Turfgrass Management Plan for The Wellesley Country Club Using an Integrated Pest Management Approach

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PROJECT OVERVIEW

This Golf Course Turf Management Plan (IPM/TM) has been developed as part of an overall strategy for the operation of the Wellesley Country Club golf course. It addresses turf management strategies, and provides for uniform and controlled handling of turf management products. The IPM/TM for the Wellesley Country Club was first published in 2007 and this site-specific turf management program is based on the principles of Integrated Pest Management and follows the program originally developed by William A. Torello, PhD, retired Director of the Turfgrass Research Program, Department of Plant and Soil Sciences, University of Massachusetts at Amherst.

The concept of Integrated Pest Management/Turf Management (IPM/TM) has been developed over the past 25+ year period as a "systems" approach to turfgrass management with the prime objectives directed at reduction to acceptable limits or elimination of potentially adverse environmental effects. University turfgrass programs throughout the nation as well as the USDA and private industry have focused intensely upon the goal of reduced input. Research programs (long and short term) have yielded important data concerning water and soil management, fertility and nutrition of turfgrass, genetic improvement of turfgrass toward lower maintenance requirements and pest resistance. Further studies into the efficacy and fate of commonly utilized pesticides and fertilizers along with precise models to predict the timing and extent of pest problems and the development of biological controls for insect, disease and weed problems have also been extensively researched. Much effort has also gone into characterizing the turfgrass environment with regard to its very unique features compared to any other agricultural commodity. The concept of IPM is, very basically, to integrate all the above listed research knowledge into a "systems approach" to turfgrass management with the ultimate result of reducing all facets of input into the environment. IPM not only greatly reduces environmental impact it also is an extremely cost-effective approach for professional turf managers, which is an extremely attractive facet that course owners very much appreciate.

Critical components of IPM/TM include:

- turfgrass species and cultivars;
- soil management practices;
- clipping and cultivation practices;
- fertilizer/nutrient management;
- irrigation and drainage management;
- chemical, biological and cultural pest management;
- complete and accurate record keeping.

Conservation of soil, water, energy and other natural resources are also primary goals of IPM. IPM seeks to minimize the disadvantages associated with intensive nutrient, pesticide and water inputs and to maximize the advantages of their use. The development of site-specific IPM programs offers one of the few comprehensive solutions for systematic control of environmental problems related to management of ecosystems. Such integrated approaches offer options for selections of alternate control strategies and to maximize chemical efficiency. IPM does not preclude the use of pesticides and inorganic fertilizers when needed.

The basic components of IPM are:

- A system using multiple control methods, including biologic controls;
- A decision process based on intensive use of information;

- A risk reduction system;
- A cost effective and site-specific management strategy.

THE TURFGRASS ENVIRONMENT

♦ *Soils*

Soil composition is the starting point for an IPM program. Properly structured soil supports healthy turf that can crowd out undesired weeds during grow-in and fend off pest attacks with minimal chemical intervention. Soil composition also greatly influences the risks of ground water contamination from the transport of nutrients and/or pesticides. Soils are comprised of a wide variety of mineral and organic complexes. Organics are derived from decomposition of plant and animal matter are generally classified as humic and fulvic acids, and humin, based on their water solubility in terms of pH.

Both the organic matter and mineral complexes in soils function in cation exchange (CEO), pH buffering, and water retention. Though the organic component seldom is greater than 6% by dry weight of the soil, it contributes the most to each of these functions. A typical mineral fraction will have a CEC of 0.05 to 0.3 $cmol_c/kg$ whereas the organic component will range from 1 to 2 $cmol_c/kg$, depending on the pH buffering. These and other characteristics contribute to the benefits of organic matter in soils by providing slow-release sources of N, P, and K useful to plants and organisms, as well as buffering soil pH. Microbial activity and heat retention are improved with increasing levels of organic matter compounds. These benefits combine to create healthy root development through improved nutrient availability.

The nutrient status of turfgrass can be determined by a combination of several components, such as soil or tissue testing, on a continual monitoring basis. In addition, it can also include analysis of visual symptoms on an individual leaf, a single plant or across a landscape. In addition, the turfgrass manager's experience and knowledge of the turf's nutritional needs under the specific climate, soil, use patterns and budget can also play a part in the analysis.

