Turgeon, 1991). Cultivation practices are primarily designed to reduce problems associated with excessive thatch and soil compaction namely decreased water infiltration, decreased root penetration, decreased fertilizer and pesticide efficiency, restrictive soil layering, and other factors that lessens the turf's ability to compete with weed pests and/or resist fungal and insect damage. The principal types of cultivation are coring, slicing, and vertical mowing.

Coring or core cultivation is the practice by which hollow tines are used to extract soil cores from the turf. Extracted cores are either removed from the turf's surface or broken up in-place. If cores are removed, then the cultivation is often followed by topdressing with a sand based soil. Coring has been shown to: (1) reduce toxic gases (i.e. CO_2) from the soil, (2) improve wetting of dry or hydrophobic soils, (3) accelerate drying of persistently wet soils, (4) increase infiltration capacity, especially when surface compaction or thatch limits infiltration, (5) stimulate root growth within the holes, (6) increase shoot growth atop the holes, (7) disruption of soil layers resulting from topdressing, (8) control of thatch and (9) improved response to fertilizers.

Less intense forms of cultivation include slicing and spiking. Slicing is the process by which a turf is penetrated to a depth of 3 to 4 inches by a series of V-shaped knives mounted on disks. Unlike coring, there is no removal of soil cores; therefore, disruption of the turf is minimal. Spiking is a similar process except that penetration is limited to approximately 1 inch, and the length of the perforations along the turf's surface is shorter. Slicing is typically practiced on fairways and other heavily trafficked turfs during midsummer stress periods when coring might be too injurious or disruptive. Spiking is primarily practiced on greens. As with coring, slicing and spiking are used to improve infiltration, especially where surface compaction is severe. Because of the severing of stolons and rhizomes, these types of cultivation often result in stimulated root and shoot growth in the immediate vicinity of the perforations. Many turfgrass managers consider slicing and spiking as practices to be employed between core cultivations for achieving similar but less dramatic results. Since they cause only minor disruptions of the turf, they can be practiced as often as weekly during the growing season to mitigate the soil-compacting effects of traffic.

Vertical mowing is a cultivation procedure involving the use of vertically oriented knives mounted on a rapidly rotating, horizontal shaft. Depending on the penetration depth of the knives, different objectives can be met. When the knives are set to just nick the turf, stolons and decumbent leaves are severed to reduce grain on greens. Following coring, shallow vertical mowing can be employed to break up the cores to facilitate reincorporation of the soil. With deeper penetration of the knives, much of the accumulated thatch can be removed. Setting the knives to penetrate still deeper results in a cultivation of the underlying soil to alleviate surface compaction.

3.2.2 Rolling

Rolling is a maintenance practice used to push grass roots in contact with the soil after a physical disturbance. Without rolling turf would be subject to desiccation and scalping. Creating compaction can be an undesired side effect if rolling is implemented improperly. A light roller is usually sufficient to press plants into the soil. A soil that is too wet should not be rolled, but adequate moisture is necessary to enable roots to grow quickly back into the soil.

3.2.3 Topdressing

Topdressing of greens and possibly tees is the practice where a thin layer of soil is applied to an established turf to control thatch, smooth a playing surface, promote recovery from injury or disease, protect greens in winter and change the characteristics of the turf growth medium.

Selection of the topdressing material is critical to the success of the program. Where the indigenous soil is favorable, the topdressing should be identical to it. Even relatively small differences in soil type among layers that could be created by topdressing may be deleterious to proper drainage/moisture retention for turf growth.

The amount of a topdressing soil required per application, or during a growing season, depends on the purpose for which the program is being carried out. The rate and number of applications are limited by the capacity of the turf to absorb the material; excessive amounts of topdressing soil can prevent light from reaching the turfgrass leaves and lead to substantial loss of turf. As a rule of thumb topdressing should be initiated after the grass has germinated. The amount of topdressing soil required under these circumstances would be about 0.2 yd^3 per 1000 ft^2 that provides a layer approximately 1/16 inch thick. The short term effect of topdressing is thatch modification, but with time thatch decomposition is favored by topdressing, resulting in an increased humus content in the soil. Topdressing will be done once every two to three weeks during the part of the year when turf is actively growing.

3.2.4 Matting

Matting is the procedure by which a heavy steel mat or similar service is pulled across a turf. Following topdressing, matting is usually necessary to remove soil adhering to the foliage and work it into the turf; otherwise, it would interfere with mowing, putting, and other activities. Where surface irregularities exist, matting redistributes topdressing soil to fill in low areas. Matting of loose soil can also be accomplished by brushes, brooms, and other devices. Following coring, a heavy steel mat or section of chain-link fence can be used to break up the cores as well as to work the soil into the turf. Usually, with fine-textured soils, the optimum soil moisture for coring is higher than that for matting. The soil cores should be allowed to dry sufficiently so that they can be easily crumbled between the fingers. When too wet, the soil tends to smear; when too dry, the soil cores are hard and brick-like.

Following seeding onto an existing turf (usually after coring or vertical mowing), the seed is worked into the turf by matting. Where organic debris remains on the turf's surface following vertical mowing, matting can be performed to "ribbon" the debris to facilitate its subsequent removal from the site.

3.2.5 Other Practices

A number of operations routinely performed on golf courses, while not true cultivation practices, are performed for the same reasons as the cultivation practices. Promotion of a healthy, resistant turfgrass and inhibition of pest occurrence of proliferation are similarly accomplished by these practices.

Cup location on greens should be changed daily. Moving cup locations changes the location of concentrated activity on the green. Compaction will not occur unevenly on a green if cup location is changed regularly. Physical wear on the low-cut turf is also distributed across the green when cup location is varied.

Similarly, tee marker locations should be varied on the tee surface in order to avoid serious physical damage and pest infestation because of divots being removed. Areas in which turf is damaged by divots should receive an application of divot mix that contains pre-germinated seed to insure rapid turf re-establishment.

An additional measure that can be taken to avoid soil compaction and its deleterious effect on the golf course turf is to use the newly developed lightweight mowers. Reduced overall weight and tires with greater surface area help to minimize the potential for compaction, especially on fairways. Use of lightweight mowers has been shown to increase the interval between cultivation activities and generally reduce the frequency and severity of pest problems, especially weeds and diseases.

3.3 Scouting or Monitoring Pest Occurrences and Levels

The cornerstone of all successful ITM plans is a properly planned and implemented pest scouting, monitoring, and record keeping program. Documenting pest occurrences, their levels, timing, location, and extent aid the turf manager in making informed decisions on the need for remedial actions, including pesticide treatments. Effectiveness of cultural practices in preventing pest proliferation and chemical practices in reducing pest levels is also documented as part of the scouting and record keeping program.

3.3.1 Scouting Responsibility and Frequency

Ultimately, it is the golf course superintendent's decision as to what practices should be implemented to combat pests. However, because of the extensive responsibilities of the course superintendent, it is unlikely that they would have the time necessary to personally conduct the full scouting program. Therefore, it is recommended that a member of the maintenance team, preferably the Assistant Superintendent, be assigned the duty of regular course scouting. Properly scouting an 18 hole golf course requires a minimum of 3.5 hours and regularly takes up to 4.5 to 5 hours to complete. Depending on the maintenance budget, scouting should be performed at least once per week for fairways and up to once per day on selected greens and tees with a history of pest problems.

Because of these time requirements, the individual responsible for scouting should make this task the first priority of his responsibilities. If time or budgetary restraints do not allow for a maintenance team member to perform the scouting duties, private scouting consultants are currently offering their services in New York State. Regardless of who is performing the scouting, time should be allocated for a weekly meeting between the scout and the golf course superintendent to discuss the status of the course. Information regarding imminent pest threats should be passed along to the superintendent immediately. Although the superintendent would be familiar with the general "health" of the golf course at all times, the detailed information collected by the scout would be invaluable in pest control decisions. All maintenance staff will be trained in the major turfgrass pests and will provide another layer of scouting.

Areas to be scouted and the intensity of the scouting program vary from course to course. Priorities are established for each course in terms of areas and time to be allocated. For example, greens are the areas where turf quality is most critical. Therefore, scouting should be most intense for these areas. A commonly implemented scouting strategy is to scout 6 or 9 greens per day so that each green is scouted on a two or three day interval. Tees should be scouted with similar intensity. Fairways should be scouted once or twice per week. Scouting intensity should be increased in areas historically prone to weed, disease or insect problems. More intense scouting at these "indicator areas" can be used as a predictive tool for the entire course and also serve as a method of determining the effectiveness of cultural or chemical remediation practices.

Documentation of scouting observations is critical to the success of the program. Figure 5, "Golf Course Scouting Report," presents a sample data form for recording pest monitoring data. Information which should be collected includes the date, location, pest, pest level, sample number (if one taken) and any comments, including possible causal factors. Obviously, the scout must be able to recognize the pests that could potentially occur on the proposed golf courses. While turfgrass insects and weeds are fairly easy to identify correctly in the field, proper identification of disease fungi is often difficult. For this reason, diagnosis of disease should be done by an examination of spores, hyphae and mycelium with a hand lens or microscope when symptamology is unclear. The scout can perform this, if they are qualified, or assistance can be obtained from Cooperative Extension personnel. Disease samples will routinely be sent to a diagnostic laboratory for confirmation of the suspected disease.

It is critical that the scout be consistent when identifying the severity of a weed, disease or insect occurrence. Decisions to implement specific control practices would be based on the exceeding of pest level thresholds.

To implement the ITM approach, superintendents must establish thresholds for unacceptable economic or aesthetic injury based upon some reliable system of

Course ______________________
Date ____________

GOLF COURSE IPM SCOUTING REPORT

IPM ID # _____ -290- _____
Scout ____________

HOLE	LOCATION	Non-infl.	Diseases	Weeds	Insects	Samp?	COMMENTS
1 Tee	M/W L C R						
Tee	M/W L C R						
Fway	yds. L C R						
Fway	yds. L C R						
Green	fr/back L C R						
Green	fr/back L C R						
2 Tee	M/W L C R						
Tee	M/W L C R						
Fway	yds. L C R						
Fway	yds. L C R						
Green	fr/back L C R						
Green	fr/back L C R						
3 Tee	M/W L C R						
Tee	M/W L C R						
Fway	yds. L C R						
Fway	yds. L C R						
Green	fr/back L C R						
Green	fr/back L C R						
4 Tee	M/W L C R						
Tee	M/W L C R						
Fway	yds. L C R						
Fway	yds. L C R						
Green	fr/back L C R						
Green	fr/back L C R						

Maps (when necessary) & additional comments

Figure 5

Course [illegible]

HOLE 7

GOLF COURSE IPM SCOUTING REPORT

IPM ID # [illegible] -290- 03

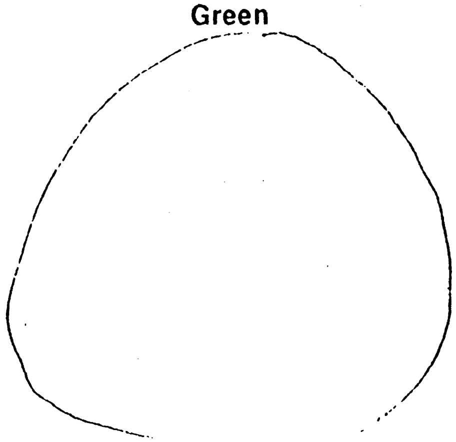
Scout JG

Location	DATE	Non-Inft.	Diseases	Weeds	Insects	Samp?	COMMENTS
TEES							
(M)/W L (C) R	5/28			Crab = 2			Several small patches of Crabgrass
M/W L C R							
M/W L C R							
M/W L C R							
M/W L C R							
M/W L C R							
M/W L C R							
M/W L C R							
FAIRWAY							
100 yds. (L) C R	5/28	DS = 5		Cl = 5			Several dry spots. Clover scattered throughout
375 yds. L C (R)	5/28		? = 1	Cl = 5		✓	fairway, Diseased area - unknown sample taken
yds. L C R							
yds. L C R							
yds. L C R							
yds. L C R							
yds. L C R							
yds. L C R							
GREEN							
(L C R)					BTA = 1		BTA adult activity on whole green
L C R							
L C R							
L C R							
L C R							
L C R							
L C R							
L C R							

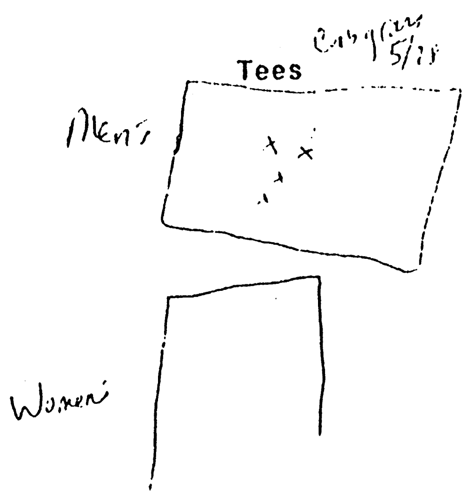
Ratings are based on a 1,000 sq. ft. sampling area.

MAPS:

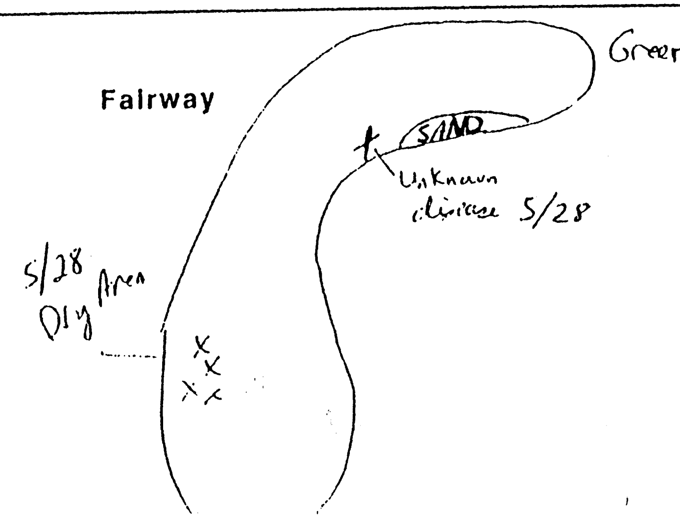
Green



Tees



Fairway



NON-INFECTIOUS

Chl = Chlorotic
DS = Dry Spot
GD = Golfer Damage
Moss = Moss
OD = Oil Damage
Sc = Scalping

DISEASES

$ = Dollar Spot
? = Unknown
AN = Anthracnose
BP = Brown Patch
CS = Copper Spot
FP = Foliar Pythium
GSM = Gray Snow Mold
LS = Leaf spot
NRS = Necrotic Ring Spot
PSM = Pink Snow Mold
RP = Root Pythium
RT = Red Thread
TAP = Take All Patch
WBP = Winter (cool season) Brown Patch
YP = Yellow Patch

WEEDS

?BL = Unknown Broadleaf
?G = Unknown Grass
Cl = Clover
Crab = Crabgrass
D = Dandelion
GG = Goose Grass
Pl = Plantain
PW = Pearlwort
QG = Quackgrass
Ver = Veronica

INSECTS

A = Adult
ABW = Annual Bluegrass Weevil (Listronotus, Hyperodes)
Ant = Ants
BTA = Black Turfgrass Ataenius
CB = Chinch Bugs
CW = Cutworm
EC = European Chafer
JB = Japaneese Beetle
L = larva(e)
SWW = Sod Webworms
WG = White grubs

measurement. Before using any chemical pesticide, it should be established by actual monitoring of the turf that injury thresholds, or action levels related to such thresholds, would be exceeded unless chemicals are used (Grant, 1989). Until these thresholds are crossed, use of alternative methods should be attempted as feasible.

"Because IPM is inherently site specific, explicit threshold and the means of measuring injury cannot be standardized for the golf industry" (Grant, 1989). However, this should not deter experienced professionals from drawing upon their best judgment in making such determinations. Golfers and superintendents at different courses would have different tolerance levels for turf injury and differing maintenance regimes would result in different degrees of injury from the same number of pests. "The setting of injury thresholds just isn't subject to uniform standards" (Sheila Daar, IPM consultant and Executive Director of the Biointegral Resource Center In Grant, 1989).

3.3.2 Sampling for Pests

Specific methodologies for determining pest presence/absence and density vary between pests. For weed species, density is most commonly reported simply as number of plants per unit area or percent coverage of an area. Presence is easily ascertained by visual examination of the turf surface. For insects, detection and quantification often is not as simple since many insect pests may occur within turf leaves (i.e. chinchbugs) or stems, reside within the thatch (i.e. sod webworm, bluegrass billbug), or have the deleterious life stage present within the soil below the turf (i.e. white grubs) rather than on the turf surface.

A. Insects

A number of techniques have been devised for sampling insect populations in turf. Detection techniques include visual observation, the use of irritants, traps, sweepnets, soil sampling, flotation, and the increased presence of pest predators. Visual observation can often be used to quantify hairy cinch bug presence. Observation of 20 adults in 20 minutes in a fairway area has previously been used as a treatment threshold (Thresholds reported in this section are from Dr. Michael Villani, Asst. Prof. of Entomology, Cornell University, June 10, 1991, "Golf Course Pest Monitoring and IPM Techniques"). For bluegrass billbugs, visually observing 5-10 adults in 5 minutes on pavement adjacent to turf has also been previously used as a treatment threshold (obviously this technique is limited in its usefulness, primarily to areas around buildings, cart paths, etc). Disclosing solution (irritant) of 1-2 teaspoons of soap per 2 gallons of water may be applied to a square yard of turf to determine the density of sod webworm populations. Observing 1 to 5 webworm larvae per square yard has previously been used as a treatment threshold. The use of traps, pitfalls or otherwise, are limited in their usefulness because they are species specific (pheromone) and only attract adults. Adult populations are not usually indicative of larval levels, which are often the life stage of concern (i.e. white grubs), and thus do not provide the information required to assess potential for pest insect damage. Sweep nets may be used to determine the presence and absence of insects on the turf surface, but determination of density is difficult to estimate based on sweep net collection.

By far, the most common method of turfgrass insect sampling is by soil sampling. Since many of the most common and most distinctive insect pests inflict their damage during the larval stage of their life history, soil sampling has become standard for obtaining population density measurements.

Grubs of the scarab beetle complex are sampled either by cutting back a square foot of sod using a pocket knife or by use of a cup cutter. Identifying and counting individuals of species allows for determining pest levels in relation to thresholds. Generally, the following numbers per square foot have been used as thresholds for chemical treatment on golf course turf in New York State; Japanese beetle (8-10), Masked Chafer (5-7), Oriental Beetle (7-10), Asiatic Garden Beetle (10), and May or June Beetle (7). However, it is important to realize that these are general guidelines. Certain turf, in an extremely vigorous state, could tolerate 20 to 30 grubs per square foot without exhibiting ill effects. Or, a highly stressed turf may show ill effects from as few as 1-2 grubs per square foot. In time, a turf manager would be able to gauge the resistance of his turf to insect infestation and set his own thresholds accordingly.

B. Diseases

Setting thresholds for diseases is the most difficult. Thresholds for fungal diseases are less well defined and depend to a great extent on the turfgrass species, prevailing environmental conditions, economic or aesthetic value of the site, and the cost of chemical treatment versus renovation of damaged turf sites (Peacock et al., 1996). Below-threshold levels of diseases are usually present as spores, hyphae, mycelia and/or fruiting bodies that are not visually evident. Quantification in relation to threshold is almost impossible for these characteristics. Furthermore, since factors affecting disease occurrence and severity are more related to climatic conditions, and since these climatic features can change rapidly, prediction of trends in numbers is difficult if not impossible by observing disease trends in the turf alone. It is the difficulty in diagnosis that led to the proliferation of the practice of preventative chemical application for disease. Fortunately, recent technology has allowed for greater precision in detecting disease presence in the field and predicting the occurrence of disease outbreaks based on recent on-site weather conditions.

Recent advances in biotechnology are being applied to plant pathogen systems to provide diagnostic tests directly applicable to pathogen detection at the turf manager's level. For broad acceptance these assays had to be sensitive, specific, reliable, and user-friendly. These criteria are met by the immunoassay-based diagnostic system. Agri-Diagnostic Associates of Cinnaminson, NJ have developed immunoassays for the detection of three fungal pathogen complexes in turfgrass; Pythium Blight, Brown Patch, and Dollar Spot.

The Reveal® disease detection kits employ the dipstick format for performing double antibody sandwich immunoassay. The assay requires no specialized equipment beyond what is supplied by the manufacturer, and can be completed in ten minutes. The assay is quantitative, yielding a color endpoint, the density of which is directly related to the amount of pathogen in the turfgrass sample.

If necessary, it is recommended that the scout for the proposed golf courses be equipped with Reveal® products and be familiar with their use. Visual observations of turf quality can then be consistently correlated with immunoassay endpoint results that would enable the scout to imply disease pressure on areas that are not directly tested. Intensity of analysis should be correlated with general knowledge of the factors promoting disease proliferation to best document the need for remedial actions, including curative fungicide applications.

C. Weeds

Scouting for weeds is easier than for insects or diseases simply due to the fact that weeds have obvious above ground structures that are easily identifiable. Scouting for weeds can be performed easily and quickly while riding in a golf cart. With experience the scout would be able to describe weed occurrence levels in relation to the established tolerance thresholds. Consistency in applying occurrence levels would be important as would the mapping of occurrences and keeping records of occurrences.

3.3.3 Record Keeping

It is imperative that all data collected as part of the scouting/monitoring program be compiled and analyzed on a regular basis. Scouting data shall be used to determine historical trends of times and areas of increased pest presence, the effectiveness of cultural and chemical remediation practices, and refinement of pest threshold levels. The scouting program and analysis of the data that it provides can aid in communication between all of those affected by chemical control practices including the scout, golf course superintendent, the local community, and regulatory agencies. Documenting the decision making process for chemical applications promotes the judicious use of pesticides with respect to target efficacy and minimization of non-target impacts, which is the primary goal of integrated pest management. The monitoring data forms in Figure 4 should be maintained in a system that allows for easy retrieval and analysis of data.

3.4 Chemical Control

The use of chemical pesticides has tremendous impact on the productivity and quality of turfgrass (Beard, 1973, 1982; Engel and Illnicki, 1969; Britton, 1969). Color, uniformity, and density may be affected adversely by incursions of weeds, diseases and insects. The public demand for turfgrass of high quality and uniform playing surfaces on golf courses often requires the use of intensive management to control pests. Chemical pesticides promote sustained turfgrass quality, reduce labor costs, and reduce energy expenses.

Despite these obvious cultural and economic benefits, conflicts have developed over pesticide use in relation to environmental quality issues. In the past, pesticide residues have been associated with adverse environmental effects resulting from improper or over use including: 1) reduction of certain predator bird populations; 2) appearance of detectable residues in aquatic ecosystems on a global scale; 3) implication of many pesticides as potential carcinogens; 4) long-term contamination of soils with persistent pesticides; 5) destruction of non-target organisms (fish kills and beneficial soil organisms) and elevation of non-pest species to pest status; and 6) evolution of resistant pest strains (Anderson et al. 1989; Potter et al. 1989; Metcalf 1980, 1989).

A wide range of chemicals provides control of pest and disease infestations on golf courses. Appropriate selection of chemical formulation and timing of chemical application in relation to temperature, precipitation, irrigation, and pest life state is critical for effective suppression of turfgrass pests (Niemcyzk, 1987; Reinert, 1976; Tashiro and Kuhr, 1978; Villani et. al., 1998; Vittum, 1985).

Pesticides would be applied to the proposed golf courses' turf only when needed. Products that would be used, the areas that receive pesticide application, the rate of application, and the timing of applications would vary between maintenance seasons. The factors that would dictate when, where and how much pesticide would be applied are pest levels in relation to threshold levels and the environmental sensitivity of specific areas. Pesticide applications would target specific pests at the times when they are most susceptible to pesticide treatments in order to insure the maximum achievable efficacy.

Additional measures that would be taken to further minimize potential impacts from pesticide use and maximize pesticide efficiency in those instances where it has been determined by the golf course superintendent that pesticide use is necessary include the following:

1. The target pest shall be properly identified. The Fertilizer and Pesticide Risk Assessment in Appendix 15 gives a lists of potential pests that was derived from the "2002 Cornell Recommendations for Commercial Turfgrass" as well as other published literature sources. Each pest is discussed individually in Sections 4, 5, and 6 of this document.

2. The pesticide used shall be labeled for use on turf and for the target pest. Use of a pesticide that is not in accordance with its labeling is a violation of both federal law and state law.