Soils at the Wellesley Country Club site consist primarily of sandy loams (Hinckley, Merrimac, Scio, and Sudbury) with Hinckley sandy loams dominating (approximately 49% of the total property). Other sandy loams and loamy sands account for another 33% of the land area. Developed portions of the club account for about 9% of the land area. Finally, silty and mucky soils and water account for approximately 9% of the land area. Therefore, most of the area used by the golf course consists of moderately to well-drained soils.

♦ *Turfgrass Varieties*

Greens, tees, and fairways are planted with grasses that meet the requirements of the game and that also lend themselves to being managed in an environmentally sensitive manner. These playing surfaces require a high level of maintenance because of the need for the turfgrass to resist and recover from damage incurred during play and from close and frequent mowing. It is important to establish appropriate turfgrass for each playing surface (greens, tees, fairways, roughs).

The following criteria are used to determine appropriate turfgrass species for use on a course:
- Climatological and soil conditions of the site;
- Desirability for golf in the playing & environmental setting;
- Drought tolerance;

- Resistance to disease and insects;
- Resistance to annual grasses and weeds;
- Establishment in sunny and shady environments;
- Winter recovery and tolerance to snowmold conditions;
- Compatibility with other grasses including forbs and sedges;
- Irrigation water quality;
- Availability of seed that is clean of harmful pests and grown in accordance with good turf growing practices.

At the Wellesley Country Club the greens are a mixture of bentgrasses (*Agrostis sp.*) and *Poa* (meadow bluegrass or low-gro bluegrass), as are the tees. The fairways are primarily fescue (*Festuca spp.*) with bentgrass, poa and some other bluegrasses in places. The primary roughs have a composition similar to the fairways. This blend of bluegrass and fine-leafed fescues is suitable for loamy sands as well as till soils. During summer drought, the fine-leafed fescues, even in dormancy, provide an excellent lie for golf balls. Both chewings fescue and red fescue perform under droughty conditions with minimal nitrogen fertilization levels.

FERTILITY

The fertility program has been devised and maintained to use minimally acceptable application rates according to the following criteria:

- Determination and selection of realistic goals for turfgrass quality at all locations such as tees, fairways, greens and rough areas. The objective is to use fertility rates recommended by research programs so that fertilizer input is reduced. Tees and greens receive higher maintenance levels and require higher rates of fertility, while fairways fertilizer input is reduced and rough areas are left to natural nutrient turnover wherever possible.
- Utilize organic or slow-release forms of nitrogen on all locations to the greatest extent possible. Current practices at the Wellesley Country Club include fertilizing with a combination of liquid and granular fertilizers on an as-needed basis based on tissue testing. In 2019 fertilizers included "Sea Blend" (a granular fertilizer derived from sea kelp) and a combination of urea-based and ammonia-based liquid fertilizers. Fairways are predominantly fertilized with natural or synthetic forms of nitrogen while tees and greens include at least 25% of their total nitrogen as a slow release form. In June and September organic fertilizers are used and in July and August liquid fertilizers are used. In May synthetic fertilizers are used after aeration. Liquid fertilizers are used sparingly (less than $1/10^{th}$ pound liquid nitrogen per week). Natural organics radically reduce or even eliminate the leaching of nitrate while at the same time dramatically stimulating soil microbial populations and activities, which enhance pesticide immobility and degradation. Greens comprised of 70-80% sand need to be fertilized (particularly with nitrogen) very frequently - usually at a rate of 1/4 to 1/2 pound of nitrogen per 1000 sq. ft. every six weeks. At the Wellesley Country Club there are six "USGA type" greens (the 2 putting greens and the greens at the 6th, 7th, 10th, and 12th golf holes) which are approximately 80% sand. The remaining greens are "push-up" greens which are made from the native sandy-loam soils (approximately 60% soil and 40% sand to 50% soil and 50% sand).
- The Wellesley Country Club had begun to use potassium applications in June, August, September, and October to help with drought tolerance, wear stress, and winter hardiness of the turf. This also appears to have helped reduced nitrogen inputs.
- The Wellesley Country Club has also been using gypsum to neutralize sodium in the soil which makes calcium more bioavailable.

Timing fertilizer application to coincide with the period of active plant growth and nutrient uptake optimizes nitrate absorption and reduces the amount of soluble nitrogen available for leaching. Slow release fertilizers that do not release excessive nitrogen during heavy rain are applied during the wet months. Studies show that when evapo-transpiration is closely matched by irrigation during seasonably wet months and periods of active plant growth, water soluble nitrogen can be applied at rates of up to 1 pound of nitrogen per 1000 sq. ft. per month without any significant accumulation or leaching. Application rates at the Wellesley Country Club are far below that level.