3. The pesticide shall be registered for use by the USEPA and New York State, be recommended for use by Cornell Cooperative Extension, and meet the rigorous screening criteria described in Appendix 15, "Pesticide and Fertilizer Risk Assessment" (i.e. reduced toxicity, low mobility).

4. Pesticides shall be applied by a New York State licensed pesticide applicator.

5. All application equipment shall be calibrated before an application is made.

6. Application equipment shall be equipped with spill control absorbent pillows in the remote incident that any unintended release occurs.

7. All application equipment shall be filled on a flat impervious surface where any accidental runoff can be controlled.

8. No applications shall be made in weather that is windy enough to allow pesticide to "drift" off of the target area. Additionally, spray equipment will be equipped with shrouds to further reduce the potential for drift.

9. No application shall be made when heavy rain is forecasted for the near future (48 hours).

10. All used pesticide containers would be disposed in a proper and safe manner.

11. No pesticides would be applied through an irrigation system.

3.5 Biological Controls

In the past several years, particularly in the early 1990's, the turf industry came under intense scrutiny regarding the use of pesticides. This may be in part because the industry is more "visible" than the agricultural community for most urban and suburban homeowners. In addition, the home lawn care industry faces a particular challenge because the steps taken to provide the coveted thick, lush lawns involve making pesticide applications on the home lawn. Of course, most lawns serve as recreation for families and pets, so pesticide exposure in these areas is viewed with more concern.

At the same time, the news media seemed to thrive on presenting pseudo-factual reports about pesticides and the home environment (Vittum, 1991). It is probably not a coincidence that anti-turf pesticide reports appeared in many places each spring. As a result, turf managers faced increased pressure to reduce pesticide and fertilizer applications while still maintaining high quality turf.

One approach that may provide some level of relief for turf managers would be the use of biological control agents to control some turf insect pests. Biological control agents are living organisms that are used to control other living organisms. The biological control organisms occur in a variety of shapes and forms. In addition, some are general feeders while others are quite specific in their action.

Biological control agents are complex, not totally effective, and not always predictable. The concept of biological control has been so widely publicized that the general public views it as a viable and readily available alternative to all pesticides. Unfortunately, this is not the case, but this area is currently receiving much needed attention and hopefully will provide additional control agents in the future. The public must be informed that biological controls are not the answer to all pest problems, but may be useful component of a good IPM program (McCarty and Elliot, 1994).

Use of biological control agents is more difficult than using standard insecticides and fungicides. First of all, the biological agent has to have something to feed on, so it must be applied to an area where the pest is present and active or it must be a general feeder that can survive on a supplementary food source until the pest appears. Often there is a delay between the time the biological agent is applied or released and the time when it begins to have a noticeable effect on the target pest. This is usually not a problem, as long as the manager is aware of it and plans his application so that the biological agent has enough time to act before the pest reaches damaging levels.

Since biological control of turf pests is a relatively new concept there are a limited number of products that are commercially available to control diseases and insects. However, research and field testing is occurring at accelerated rates in order to develop effective biological insect and disease control in turf. Only recently has the first biological fungicide become commercially available and proven effective under field conditions that it is now recommended as an alternative treatment method (Cornell Cooperative Extension, 1998) Biological control of turf diseases, insects, and weeds are discussed in Sections 4.4, 5.2, and 6.2, respectively.

Because of the general lack of currently available commercial products, it is not envisioned that biological controls would play a significant role in the overall management scheme of the proposed golf courses during the early years of their operation. As products become available and are proven effective by field testing under conditions similar to those found on the proposed golf courses, their use would be given full consideration by maintenance directors. Because of the high quality envisioned for the proposed golf courses, direction of maintenance activities would be in the hands of a highly qualified, experienced golf course superintendent. Managers whose jobs depend on providing the highest quality course possible within budgetary and environmental constraints would be constantly searching for effective, economical and environmentally sound products to meet maintenance needs. This should ensure that consideration be given to all new products, including biological controls.

SECTION 4. POTENTIAL DISEASES AND INTEGRATED CONTROL STRATEGIES

4.1 Introduction

Most turfgrass diseases are caused by pathogen fungi that can invade leaves, stems, and roots of plants. The second leading cause of turfgrass disease is plant parasitic nematodes that attack the roots. There are very few bacterial or virus diseases of turf. Fungi and plant parasitic nematodes use a combination of physical pressure and enzymes to enter plants, invade tissues, and/or disrupt metabolic processes. As a result of the injurious effects of a pathogen (disease-causing agent), a plant may exhibit various responses known as symptoms. Examples of symptoms include leaf spots; root and stem rots; bronzing, yellowing or other changes in leaf color and death of leaves, tillers, or entire plants. Symptoms may be unique to a particular pathogen and can be used to easily identify certain diseases. Unfortunately, symptoms can overlap with several different diseases. Fungal pathogens sometimes produce visible structures known as signs. It is through the use of a combination of symptoms and signs that disease problems are diagnosed. Many signs, such as spores, can only be seen with a microscope. Only those signs and symptoms that can be seen with the naked eye or the aid of a hand lens would be emphasized here.

Time of year, turfgrass species, and environmental conditions also provide very important clues for disease diagnosis. For example, brown patch and Pythium blight are seldom a problem in cool-season grasses when night temperatures fall below 65°F, and Pythium blight rarely causes severe injury to mature stands of Kentucky bluegrass. Conversely, dollar spot is more damaging during the cooler night temperatures of early and late summer than during the hottest weeks of summer. It is important to realize that not all grasses are susceptible to all diseases. Summer patch is strictly a high temperature, summer disease of Kentucky bluegrass, fine leaf fescues and annual bluegrass. Species such as perennial ryegrass, creeping bentgrass, and tall fescue are resistant to summer patch. In summary, diseases are diagnosed using a combination of signs, symptoms, weather conditions, locations and a knowledge of those diseases that are most likely to appear on a given turf species in any particular season of the year.

The remainder of Section 4 consists of two parts. The first part (Sections 4.2-4.4) focuses on the non-fungicide methods used to reduce disease occurrence and severity. The remainder of Section 4 discusses a number of individual diseases and focuses on disease identification by providing a guide of key factors that includes: field symptoms, distinctive and easily observed signs, predisposing environmental conditions, and grass species likely to be affected. Approaches to reduce injury through cultural, mechanical, biological, and chemical methods are outlined for each disease.

4.2 Monitoring Diseases and Establishing Thresholds

Successful disease management is contingent on early disease detection and a proper diagnosis. Knowledge of the environmental requirements for disease development, symptoms of disease, pathogen signs, and the diseases likely to affect any particular turfgrass species are the primary factors scouts use to detect diseases. Visual monitoring is essential to early detection and selection of a tactic that would effectively address each disease.

The frequency of monitoring depends on the level of management, and the economic or aesthetic value of the site. For example, greens should be scouted every other day during the growing season, and daily during periods of high temperature stress, high humidity, or extended wet and overcast weather.

Intensively managed sites, particularly greens, are rendered more susceptible to disease by virtue of high traffic combined with extremely low and frequent mowing. Manicured Kentucky bluegrass lawns or athletic fields are more likely to sustain disease damage than tall fescue or zoysiagrass. Bermudagrass or bentgrass greens have a 0% Pythium blight threshold and a dollar spot threshold of less than 0.5% blighting. A Kentucky bluegrass lawn maintained by a lawn care company may have a dollar spot threshold of less than 10% blighting. The brown patch threshold for the same lawn may be much greater (say 25%). This is because dollar spot generally is much more destructive than brown patch in a Kentucky bluegrass turf. Conversely, a tall fescue lawn affected with net-blotch or red thread would not be a candidate for chemical treatment since this species is likely to rapidly recover from these diseases. Fungicides are generally not warranted after a turf has been extensively damaged. In that situation, or wherever a disease is a chronic problem, it is wiser to renovate the turf with disease resistant, regionally adapted species and cultivars.

Thresholds also are based on the disease "history" of the site. Turf managers should maintain detailed records of all pest problems. Records should be organized by management units; green, tee, fairway, etc. The turfgrass species and cultivar(s), if known, should be recorded as well as the following: (a) date of the appearance of each disease and weather conditions; (b) the duration of disease activity; (c) level of damage tolerated before a management tactic was imposed; and (d) comments regarding the success or failure of the tactic employed. Disease histories for each turfgrass unit are invaluable information for future disease management programs.

4.3 Cultural Practices to Control Diseases

The relationship among environmental conditions, turfgrass plants, cultural practices and pathogens as they interact with one another are the key factors involved in disease development. Of these factors, the environment is the most important determinant of a disease outbreak. For serious disease problems to occur, the environment must simultaneously exert diverging conditions on both plant and pathogen.

Adherence to sound cultural practices is basic to reducing disease severity in turf. The turfgrass environment, however, is not static, and managers must continually modify cultural practices to encourage vigorous growing conditions.

Specific cultural actions for minimizing disease damage on golf course turf would include the following:

1. Plant disease-resistant species and cultivars such as the Kentucky bluegrass and fine fescue proposed for fairways on both courses.

2. Use a balanced N-P-K fertilizer at the appropriate times and based on soil tests.

3. At least 50% of all nitrogen applied per year should be from a slow-release nitrogen source including isobutylidene diurea (IBDU), methylene urea, sulfur and polymer coated urea and organic sources.

4. Maintain a high mowing height within a species' adapted range. Raise the mowing height during periods of environmental stress or disease outbreaks.

5. Avoid mowing turf when leaves are wet and foliar mycelium is evident.

6. Irrigate deeply to wet soil to a depth of 4 to 6 inches when the turf first exhibits signs of wilt. Avoid frequent and light applications of water, except when root systems area severely injured or shallow as in mid to late summer.

7. Test soil every 2 or 3 years for phosphorus and potassium levels as well as soil pH. Adjust soil pH to a range of 6.0 to 7.0.

8. Avoid application of broadleaf herbicides or plant growth regulators when diseases are active.

9. Alleviate soil compaction and reduce thatch to less than 0.5 inch in depth through core cultivation, verticutting, or a combination of these methods.

10. Overseed or renovate chronically damaged sites with disease resistant species and regionally adapted cultivars.

For the proposed golf courses putting greens the following additional actions should also be taken:

1. Irrigate close to dawn to remove leaf surface exudates and physically knock down mycelium of some pathogens.

2. Remove dew and leaf surface exudates to speed leaf drying by dragging, poling, or whipping.

3. Avoid mowing wet foliage when foliar mycelium is evident.

4. Keep mowers adjusted and blades sharp; use walk-behind greensmowers and increase the height of cut whenever possible.

5. Core cultivate or verti-drain compacted sites.

6. Employ water injection or core cultivation in combination with wetting agents to alleviate localized dry spots or fairy ring damage.

7. Never roll greens when soils are wet.

4.4 Biological Control of Turfgrass Diseases

The development of biological control agents for turfgrass disease management has lagged behind advances in biological insect pest control. It generally is easier to identify insects, isolate the disease agents, grow them in a laboratory, and direct sprays of propagules (infecting units, such as spores or mycelium) to sites infested with theses insects. Using bacteria or fungi to control a fungal turfgrass pathogen is much more complicated. The microscopic size of the target pest, and the complex environmental forces affecting both the biological control agent and the pathogen, are significant barriers to progress. Pathologists have demonstrated that several fungi and bacteria provide suppression of some turfgrass diseases in controlled laboratory studies. In field studies, however, these agents generally have failed to provide a significant level of disease suppression. Most field failures are due to the inability of biological control agents to survive, compete, or reproduce in populations large enough to provide disease suppression.

The year 1998 was the first year in which a biological control product has been recommended for use on commercial turfgrass by Cornell Cooperative Extension. The product contains 1.15% strain T-22 of the bacteria *Trichoderma harazianum*. *Trichoderma* are fungi that are present in substantial numbers in nearly all agricultural soils and in other environments such as decaying wood. The bacteria colonize plant roots and colonize and kill pathogenic fungi in the vicinity of the roots.

When added to turf the granular formulation Biotrek 22G results in establishment of the organism on roots and surpresses the pathogens that cause pythium, and brown patch. However, the pathogens may survive in sufficient numbers to cause disease (Harman, 1996). Biotrek is the first commercially available biological disease control agent for turfgrass in the United States and is suitable as a partial substitute for some turfgrass fungicides. Once the pathogens become established on the grass blades, the soil-applied biocontrol no longer can protect the plant. This granular formulation can therefore result in disease reduction, but it must be used in conjunction with compatible chemical fungicides (Harman, 1996). A spray application of the biocontrol agent for control of diseases on grass blades is under development and has provided excellent results in field tests (Harman, 1996) but is not yet commercially available.

The following is a description of the current status of biological controls of turfgrass (Nelson and Craft, 2000).

Biological Disease Control Products for the Turfgrass Industry

Today, the turfgrass manager has a number of bioaugmetative and biostimulatory products available for use. The numbers and types of organic amendments and microbial inoculants being marketed for disease control in turfgrasses are overwhelming. In many cases, it is difficult to know which of these products should be taken seriously. Biological control products currently available to the turfgass industry can be grouped into four different classes: 1) EPA-registered inoculants, 2) unregistered inoculants for which documented levels of disease reduction are claimed, 3) unregistered inoculants for which disease reduction claims have not been validated, and 4) products that are known to suppress diseases but are marketed for other purposes. These latter products are commonly marketed as natural organic fertilizers and compost amendments, whereas many of the microbial inoculants fall into the first three categories.

The first class of products is registered in the same manner as chemical fungicides. Currently, there are only two microbial-based products registered on turfgrasses as biological fungicides worldwide. Binab T is a preparation of *Trichoderma harzianum* (ATCC 20476) and *Trichoderma polysporum* (ATCC 20475) available in Sweden and the UK, and BioTrek 22G is a preparation of *T. harzianum* (1295-22) available in the United States. A number of other products that are registered for other crops will likely see registrations on turfgrasses in the future. Additionally, there are other microorganisms being developed specifically for turfgrass applications that are currently in the registration process.

Through registration as a biological fungicide, claims may be made about the control of specific diseases. However, products not registered with the EPA but with labels that claim control of specific diseases cannot be sold or used legally for turfgrass applications. Nonetheless, a number of these types of products are currently available to turfgrass managers. Some of these products are registered on other crops but currently lack a turfgrass registration whereas others are not registered on any crop.

The second class of products is one of the more difficult groups to assess. These unregistered products are marketed at least in part for disease control. Although specific diseases that are controlled are not normally listed on the label, label-wording frequently infers that the use of the product will nonspecifically reduced the incidence or severity of turfgrass diseases. By making such claims, regardless of how vague they may be, they require EPA registration to be used legally. Currently, there are dozens of these types of products available to golf course superintendents, with many new ones appearing every year. Some have been thoroughly validated by research and are likely to be effective inoculants, but are not widely known throughout the industry.

The third class of products includes a large group of biologically-based materials sold for a variety of turfgrass ailments, including disease control. In many cases, there is little or no logic to the selection of the "active" microbial strains contained in the product and no logical development of appropriate application strategies for the product. Although it is difficult to know how much testing has gone into the development of these products, it is doubtful that many have ever been scientifically tested for turf applications. These products rely primarily on marketing shrewdness and testimonials to support sales. It is this group of products that poses the greatest risk to the future health of biological control as a management strategy in turfgrasses since failures with these types of products can instill skepticism of the entire concept among turfgrass managers.

The fourth group of products includes a variety of natural organic fertilizers, root enhancers, soil inoculants, and organic amendments. Many of these materials have been used in the turfgrass industry for a number of years. Most are not marketed for disease control but may have some disease control efficacy. In some cases, these products may be well-tested whereas others have no documented efficacy. Although products such as this may have a high degree of quality control as far as fertility contents, little or no quality control is maintained over disease-suppressive properties.

The Future of Biological Disease Control in Golf Course Turf

Turfgrass management has clearly entered an age where microbiological solutions are being sought for biological problems. It is becoming increasingly apparent that maintaining active microbial communities in turfgrass soils is a vital part of overall turfgrass health. Studies on biological control clearly show the potential to affect disease control through both of the microbial-based technologies described. Currently, there are more questions than answers about how to optimize these technologies. Nonetheless, interest in and commercialization of biological control products continues to grow.

Golf course turf represents one of the most intensively managed plant-soil ecosystems. Many of the demands placed on golf course superintendents have forced them to manage turf in a manner that is detrimental to plant health. For example, the trends toward agronomically unrealistic cutting heights on rootzone mixes low in microbial activity, the ever-increasing amount of traffic on putting greens, and the low nutrient inputs to maintain high green speeds, have placed unprecedented stresses on turfgrass plants, making them highly susceptible to diseases. Along with these demands has come increased fungicide use, which, in turn, has spawned additional negative impacts on golf turf that may also require corrective treatment. As we become increasingly concerned with environmental contamination and a gradual decline of soil and plant health, a return to more biological-based approaches to turfgrass management will provide additional tools for maintaining a more sustainable and healthier turfgrass ecosystem.

4.5 Winter Turf Diseases and Their Integrated Control

Snow protects dormant turfgrass plants from desiccation and direct low temperature kill, but also provides a microenvironment conducive to the development of some low-temperature, pathogenic fungi. There is no shortage of fungi capable of damaging turf during cold periods between late fall and early spring. The most common low temperature fungal diseases are pink snow mold and gray snow mold.

Snow mold fungi are remarkable because they are active at temperatures slightly above freezing. Snow molds are damaging when turf is dormant or when low temperatures have retarded its growth. Under these conditions, turfgrasses cannot actively resist fungal infection. Although these fungi are known as snow molds, they can attack turf with or without snow cover. In general, these diseases develop when temperatures are cool (32-55°F) and there is an abundance of surface moisture.

4.5.1 Pink Snow Mold or Fusarium Patch

Causes and Symptoms

- affects perennial ryegrass, bluegrasses, bentgrasses and the fescues
- generally most destructive to annual bluegrass and bentgrasses
- conditions favoring snow mold include
  - low to moderate temperatures
  - abundant moisture
  - prolonged deep snow
  - snow fallen on unfrozen ground
  - lush turf stimulated by late season application of excessively high amounts of nitrogen fertilizer
  - alkaline soil conditions
  - prolonged periods of cold, rainy weather
- symptoms of pink snow mold:
  - small water-soaked patches 2 to 3 inches in diameter
  - fully developed patches are 3 to 8 inches in diameter
  - some patches may range from one or two feet in diameter and coalesce
  - large patches are most likely to appear in greens or fairways
  - pink coloration of diseased turf at the edge of the patches
  - plants eventually collapse and die
  - mycelium mats the leaves
  - matted leaves have a tan color
  - on close inspection leaves may display a pinkish cast
  - after snow recedes, patches are bleached white and may not have a pink fringe
  - most plants in affected patches under snow are killed

Cultural Management

- use a balanced N-P-K fertilizer in fall
- avoid excessive late season applications of water soluble nitrogen
- avoid the use of limestone where soil pH is above 7.0
- continue to mow late into the fall to ensure that snow would not mat a tall canopy
- snow fences and windbreak should be used to prevent snow from drifting onto chronically damaged greens
- divert any cross-country skiers around greens to avoid snow compaction

Biological control

No biological controls of pink snow mold are commercially available at the present time

Pesticide Control

- Fungicidal control is best achieved with a preventive application prior to the first major snow storm of the year. Preventative applications should be limited to greens only.
- Subsequent applications to greens or other prone locations should be made during mid-winter thaws and spring snowmelt in areas where the disease is chronic.

Threshold

One spot per square yard on greens/tees and 2 spots per square yard on fairways during snow free periods and forecasts are calling for cool-wet weather (32-40 f).

- Products proposed to be used for pink snow mold control on the proposed golf courses as a result of the Risk Assessment are; propiconazole, quintozene, trifloxystrobin and vinclozolin.

4.5.2 Gray Snow Mold or Typhula Blight

Causes and Symptoms

- serious disease with a wide host range

- symptoms initially light brown or gray patches 2 to 4 inches in diameter
- patches may enlarge to 2 feet in diameter and coalesce
- may occur with or without snow cover
- damage usually is minimal in the absence of snow
- more damaging under prolonged deep snow
- particularly damaging when heavy snow accumulates on unfrozen ground

Cultural Management

- see the pink snow mold section for cultural management

Biological Control

- no biological controls are currently commercially available to control gray snow mold

Pesticide Control

- curative applications in spring after sclerotia are produced provide little benefit

- products proposed to treat gray snow mold on the proposed golf courses include chloroneb, propiconazole, and quintozene. Preventive fungicide applications are more beneficial in situations when gray snow mold is consistently chronic.

Threshold

Use the same thresholds for pink snow mold above

4.6 Diseases Initiated in Fall or Spring That May Persist Into Summer

The diseases described in this section normally develop in response to cool and moist weather. Many of these diseases, however, can persist or develop anew during the summer. For example, red thread can be active at almost any time of the year when weather conditions are wet and overcast. Red thread is one of the first diseases to appear in spring and can be active in late winter during snow melt. Similarly, anthracnose basal rot can be severe in early spring, but it also frequently develops in late summer. The seasonal appearance of most diseases can never be precisely predicted since long range environmental conditions are impossible to predict.

4.6.1 Leaf Spot and Melting-Out

Causes and Symptoms

- cool weather pathogen of bluegrasses that is most active during the spring, autumn and throughout mild winter periods

- may develop in two phases: the leaf spot phase and/or the melting-out phase

- leaf spot phase
  - distinct purplish-brown, oval-shaped leaf spot lesions with a central tan spot on the leaves
  - heavily infected stand appears yellow or red-brown
  - numerous lesions can coalesce to encompass the entire width of the blade
  - causes a generalized dark-brown blight and die-back from the tip
  - lesions initially are associated with older leaves
  - leaves die prematurely as a result of the invasion
  - once the crown is invaded the disease enters the melting-out phase

- melting out phase
  - entire tillers are lost
  - turf loses density
  - most damaging to the stand

Cultural Management

- renovate or overseed resistant cultivars
- much more destructive under low mowing
- when diseases become evident, increase mowing height immediately
- avoid spring application of high rates of water-soluble nitrogen fertilizers
- irrigate deeply and infrequently
- control thatch by verticutting and/or core cultivation when more than 0.5 inches in depth
- broadleaf, phenoxy herbicides and plant growth regulators should be avoided when these diseases are active

Biological Control

No products are commercially available to treat leaf spot at the current time.

Pesticide Control

- Fungicides that should be used to control this disease, based on the Risk Assessment, are iprodione, trifloxystrobin and vinclozolin.

Threshold

Suggested threshold is 10 percent coverage of affected area.

4.6.2. Take-All Patch

Causes and Symptoms

- almost exclusively a disease of bentgrass turf
- observed in annual bluegrass on rare occasions
- attacks roots and stems, no distinctive leaf spot or sheath lesions
- most common on newly constructed golf courses, particularly those carved out of woodlands
- tends to spread more rapidly and with greater severity in sandy soils
- may appear as early as the spring immediately following a fall seeding
- becomes most severe in the second year following seeding
- attacks roots during cool and wet periods
- symptoms most conspicuous from late April, throughout summer, and may recur in autumn
- bentgrass affected by take-all in the spring may recover by summer
- if irrigation is withheld, areas affected in the spring are the first to die from drought
- initially circular patches only a few inches in diameter and reddish-brown in color. patches may increase to 2 feet or more
- most patches range from 6 to 18 inches
- perimeter of the patch usually assumes a bronzed appearance
- turf eventually turns a bleached or tan color
- patches frequently appear reddish-brown in color and bronzing may be absent
- dead bentgrass in the center of the patch may be colonized by weeds if herbicide use is restricted
- turf in affected areas is easily detached
- over time pathogenic fungi naturally decline
- decline phenomenon may occur within 3 years
- may persist indefinitely where soils are alkaline or irrigation water has a high pH

Cultural Management

- acidification of soil with ammonium forms of nitrogen fertilizer
- as little as 3.0lb N/1000 ft^2 per year from either ammonium chloride or sulfate should be used as the exclusive N-source for at least 2 years
- should be applied with P and K in a 3:1:2 ratio, but amounts based on soil test results
- use of lime or topdressing soil with a pH above 6.0 should be avoided
- control thatch through core cultivation and/or verticutting.
- irrigation water should be analyzed for pH where take-all is a problem

Biological Control

No products are currently commercially available to treat take-all patch

Pesticide Control

Propiconazole should be used when necessary.

Threshold

Since infection does not readily appear as visible symptoms, the threshold level should be somewhat low, 2-3 spots per square yard on tees/greens and 5-6 spots per square yard on fairways.

4.6.3 Dollar Spot

Causes and Symptoms

- widespread and extremely destructive
- known to attack most turfgrass species
- symptoms vary with turfgrass species and cultural practices
- appears as small, circular, straw-colored spots
- coarser textured grasses and higher mowing practices, blighted areas are larger
- straw-colored patches 3 to 6 inches in diameter
- patches frequently coalesce and involve large areas of turf
- blades often die back from the tip
- bleached-white lesions that are shaped like an hourglass on grass blades
- hourglass banding often has narrow brown, purple, or black band
- white, cobwebby mycelium covers the diseased patches during early morning hours
- favored by warm and humid weather
- favored when night temperatures cool enough to permit early and heavy dew formation
- severity peaks in late spring to early summer and in late summer to early fall

Cultural Management

- on greens, remove dew and leaf surface exudates by poling, dragging, or whipping
- mow greens early in the morning to speed surface drying
- maintain a balanced N-P-K fertility program
- application of nitrogen (50% slow-release) would stimulate growth and mask disease
- any subsequent nitrogen applications should be in full slow-release form
- increase mowing height
- core cultivate to alleviate soil compaction
- control thatch
- avoid drought stress
- irrigate deeply during early morning hours

Biological Control

No proven controls of Dollar Spot are commercially available at this time.

Pesticide Control

Products that should be used, based on Risk Assessment results, are propiconazole and vinclozolin.

Threshold

Recommended thresholds are 3 spots per square yard for tees and greens and 9 spots per square yard on fairways when weather conditions are expected to remain humid and temperatures of 70 to 85°F.

4.7 Diseases Initiated During Summer That May Persist Into Autumn

Many of the diseases in this section are initiated in response to high temperature and humidity. Some are most severe during wet and overcast periods, while others are more damaging during periods of drought. A root pathogen may damage turf during cool and moist conditions, but symptoms may not develop until periods of heat or drought stress. Hence, in some regions take-all, necrotic ring spot, and injury induced by plant parasitic nematodes may be more apparent in summer despite the fact that most damage was inflicted to the root systems earlier in the year.

4.7.1 Pythium Blight

Causes and Symptoms

- most likely to attack creeping bentgrass, annual bluegrass or perennial ryegrass grown under intensive management
- develops rapidly during nighttime and is among the most destructive turfgrass diseases
- periods of high relative humidity, night temperatures above 70°F and abundant surface moisture, the disease progresses with remarkable speed
- huge areas of turf can be destroyed within 24 hours, particularly if there are thunder showers at night
- often first observed in areas that are shaded, low lying and adjacent to water where air circulation is poor.
- kills turf in circular patches, rings, or streaks that follow the water drainage pattern
- during morning hours turf displays an orange-bronze color
- there may be a gray smoke ring or grayish-white mycelium on the periphery
- in low areas patches are brown and all plants usually are killed
- infected perennial ryegrass develops an oily or dark-gray color
- leaf blades have a water-soaked appearance
- blades later collapse, mat together, and turn brown.
- cottony web of mycelium covers the grass leaves and is visible during early morning hours

Cultural Management

- irrigate early in the day to avoid moist foliage at nightfall
- improve water and air drainage
- avoid the use of lime in alkaline soils
- avoid the application of nitrogen fertilizers during summer stress periods
- fall fertilization program using a balanced N-P-K fertilizer
- cultural practices, however, would likely have only minimal beneficial effects on Pythium blight during high disease pressure periods
- severely damaged stands should be converted to less susceptible species by overseeding
- increase mowing height and water early enough in the day

Biological Control

Bio-Trek should be applied to the greens when soil temperatures are above 50 degrees. In accordance with label recommendations, a second application should be made to areas showing symptoms.

Pesticide Control

Risk Assessment results indicate that etridiazole, fosetyl-Al, mefenoxam and propamocarb can be used safely without use restrictions.

To avoid the buildup of fungicide-resistant biotypes, and the reduction of residual effectiveness of compounds due to microbial buildup, Pythium-targeted fungicides should always be rotated or applied in tank-mix combinations whenever economically feasible. Alternating sprays of systemics with contacts, although the latter may only provide 3 to 7 days of control, also helps to reduce these potential problems from reoccurring.

Thresholds

Upon first detection at areas most prone to Pythium development and when weather forecasts calls for high humidity (90% for 14 hours) and hot weather (days > 85 F, nights > 70 F)

4.7.2 Brown Patch

Causes and Symptoms

- symptoms of brown patch vary according to host species
- patches are roughly circular and range from 3 inches to 3 feet
- outer edge of the patch may develop a 1 to 2 inch smoke colored ring
- on high-cut turfs, smoke rings are usually not present
- blades have a blight or dieback from the tip
- lesions are a light, chocolate brown color, bordered by narrow, dark-brown bands
- perennial ryegrass, smaller leaf lesions, and tip dieback commonly occurs
- on bentgrass distinct lesions may not be evident because the leaf blades are too fine
- early morning hours, a cobweb-like mycelium can develop in sparse to huge amounts
- late in the season, distinctive circular patches may not appear
- environmental conditions favoring disease:
    - day temperatures above 85°F, high humidity
    - night temperature above 68°F
    - periods of leaf surface wetness exceeding 10 hours
    - extremely severe during prolonged, overcast wet periods in summer

Cultural Management

- avoid nitrogen when the disease is active
- use of nitrogen in the spring or summer is discouraged
- nitrogen, phosphorus and potassium should be used with nitrogen in a 3:1:2 ratio with amounts based on soil tests
- increasing mowing height
- irrigating between dawn and 8 AM
- fall application of nitrogen

Biological Control

Bio-Trek should be applied to the greens when soil temperatures are above 50 degrees. In accordance with label recommendations, a second application should be made. Spot treatments should be made to affected fairway and tee areas when symptoms first appear. Treat affected area and immediate surroundings.

Pesticide Control

Flutalonil, propiconazole, quintozene, triademefon, or vinclozolin can all be used to safely and effectively treat brown patch, based on the results of the Risk Assessment.

Thresholds

One spot per square yard on greens and tees and two spots per square yard on fairways and the 24-48 hour weather forecast indicates conditions are still favorable for disease development.

4.7.3 Summer Patch

Causes and Symptoms

- destructive disease of Kentucky bluegrass, creeping red fescue, and annual bluegrass
- initially appears as wilted, dark-green or pale areas
- areas rapidly turn into straw-brown, dead patches resembling dollar spot
- patches soon increase in size and may become crescent-shaped or remain circular
- healthy turf may persist in the center of patches
- producing rings or "frog-eye" symptoms
- large areas of turf can be destroyed within a 7 to 10 day period
- no distinctive leaf lesions
- leaves generally die back from the tip
- plants at the periphery of affected patches display a bronze or copper color
- generally appears in late June or early July, daytime air temperatures above 88°F
- most severe on sunny, exposed slopes or other heat-stressed areas
- most frequent during drought stress following wet weather in late spring
- may flair up following rainy periods in late summer and September
- soil needs to be moist and root zone temperatures need to exceed 78°F

Cultural Management

- increase cutting height to the maximum acceptable level
- preferably above 0.25 inch
- use slow-release acidifying nitrogen fertilizers
- acidification with ammonium-based N-sources reduces disease severity over time
- most fertilizer use should be confined to the autumn months
- core cultivate compacted soils

Biological Control

No commercially available products currently exist to treat summer patch.

Pesticide Control

Based on results of the Risk Assessment, propiconazole and quintozene can be used to treat Summer Patch.

Threshold

Treatment threshold should be approximately 10% coverage of area.

4.8 Various Other Diseases

The following diseases, which are much less likely to occur on the golf courses, should be treated when they exceed thresholds with products from the 2002 Cornell Recommends that satisfy the conditions of the Risk Assessment; Anthracnose, Necrotic Ringspot, Powdery Mildew, Red Thread, Rusts, and Smuts.

SECTION 5. POTENTIAL INSECTS AND INTEGRATED CONTROL STRATEGIES

5.1 Goal of Insect Management in Turf

Generally, the goal of insect management is to keep pest damage to an acceptable aesthetic or damage level while using monitoring and appropriate control methods. In order to achieve this goal, several important principles must be understood:

(1) **Pest Identification:** The turf habitat provides suitable living space for a multitude of animals. These animals can be beneficial or damaging. Turf managers must be able to identify each of these animals and determine if any control action is necessary. For example, March fly larvae feeding on dead turf killed by a disease may be mistaken for the cause of the dead turf. Obviously, disease management is needed, not insect control.

(2) **Pest Life Cycles:** Each insect found in turf has a unique life cycle. Turf managers must become familiar with theses life cycles, because certain stages of these life cycles are often resistant to controls. Other stages are quite vulnerable to control, and these should be the target of control actions.

(3) **Turf, a Unique Environment:** Turfgrass is a special environment with unique attributes. Thinking of turf as a regular field crop would result in pest management failures. Turf is a perennial plant cover with distinctive zones. Each zone is utilized by pest insects and mites. Pests in the upper, **foliar/stem zone** of turf are often conspicuous and fairly easy to control because of their exposure. Pests in the **stem/thatch zone** can evade detection for some time, until their damage begins to show as discolored foliage. Pests located in the **thatch/soil zone** also evade detection until their damage to turf roots results in significant turf loss. Pests located in the stem/thatch zone and thatch/soil zone are often the most difficult to manage with pesticide unless irrigation is available to wash the pesticides into the areas occupied by the pests.

(4) **Monitoring:** Pest monitoring is one of the most important principles in insect pest management. By using regular monitoring, the turf manager can detect new pests and determine when, or if, existing pests would reach damaging numbers. Monitoring is also used to determine if a pest is in a vulnerable stage of its life cycle.

(5) **Select Appropriate Controls:** Pesticides (chemical controls) are powerful pest management tools, but using pesticides as the only tool would eventually fail. ITM approaches insect pest control as a system of decisions and control tactics. In pest management, cultural and biological controls must be used to their fullest potential. This can help reduce the unwarranted usage of pesticides, preserve their usefulness, and develop a more diversified and resilient turf habitat.

5.2 Biological Control of Turf Insects

Biological control of turf insects may occur via bacteria, nematodes and/or fungi. Bacterial and nematode products are commercially available. However, their effectiveness in high quality turf, especially in the Northeast, is currently in doubt (Sann, 1994).

Bacteria

Some bacteria are effective against insects. Most of these bacteria work by producing spores and a kind of toxin that interferes with normal digestive processes. As a result, insects which feed on the bacteria usually stop feeding fairly soon after contact with the bacteria. Eventually the internal disruption kills the target insect. One species, *Bacillus thuringiensis,* (Bt) is active against several different kinds of insects. One strain is particularly effective against caterpillars, while another does well against beetles, and another kills mosquito larvae. Research in the private and public sectors is currently directed toward genetically engineering strains of bacteria that are quite specific in their activity. At this point there are several commercial formulations of Bt available for use in greenhouse and ornamental settings. Perhaps the most familiar formulation to turf managers is Dipel®, which is effective against caterpillars. Some turf managers have reported limited success with various formulations of Bt against cutworms and sod webworms.

Another species of bacterium, *Bacillus popilliae*, attacks the gut system of Japanese beetle grubs. This bacterium is very specific, showing virtually no activity against other species of grubs. Studies conducted in the Middle Atlantic states in the 1940s and 1950s seem to indicate that milky spore disease, caused by this bacterium, can suppress grub populations for several years, but efficacy in these studies has recently come to be questioned. At this time university researchers are not sure whether milky spore actually works under fine turf settings, especially in cooler climates in the Northeast. In any case, milky spore appears to be less effective in the Northeast than in the Middle Atlantic states, partly because summer soil temperatures normally do not stay warm enough long enough for the bacterium to develop from one generation to the next. When it does work, it often takes at least a year for the bacterium to become established in a grub population. As a result it should not be used to control a damaging high population in the short term, but it could have potential in lower priority turf areas, (e.g., roughs of golf courses) or areas where pesticide exposure is deemed unacceptable (e.g., playground).

One of the attractions of using bacteria is that they tend to be fairly specific and not particularly toxic to non-target insects, so they can be used safely in a variety of settings without interfering with the overall turf setting. In addition, they are much less toxic to people or pets than most traditional insecticides.

Nematodes

Nematodes come in different shapes and sizes. Specifically, there are some nematodes that feed on insects and can be quite effective in controlling pest populations. The nematodes which are being studied on turf pests actually carry bacteria within their bodies, seek out insects in the soil or thatch, penetrate those host insects, and release the bacteria inside the hosts. The bacteria break down the internal tissue, the nematodes feed on the resulting "mush", and both reproduce within the host so that the cycle can be repeated.

One species (*Steinernema carpocapsae*) looks very promising on cutworms, white grubs, and sod webworms on a small scale. It is currently being marketed under different trade names including BioSafe® , Scanmask ® and Exhibit®. This nematode is being formulated in such a way that it can survive being sprayed through a standard hydraulic sprayer. The key to achieving successful applications is to be sure soil moisture is adequate or perhaps slightly on the moist side, to apply in plenty of water, and to water in afterwards. In addition the nematodes are very sensitive to air and soil temperatures, so applications should not be made in the middle of the day. Considerable research is currently being conducted regarding application rates, watering techniques, formulations, and other questions. Studies are currently underway to determine whether these nematodes can survive New York winters.

Other species are being studied and show potential for control of white grubs. At this point, however, these species are more difficult to produce in the laboratory and on a commercial scale, so work is still in the development stage. Preliminary results are very encouraging, and private sector units are looking for ways to solve the production problem. Again these nematodes are very sensitive to soil moisture and temperature and post-application watering, so use on home lawns by commercial applicators may be limited. However, areas that have direct control over irrigation (golf courses, athletic fields) may consider nematodes as an alternative.

Fungi

Another kind of biological control agent that shows some potential in turf insect control is fungi. Again these fungi are very different from the plant-attacking fungi, and do not cause disease of any kind on the turf plant. Most insect-attacking fungi attack insects after they have been weakened by some other condition. *Beauveria bassiana* is one species of fungus that thrives and attacks many billbugs and chinchbugs. The effected insects have cottony growths coming our of their bodies.

Several private and public sector units are studying the use of fungi for insect control, and are attempting to identify and develop fungi that are even more aggressive and can be produced commercially. While none is available yet for use on turf insects, the future for fungi looks particularly promising, and there is a good chance that at least one fungus would be available commercially within the next five years. Research studies on the commercial production, cost and reliability of this type of biological control is just underway (Kenna and Snow, 2000).

This discussion of biological control of turf insects seems to be full of the word "potential" and short on the mention of currently available and effective alternatives. While some turf managers may feel that this has been the case for many years, the efforts being put into development of new strains or new organisms has increased tremendously over the past two or three years. The ultimate pay-off may still be a couple of years down the road, but it appears that the pay-off would be substantially better than that which was visualized just five or six years ago. Many companies are getting involved in one or more aspects of biological control. As new techniques and technology become available, the field would continue to expand so that eventually the turf manager would have effective and cost-effective alternatives available.

Biological Pesticides

The year 2001 was the first year in which the Cornell Recommends included what could be considered biological pesticides for control of turf insects on commercial turfgrass.

The first product, known commercially as spinosad, is available as a commercial formulation in the turf and ornamental insecticide known as Conserve®. Spinosad is an active, naturally occurring metabolite produced by the soil actinomycete bacteria *Saccharospolyspora spinosa.*

Spinosad is registered for use on turf by the USEPA and New York State. As stated previously, it is also recommended for use on commercial turfgrass by Cornell University. As such, it was included in the Pesticide and Fertilizer Risk Assessment presented in Appendix 11 of this DEIS. The product performed favorably in the risk assessment and is thus recommended in the following sections for use on black ataenius, billbugs, chinch bugs, and sod webworms.

The second biological insecticide in the 2001 Cornell Recommends was the product known commonly as cyfluthrin. Cyfluthrin belongs to a class of natural insecticides known as pyrethroids. Pyrethroids are those chemicals derived from the chrysanthemum plant that display insecticidal properties.

Like spinosad, cyfluthrin was included in the Fertilizer and Pesticide Risk Assessment. Based on the results of the Risk Assessment, cyfluthrin is NOT recommended for use on the proposed golf courses. The pyrethroids, as a group, and cyfluthrin in particular, are extremely toxic to aquatic organisms. With even a small amount of this "natural" product in runoff in the Risk Assessment there was enough threat to fish and aquatic invertebrates to not recommend it for use, especially since safer non-organic products were available to more safely treat target insect pests.

This case clearly illustrates that just because a product is organically derived, does not necessarily mean it is safer to the environment as opposed to a synthetic equivalent.

In 2002 the Cornell Recommends included three additional pyrethroid insecticides, bifenthrin, deltamethrin and lambda-cyhalothrin. Based on a the risk analysis of these three new products, bifenthrin and lambda chyhalothrin may be used on the golf courses, but deltamethrin is not recommended for use because of its runoff potential and high toxicity to aquatic life.

5.3 Leaf and Stem Infesting Insect Pests

This category includes those insects that feed on the upper leaves and stems of turfgrass plants. Many of these pests often hide in the thatch, others remain exposed on the leaf surfaces, and the rest hide in the spaces beneath leaf sheaths and between nodes. Those insects with chewing mouthparts eat entire leaves and stems. These are usually the larvae of various moths and butterflies. The rest of the pests have rasping or sucking mouthparts and include the mites, thrips, aphids, and mealybugs.

Leaf chewing pests leave behind ragged edges on the leaves, sunken spots in the turf and, in case of severe infestations, they eat all the green material down to the brown thatch. Pests with sucking mouthparts tend to discolor the turf, leaving it yellowed, rusted, or blanched white in color.

5.3.1 Cutworm

Hosts: All species of turfgrasses may be attacked.

Damage Symptoms:
- dig a burrow into the thatch/soil or use existing cracks and crevices or aeration holes
- emerge at night to clip off grass blades and shoots
- feeding damage often show up as circular spots of dead grass or depressed spots that resemble ball marks on golf greens.

Monitoring and Thresholds:
- use of a disclosing solution is beneficial in determining population pressure
- if a soap flush reveals 5 to 10 larvae per yd^2 on golf course fairways, remedial controls would be necessary

- only several cutworm spots on greens may require treatments, threshold of one per square meter

Control Options: Black cutworms are generally controlled by using one of the contact or stomach pesticides. However, if populations are high in surrounding areas, such as in field crops, continual reinfestations may occur. Because of this, contact with local cooperative extension services or pet management consultants may be beneficial.

Option 1: *Biological Control - Entomopathogenic Nematodes* - The insect parasitic nematodes are generally effective against the larvae of this pest. Products containing *Steinernema carpocapsae* (= Biosafe®, Biovector®, Exhibit®, Scanmask®) can be applied when the larval populations have been surveyed. Best efficacy is obtained by applying the nematodes in the late afternoon, just before sunset.

Option 2: *Cultural Control - Weed and Aeration Management* - Since this pest is attracted to various broadleaf weeds, reduction of these populations would reduce the attractiveness of the turf environment. Since the larvae have better survival in existing burrows, hold back aeration when significant activity is possible.

Adults may be included with clippings from greens. Clippings should not be disposed within 200 feet of any green.

Option 3: *Chemical Control* - Based on the Risk Assessment, control of cutworms should be done with spinosad, acephate, ethorprop, or lambda cyhalothrin.

5.3.2. Sod Webworms

Hosts: All species of turfgrasses are attacked.

Damage Symptoms:
- generally tunnels are constructed in the soil and thatch, and lined with silk.
- cut down individual blades of grass
- eventually gives a sparse and ragged appearance to the turf
- extensive infestations may lead to irregular brown patches of turf, especially in dry periods
- high populations can literally mow down turf
- birds are commonly seen feeding where sod webworm populations are high

Life Cycles: These pests have complete life cycles with eggs, larval, pupal, and adult stages. Species in northern areas have one to three generations per year.

Identification of Species: The adults are fairly easy to identify to species by using wing color patterns. The larvae are quite difficult to identify to species, and an expert should be consulted if larval identification is needed.

Monitoring and Thresholds:
- use soap disclosing solution over a square yard of turf and count the number of emerging larvae
- soap disclosing solution should use two gallons sprinkled over a one yd^2 area in order to force any caterpillars to the surface
- generally, 5 to 10 larvae per yd^2 may warrant control on fairways, 2-3 per square yard on tees/greens
- adults may be captured using an insect net or light trap

- visual inspection often reveals larger, sawdust-like fecal pellets (=frass) with silk webbing
- green frass indicates recent or current activity
- bird feeding may indicate sod webworms, but is not a confirmation of their presence

Control Options: Most sod webworms are easy to control, through they may be difficult to reach within their silken tunnels.

Option 1: *Cultural Control-Use Fertilizer and Water*-Damage can often be outgrown if water is continually available. Considerable damage may occur if irrigation is not possible during periods of drought, or close mowing is used.

Option 2: *Biological Controls*-Natural parasites are known, but ground beetles and rove beetles are major predators of eggs and smaller larvae. Fungal and viral diseases have also been identified, but these usually do not provide consistent control. The insect parasitic nematodes, *Steinernema* spp., seem to provide adequate control of this group when used at 1 x 10^9 juveniles per acre. Nematode efficacy can be improved by applying them in the early morning or late afternoon when sunlight is at a minimum, the thatch has been thoroughly moistened, and irrigation occurs immediately after application (before the spray droplets dry).

Option 3: *Cultural Control-Use Resistant Turfgrass Varieties*- resistance to crambids has been demonstrated in bluegrass cultivars. Perennial ryegrasses, tall fescues, and fine fescues with fungal endophytes are also highly resistant to sod webworm attacks.

Option 4: *Chemical Control-Use Contact and/or Stomach Pesticides*-Most webworms are easily controlled if the pesticides are ingested or penetration of the webbing tunnels is achieved. Since the larvae feed shortly after dark, best control is achieved by spraying in the late afternoon. Late fall or early spring applications are often not effective because many larvae are hiding in deeper soil chambers. Some species may require additional treatments to control second generation larvae produced by migrating adults.

Sod webworms can be controlled with spinosad, acephate, ethoprop, bendiocarb, lambda cyhalothrin or bifenthrin. Liquid applications that are not irrigated would perform better than granular applications.

5.4 Stem and Thatch Infesting Insect Pests

This complex and poorly defined area is composed of mainly grass stems and stolons, and organic material in various states of decay. Turf that is overwatered and fertilized may grow roots in this zone without having much contact with the soil. In this situation, true thatch/soil dwelling pests may invade this stem and thatch area. This zone provides high humidity, temperature mediation, and an abundant supply of living and dead organic matter for food.

Pests with sucking mouthparts seem to prefer this zone. They usually feed by removing plant fluids from the vascular system located in the stems, stolons, and lower leaf sheaths. Many of these sucking pests form salivary tubes or inject salivary materials that clog the vascular bundles. This results in discoloration, stunting, or death of the leaves or tip ends of stems. Of major concern is when these sucking pests attack the vegetative crowns of various grasses. When this happens, the entire plant may not survive. Sucking insects are often difficult to manage with traditional stomach insecticides. Since these pests do not chew and ingest plant matter, contact insecticides are more effective in management.

A few pesticides have systemic action, and these are often very good for management of this group.

Pests with chewing mouthparts may enter the stems, stolons, and crowns, and are called borers during this phase. Others simply feed externally on the living and dead organic matter.

Pests located in the stem and thatch zone may escape detection until considerable damage has been done. Turf managers must train themselves to thoroughly search this thick matted area, either visually or with other monitoring tools. Soap flushes and water flotation methods are often successful in disclosing pests located in this area.

5.4.1. Chinch Bug and Hairy Chinch Bug

Hosts: The hairy chinch bug prefers turfgrass species such as fine fescues, perennial ryegrasses, Kentucky bluegrass, and bentgrass. The common chinch bug prefers grain crops but would attack turfgrasses such as fescues, Kentucky bluegrass, and perennial ryegrass.

Damage Symptoms:

- irregular patches of turf begin to yellow, turn brown, and die
- patches continue to become larger in spite of watering
- damage generally occurs during hot, dry weather from June into September

Life Cycle and Habits:

- adults become active when the daytime temperatures reach 70°F
- egg laying usually occurs in May from New York to Illinois
- take about 20 to 30 days to hatch at temperatures below 70°F
- can hatch in as little as a week when above 80°F
- generally the first generation matures by mid-July
- at this time, considerable numbers of adults and larger nymphs can be seen walking about on sidewalks or crawling up the sides of light colored buildings.
- in hot dry spring turf injury by the first generation can be evident by June
- major damage is usually visible in July and August when the spring generation adults are feeding, and their second generation nymphs are becoming active

Monitoring and Thresholds

- simplest method is to visually inspect the turf by spreading the canopy
- nymphs tend to hide in the deeper thatch, and careful inspection is necessary
- one reliable method is to use the flotation technique, counting the number of adults and nymphs present over a 10 minute span
- populations of 25 to 30 per ft^2 warrant control, especially if these numbers are encountered in June and July
- More complicated sampling methods use repeated sampling over a long period of time, relating the population numbers to temperature and humidity parameters and predict future populations.

Control Options These two chinch bug types are some of the oldest known American insect pests. Because chinch bugs are major crop pests, a tremendous number of control strategies have been developed. Only those useful in turfgrass management have been selected. Chinch bugs are relatively easy to control when they are detected early.

Option 1: *Cultural Control-Watering the Turf*-Since this pest requires hot dry conditions for optimum survival and reproduction, irrigation during the spring and early summer may increase the incidence of natural pathogen spread, especially the lethal fungus, *Beauveria* spp. The adult chinch bugs can withstand water because of the protective hairs on the body, but the nymphs readily get wet and can drown.

Option 2: *Cultural Control-Use Resistant Turfgrasses*-The hairy chinch bug seems to prefer perennial ryegrasses and fine fescues, especially if these are in the sun and have greater than 0.5 inch of thatch. Bentgrass is also attacked. Bluegrass with 50% or more ryegrass and/or fine fescue are the most likely to be attacked. In field tests, Yorktown, Yorktown II, and Citation perennial ryegrasses are the most susceptible to chinch bug buildup, while Score, Pennfine, and Manhattan are avoided. Jamestown and Banner fine fescues are more commonly attacked than FL-1, Mom Frr 25, and Mom Frr 33. In general, perennial ryegrasses, fine fescues, and tall fescues with endophytes are highly resistant to this pest.

Option 3: *Cultural Control-Recovery From Damage*-Turf with light to moderate damage would recover rather quickly if lightly fertilized and watered regularly.

Option 4: *Biological Control*-Several researchers have been trying to develop a usable formulation of the *Beauveria* fungus, but at present no practical material is available. Several egg parasites and an adult parasite are known, but these do not seem to build up populations rapidly enough to control this pest. Currently, no work is being undertaken to augment these parasites. Several predators, especially the big-eyed bugs, *Geocoris* spp., are noted to kill large numbers of chinch bugs. Big-eyed bugs are often mistaken for chinch bugs because of their similarity in size and shape. Big-eyed bugs usually do not build up large populations until after considerable turf damage has occurred. Use of the insect parasitic nematodes *Steinernema* spp. and *Heterorhabtitis* spp. have given inconsistent results when used against these chinch bugs.

Option 5: *Chemical Control-Target Spraying*-Chinch bugs are rather easy to detect in turf, and targeted insecticide sprays can be applied to reduce populations which appear to be building to damaging levels. Based on the results of the risk assessment, acephate, ethoprop, bendiocarb or bifenthrin should be used to treat chinch bugs.

5.5 Thatch and Root Infesting Insect Pests

The insects that inhabit the thatch and soil zones can be some of the most devastating pests because they destroy turf roots, crowns, and underground rhizomes and stolons. These critical parts of the turf plant can tolerate light to moderate damage but when heavy damage occurs, the plant dies.

This group of pests is also the most difficult to control because of their isolation from control materials. Pesticides and biological controls have to travel through the turf canopy, then thatch which may be compacted and impervious to water, and finally the high organic matter in the upper inches of soil. Many pesticides tend to bind to the organic matter and surfaces of living plant tissues. Tiny biological controls such as entomopathogenic nematodes and bacteria are fractions of a millimeter long and quite susceptible to ultraviolet light radiation as well as immediate death from drying.

Management of thatch thickness and texture is important to managing pests that live in the thatch/soil zone. Turf managers should carefully review techniques of core aeration, top dressing, and verticutting, as well as turf cultivar selection and usage of fertilizers and irrigation.

White grubs are the most common and serious pests in this group in the northeast. White grubs can literally graze off all the roots, so that the turf lifts up like a loose carpet.

5.5.1 WHITE GRUBS

Hosts: All species of turfgrass may be infested.

Damage Symptoms:
- heavily infested turf first appears off-color gray-green, and wilts rapidly in the hot sun
- continued feeding would cause the turf to die in large irregular patches
- tunneling of the larvae causes the turf to feel spongy underfoot
- the turf can be rolled back like a loose carpet
- populations may not cause observable turf injury, but predatory mammals such as skunks, raccoons, opossums, and moles or birds may dig in search of a meal

Monitoring and Thresholds

Adult Sampling. Adult activity of May/June beetles, masked chafers, European chafers, Oriental beetles, and Asiatic garden beetles can be monitored using light traps. Useful predictive data can be obtained by monitoring beetle captures one to two times a week. Simply plot the number of beetles collected over the date sampled on graph paper. If the number of beetles collected drops for 7 to 10 days in a row, you can assume that the peak emergence and oviposition time has passed. Most species have eggs that hatch within 14 to 21 days, therefore, grub insecticides can be applied 3 to 4 weeks after the peak adult activity was noted, in order to target the young grubs feeding at the soil/thatch interface.

Grub Sampling. White grub populations should be assessed when the grubs become large enough to be easily seen (August for the annual grubs and early June for black turfgrass ataenius). Assess by taking square foot samples several places over the turf area. Populations of annual grub species that are less than six grubs per ft^2 can usually be masked by water and fertilizers. Populations between 10 and 15 per ft^2 can cause significant turf damage later in the fall, September and October. Of course, populations occasionally reach 40 to 60 grubs per ft^2 and these levels can cause damage by late August.

Sampling only in the most likely turfgrass habitats can usually reduce time spent doing grub sampling. Most of the annual white grubs seem to prefer grass in sunny areas. The night flying adults are often attracted to street lights and may lay large numbers of eggs under or near these lights. Black turfgrass ataenius adults prefer to lay their eggs in the compacted, moist, and decaying thatch. The green June beetle prefers sunny, thatchy turf or areas which have had manure applied as a fertilizer. Japanese beetle adults usually attack high quality turf near favorite food trees and shrubs.

Identification of Species: The adults are easily identified to genus but the grubs are the stage usually found in the turf. The grubs are identified by the form, shape, and arrangement of bristles (the raster) on the last abdominal segments. A 10X or 15X hand lens is usually adequate for identification and the common white grub groups can be identified using a raster pictorial key.

Control Options: White grubs seem to be periodic pests, attacking turf areas irregularly from year to year. The major factor influencing development of damaging numbers of grubs is soil moisture and rainfall. In general, in years with normal or above normal rainfall, grub populations increase. Well maintained turf next to ornamental plants favored by the adults seems to be more commonly attacked. However, masked and European chafer adults do not feed, and these pests build up in well watered and maintained turf. Black turfgrass ataenius and green June beetle adults seen to be highly attracted to turf with decaying thatch layers.

Option 1: *Cultural Control* - Host Plant Modifications - Certain species of scarab adults prefer specific host plants. Where Japanese beetles are common, do not plant roses, grapes, and lindens along high maintenance turf areas. May/June beetles prefer oaks, and the green June beetles feed on ripening fruit such as peaches. The fine and tall fescues are not as severely attacked as Kentucky bluegrass and perennial ryegrass.

Option 2: *Cultural Control - Water Management* - Practically all white grub species require moist soil for their eggs to hatch. The young larvae are also very susceptible to desiccation. In areas where turf can stand some moisture stress, do not water in July and early August when white grub eggs and young larvae are present. On the other hand, moderate grub infestations can be outgrown if adequate water and fertilizer is applied in August through September and again in May when the grubs are feeding.

Option 3: *Natural Controls* - Parasites - Several parasitic wasps and scolids attack white grubs and may effectively reduce populations in certain areas. Masked chafers and green June beetles are the species most commonly attacked. However, these parasitic wasps may take 2 to 3 years to build up effective populations, during which time turf damage may occur. Several parasites have been imported for control of the Japanese beetle, but most are poorly established and restricted to only a few states, not including New York State.

Option 4: *Biological Control - Parasitic Nematodes* - Insect parasitic nematodes in the genera *Steinernema* (=*Neoaplectana*) and *Heterorhabtitis* have been shown to be effective against white grubs. Field trails of *S. carpacapsae* strains have generally resulted in less than 50% control, though *H. heliothidis* strains have achieved 80% control or better. At present, available strains do not appear to be effective from one season to the next.

Option 5: *Chemical Control - Early Reactive Pesticide Applications* - Most of the modern soil insecticides have short active residual periods (three weeks or less) and must be used when the grubs are actively feeding. The exception to this is imidiacloprid, whose manufacturer claims season-long control. No registered insecticide is 100% effective; they usually kill 75% to 90% of the grubs present in any given area. This is why reapplications may be necessary when grub populations get very high. Timing of treatments is critical for success. Apply the pesticide early, when the grubs are small and actively feeding, yet late enough to catch all of the population. In general, reducing thatch and using good irrigation after making a pesticide application would increase control.

Option 6: *Chemical Control - Late Season Reactive Pesticide Applications* - Occasionally turfgrass damaging populations of white grubs may go undetected until September or October. By this time the annual white grubs are usually third instars and may be 70-80 times the body weight of a newly hatched grub. These mature grubs are voracious feeders, but are ready to dig down into the soil when cold weather arrives. Chemical control of these large grubs is difficult, at best. If a late season insecticide application is needed, ethoprop or bendiocarb may be used.

Option 7: *Chemical Control - Spring Pesticide Applications* - As with the late fall pesticide applications, spring treatments are often ineffective. Though the grubs feed during the spring, they are quite large and the span of time for treatment is short. It is anticipated that a spring application will not be made.

Maximizing Control of White Grubs with Insecticides

An appropriate registered pesticide should be selected according to the current needs and situation. If irrigation is available, liquid applications are very effective; granular insecticides are often more effective where irrigation is not possible. Do not wait more than 30 days to recheck the grub infestation, especially if the original population was high. If the grub population has not been reduced below six grubs per square foot, consider reapplication of another pesticide. To reiterate, the smaller the grubs the easier they are to kill with insecticides.

Recent studies have established that 95% to 99% of any pesticide used for grub control ends up in the thatch. Pre or post-irrigation does not seem to change this binding. If the thatch layer is one inch thick or more, the grubs probably would not contact challenging doses of the insecticides.

Several of the grub insecticides seem to be working less effectively in some geographic areas. Grub resistance was suspected, but the actual problem has been documented to be microbial degradation (enhanced degradation). Modern synthetic pesticides generally degrade rapidly. However, many are subject to additional degradation by bacteria and fungi that use the compounds as food sources. These microbes tend to build up if a pesticide is used continuously. To reduce the chances of creating enhanced microbial degradation problems, use a pesticide only once, when needed, and alternate pesticides.

Bendiocarb or ethoprop can be used for white grub control on the proposed golf courses, when necessary.

SECTION 6 POTENTIAL WEEDS AND INTEGRATED CONTROL STRATEGIES

6.1 Introduction

Much has been written about turfgrass weed control over the years. Early information emphasized cultural controls that combined best management practices and mechanical techniques to provide the desired species with a competitive advantage. As the chemical age developed, turfgrass weed control took on another dimension - the use of herbicides. Initially, chemicals used in turfgrass weed control were non-selective, mostly acidic compounds that did little to advance the state of the art of chemical weed control. However, after the introduction of 2,4-D in 1944, chemical control quickly became the dominating force in turfgrass weed control programs. Over the past 40 years, many herbicides have been commercialized for use in turfgrass. Chemical weed control utilizes materials that are used for preemergence, postemergence, or total vegetation control. There are contact, systemic, selective, nonselective, and various combinations of such chemicals available for use.

Alternatives to herbicides are not as prevalent as alternatives to insecticides and fungicides. Some fungi and bacteria have been investigated for their potential herbicidal effects on certain weeds. Limited success has been achieved. However, interest remains high and research programs continue to investigate the potential of various substances. Recently a substance identified in corn meal gluten has been showed to control some annual grasses when applied preemergent. However, the amount of nitrogen that accompanies the rate of application needed for commercially acceptable control may be considered excessive and lead to secondary problems such as increased disease severity. Researchers in turfgrass weed science would continue to develop weed control substances that can be alternatives to herbicides as we know them today.

In the final analysis, successful weed control programs begin with cultural practices that favor nature of the desired turfgrass species over all others. The existence of weeds indicates a lack of turfgrass health and vigor. Consequently, one or more cultural practices and/or environmental influences have reduced the competitiveness of the desired turfgrass. Certain weeds serve as excellent indicators of correctable conditions that have favored their development. Examples include:

- low pH - sheep sorrel
- compaction - goosegrass
- low nitrogen - clover
- poor soil - quackgrass
- poor drainage - sedges
- excess surface moisture - algae
- high pH - plantain

Once a weed has been accurately identified, the proper course of action is to determine why a void existed in the turf that allowed the weed to encroach in the first place. The causes for voids generally can be arranged into two groups. The first group can be considered natural causes such as environmental stress, disruptive use of the area (i.e. divots), animals, diseases, insects, etc. The second group could be considered as management causes for voids that include, improper mowing, improper fertilization, improper irrigation, lack of cultivation, drainage problems, lack of soil test information, etc.

Consequently, the steps for successful weed management are as follows:

1. identify weed
2. discern how introduced
3. impose cultural solution
4. use appropriate herbicide, if needed

For chemical control, weeds can be divided into four functional categories: annual grasses, broadleaf weeds, sedges, and perennial grasses.

A typical herbicide approach to annual grass (i.e. crabgrass) control is the use of preemergence herbicides. When preemergence control is not successful, postemergence controls can be used. Postemergence herbicides are generally not as consistent or effective as preemergence materials.

Although some annual broadleaf weeds (i.e. clover) can be controlled preemergence, broadleaf weeds are generally most often controlled postemergence. Postemergence control of broadleaf weeds can be accomplished selectively, but control of perennial grassy weeds cannot be accomplished as readily using herbicides. Selective control of perennial grasses is the result of spot treatment applications of nonselective herbicides. Selectivity is the result of application placement rather than chemical specificity.

6.2 Weed Management ITM

As with other pests, ITM for weeds is a viable management philosophy that has been practiced for years. Managing weed problems is, perhaps more complex than managing other pests that afflict turf in that the pest is also a plant rather than some other type of organism. Therefore, successful weed management requires skillful manipulation of plant competition through proper cultural practices in addition to exercising outstanding control of insect and disease pests. Lack of control of these pests often leads to turf losses that then result in weed encroachment.

It has been shown that weeds are good indicators of certain soil conditions and that some species often occur as a result of mismanagement of the turf. Such knowledge provides the basis of forming a scouting plan.

The first part of this plan should include an historical account of the property (including records of previous weed problems, cultural attempts to manage, herbicide use and success rate, and changes in species predominance). For new golf courses such as these, the historical record would be built during the grow-in phase. After the historical record is assembled and understood, the next step is to scout the golf course. This requires an appropriate transect accompanied with a detailed record of those weeds identified and their distribution and abundance. Scouting provides the information necessary to develop a customized and efficient weed management strategy. Particular attention should be given to those weed species that have escaped previous control efforts. Any unknown weeds should be sampled and identified by any and all appropriate measures available.

From a scouting perspective, in areas where control has been limited, a simple notation reflective of the fact that a number of broadleaf weeds are present is sufficient. In any event, the scouting report form that is developed should provide the opportunity to generalize, but also to allow for specific notation of troublesome weeds and those that require specific management actions. For example, the occurrence of several summer annual weeds can be reported as "summer annual weeds". However, a notation that goosegrass is the dominant species signals the important fact that the area is probably compacted. Therefore, core cultivation would undoubtedly improve turf competition and enhance the effectiveness of any herbicide that might be chosen as a chemical control strategy.

Scouting for weeds can be done in a number of ways. Walking or riding the golf courses in a zigzag fashion, stopping periodically to sample and identify weeds, would begin to build a plant inventory of the site. Once this inventory of weeds is assembled, underlying reasons for the particular array of weeds might be discerned. Such information should provide the basis for a management strategy that would maximize the completion of the desired turfgrass species and enhance the effectiveness and efficiency of any herbicide that might be chosen as a chemical control agent.

6.3 Individual Weeds and Their Control

6.3.1 Dandelion

Description

Dandelion has deeply lobed leaves arranged in a rosette. Lobes may be opposite or alternate and the tips may point away from or towards the apex. The large fleshy taproot contains vegetative buds mostly near the soil surface that can develop new plants. The flower is bright yellow turning to white and is wind disseminated.

Control Options

Strategy I, Cultural: Maintain dense turf through adequate nitrogen fertility and disease and insect control to reduce voids in the turf in the spring into which dandelion seed can be disseminated.

Strategy II, Cultural: When present in high value areas at low densities physically remove, being careful to include all reproductive vegetative plant parts. Care must be exercised when physically removing dandelions so a majority of the taproot is removed, at least two-thirds. If not, vegetative buds on the upper portion of the taproot would produce rosettes and two to three plants would grow where one was removed.

Strategy III, Chemical: Apply a selective postemergence broadleaf herbicide when dandelions are actively growing. Fall applications are most effective. Based on Risk Assessment results, products that can safely be used to control broadleaf weeds are 2,4-D, Dicamba, 2,4-DP, 2,4-DP MCPA, MCPP and triclopyr, generally in various combination products.

6.3.2 Plantain

Description

This perennial is a commonly occurring weed that has a broad tolerance to soil types. It grows in a rosette with large, broad leaves that have nearly parallel prominent veins. Leaves are often pointed parallel to the ground and the margins are often wavy. Seedstalks grow erect, with seeds forming along more than half the length. Common plantain is green with surface hairs on the leaves.

Common plantain persists in thin turf by competing for space with its large, broad prostate leaves that shade out tillers of new grass that emerge. Maintain turf density with good management or physically remove where practical.

Control Options

Strategy I, Cultural: Proper pH and fertility levels should be maintained. Common plantain can compete particularly well where pH is high (>8.0). Areas of lime spills or where irrigation water has a high pH may have more serious plantain encroachment problems. Acidify soil, 6.5 to 7.0, if soil testing so indicates.

Strategy II, Cultural: See Strategy II for dandelion.

Strategy III, Chemical: Apply a selective postemergence broadleaf herbicide in mid-spring or fall. Plantain resumes seasonal growth later in the spring than dandelion, and is often poorly controlled with herbicides when applied prior to dandelion bloom. See dandelion for products that could be safely used on the proposed golf courses.

6.3.3 White Clover

Description

This perennial stoloniferous legume has compound leaves, usually palmately divided into three leaflets. Flowers are white, globular, and appear from mid-May through September. White clover can flower and produce viable seed even at very low mowing heights of 1/4 inch. Low nitrogen nutrition and other causes of thin turf make it particularly susceptible to invasion by white clover.

Physical removal of white clover is not a good management strategy as stolons spread further than expected and portions can be left behind. Good liming and fertilization practices that maintain turf density are desired.

Control Options

Strategy I, Cultural: Nitrogen fertility is of greatest importance. When the nitrogen level for a particular turf species is not adequate, white clover or other low growing legumes commonly invade.

Strategy II, Cultural: Physical removal is recommended only under conditions of very close mowing of 1/4-1/3 inch where pluggers can be used effectively.

Strategy III, Chemical: Apply a selective postemergence broadleaf herbicide before clover begins to flower in combination with increased nitrogen fertility. Do not apply herbicides when clover is in flower or under moisture stress, as poor control would result. See dandelions for herbicides to use on the proposed golf courses.

6.3.4 Mouse-Ear Chickweed

Description

This low-growing perennial spreads by stolons and seed. Mouse-ear chickweed can adapt to mowing heights as low as 1/4 inch and even produce viable seed under such conditions. The leaves are opposite, oval, and quite hairy, resembling a mouse's ear. The stolons also are hairy with leaves attached directly. Flowers are small, 5-petaled, and white.

Although mouse-ear chickweed grows quite well in full sun, it also can compete in shaded sites. Use turfgrass species adapted to shade and improve soil drainage.

Control Options

Strategy I, Cultural: Decrease shade and improve drainage.

Strategy II, Cultural: See Strategy 2 for White Clover.

Strategy III, Chemical: See Strategy 3 for White Clover.

6.3.5 Crabgrasses and Other Summer Annual Grasses

Description

Smooth and large crabgrass are warm-season annuals reproducing by seed. They are light green and have a prostrate growth habit. Smooth crabgrass is smaller and less hairy than large crabgrass. Crabgrass leaf blades are short, pointed, hairy to sparsely hairy, and rolled in the bud. Seedhead consists of 3 to 9 spikes atop the main stem. Both species can root at culm nodes.

Crabgrass species are relatively easy to manage through sound cultural practices, use of leaf spot resistant species for cool season grasses, and the proper use of preemergence herbicides when needed.

Control Options

Cultural Strategy I: Avoid establishing turf at the time crabgrass normally is germinating (soil temperature near the surface of 55°F). Avoid verticutting or core cultivation at the time crabgrass is germinating or after application of a pre-emergence herbicide. Irrigate to avoid wilting of turf. Maintain turf density so that no bare areas greater than two inches by two inches will occur.

Cultural Strategy II: Raise mowing height slightly at the time crabgrass seed is germinating. Lower height of cut slightly and collect clippings during time that crabgrass seed is germinating or when crabgrass is setting seed.

Cultural Strategy III: Reduce available nitrogen when crabgrass is most competitive (warmest and most humid weather) via timing and low application rates of soluble nitrogen sources and/or proper selection of slow release nitrogen sources.

Chemical Strategy IV: Use a pre-emergence herbicide when soil temperature under turf areas has been 55°F for four to five consecutive days (at one-half inch soil depth). If seed germination has occurred, use a postemergence herbicide according to label and local recommendations or combinations of pre and post-emergence products. Products recommended for the proposed golf courses are benefin, bensulide, trifluralin, oxadiazon, siduron, dithopyr, or prodiamine preemergence, and fenoxaprop, MSMA or dithiopyr postemergence.

6.3.6 Annual Bluegrass

Description

Annual bluegrass is mostly bunch-type in growth habit, although the sub-species of a perennial type frequently has stolons. Stoloniferous plants usually are found in irrigated, closely mowed situations. Annual bluegrass is folded in the bud and can be distinguished from Kentucky bluegrass very readily by comparing ligules. Annual bluegrass has a very conspicuous, membranous ligule, while Kentucky bluegrass has a ligule that is a very short, blunt membrane. Annual bluegrass can be easily distinguished from creeping bentgrass because bentgrass is rolled in the bud and the veins on the blade are prominent. Most of the time, estimates of annual bluegrass are made in late spring when a majority of the plants have seedheads. Annual bluegrass can produce viable seed at all cutting heights, even as low as a golf course putting green.

Control Strategies

Annual bluegrass is most competitive under conditions of close mowing, frequent irrigation, moderate to heavy nitrogen fertilization during cool weather, and moderate soil compaction. Cultural practices employed to minimize conditions favoring annual bluegrass must be used in combination with herbicide and/or plant growth regulators.

Cultural Strategy I: Correct any drainage problems, raise height of cut when possible, even a millimeter can help, fertilize to favor desired turf species (for creeping bentgrass, nitrogen fertility should be applied during warmer months). If feasible, allow turf to wilt during periods of moisture stress. Annual bluegrass does not have a dormancy mechanism for drought, while other cool-season grasses may become dormant and would recover when irrigated. Annual bluegrass that is allowed to go to the permanent wilting point dies due to the inability to go dormant.

Chemical Strategy II: Ethofumesate on areas of ryegrass according to label instructions as a pre/post-emergence herbicidal control, based on the Risk Assessment.

Cultural Strategy III: Avoid turf cultivation during periods when soil temperature has consistently cooled causing annual bluegrass seed to germinate early fall. Maintain maximum shoot density during this time of the year, as annual bluegrass seedlings require space and light to become established.

Cultural Strategy IV: Use mowing equipment that causes the least amount of turf wear and soil compaction. Where feasible, collect clippings on tees and greens, especially during the peak seed production period of the year (late spring). Light verticut and collect clippings when seedheads are being produced.

Cultural Strategy V: Apply a preemergence herbicide prior to weed seed germination. Application of growth regulators labeled for conversion of turf from *Poa annua* to creeping bentgrass, ethofumesate may be made per label instructions. Successful conversion has been inconsistent and appears to be associated with the length of time that applications have been made. In locations where at least two applications are made for a period of four to five years, noticeable conversion has been observed.

6.3.8 Other Weed Species

The individual weeds discussed above are very common and have the highest potential to be problematic on the proposed golf courses. The 2002 Cornell Recommends lists a number of other weed species (predominantly other broadleaf weeds) some of which could reach levels that could warrant herbicide treatment. The Risk Assessment contained in Appendix 6 indicates that almost all of the species in the 2002 Cornell Recommends can be treated without risk to surface water or groundwater contamination, with the exception of pre-emergent control of knotweed with Pendemethalin. This is not problematic since broadleaves will not be treated pre-emergence on the proposed golf courses.

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