INTEGRATED PEST MANAGEMENT

There are several aspects to developing a site-specific Integrated Pest Management (IPM) Plan. In the case of an existing course several things can be incorporated into the golf course design that can optimize turf vigor and/or minimize pest activity (e.g., adequate irrigation and drainage, well adapted species and varieties, air movement). In addition, the course design can reduce the reliance on pesticides by using native plants and selecting ornamental trees and shrubs carefully to minimize pest activity. All of these structural strategies are part of an IPM program, optimizing the adaptation of the turf plant and enabling it to withstand some pest pressure without exceeding tolerance levels.

The Golf Course Superintendents Association of America (GCSAA) wholeheartedly endorses environmental stewardship and collaborated with several other organizations (including the U.S Environmental Protection Agency, National Coalition Against the Misuse of Pesticides, and The Sierra Club) to develop a set of Environmental Principles for Golf Courses in the United States. The primary precepts of these principles are:

- to enhance local communities ecologically and economically;
- to develop environmentally responsible golf courses that are economically viable;
- to recognize that every golf course must be developed and managed with consideration for the unique conditions of the ecosystem of which it is a part;
- to use natural resources efficiently;
- to respect adjacent land use when planning, constructing, maintaining, and operating golf courses;
- to create desirable playing conditions through practices that preserve environmental quality;
- to educate golfers and potential developers about the principles of environmental responsibility;
- to promote the understanding that environmentally sound golf courses are quality golf courses.

Most of these precepts are directly or indirectly related to IPM and stress the importance of environmental stewardship. The specifics of IPM related to pest management include: scouting/monitoring pest activity and turf health, setting tolerance levels (thresholds), selecting and implementing appropriate management strategies, and evaluating the results.

♦ *Scouting and Monitoring*

For each potential turf pest, a golf course superintendent must develop techniques to look for the pest and to measure the pest population. Scouting is conducted at the course on a daily basis. For insects, this is relatively easy. Most insect activity can be monitored by simply looking at the

turf (and seeing insects moving), collecting soil samples, or applying a soapy flush to drive insects to the surface. Similarly, weed activity is relatively straightforward. Once a seed has germinated and the plant has emerged above ground, standard botanical guides can be used to identify the weed, and transect lines can be used to quantify weed populations. Identification and quantification of turf diseases, however, is much more difficult because several causal agents can produce very similar symptoms. It is imperative that the golf course superintendent has a good working relationship with a reputable disease diagnostics laboratory - one that has a rapid turn-around for processing samples. The Wellesley Country Club does tissue testing on its greens every six weeks and takes soil plugs on an as-needed basis to help correctly identify diseases. These tissue samples and soil plugs are sent to outside diagnostic laboratory for inspection by plant pathologists. In addition, the Wellesley Country Club joined the UMass Dollar Spot (fungus) resistance assay as a test site for fungicide resistance (testing efficacy of treatments) in 2011.

Monitoring also includes observations of general turf vigor and can identify areas that have an agronomic imbalance of some sort - e.g., a localized dry spot, impenetrable thatch, poor drainage or a leaky irrigation head, uneven application of fertilizer, compaction from repeated traffic, or wear spots from repeated mowing patterns. Each of these situations can weaken turf so that it becomes less able to tolerate a pest infestation.

- ***Setting Tolerance Levels***

One of the most challenging aspects of an IPM program is setting quantifiable numbers for tolerance levels or action thresholds. These thresholds are discussed in more detail later in this document. While the act of scouting and confirming the presence of a pest is fairly straightforward, determining how many is too many is much more complicated. In general, turfgrass can handle one or two stresses but cannot handle several stresses simultaneously. If there are agronomic imbalances, the turf is less likely to be able to tolerate insect or weed or disease activity. In addition the turf use (green vs. tee vs. fairway vs. rough) has a direct bearing on the tolerance level. Normally tolerance levels will be lowest on greens and highest on roughs.

- ***Selecting Management Strategies***

If scouting documents the presence, or the inevitable development of an unacceptably high population of pests, the superintendent then must decide whether to manage the pest. Many factors will be considered, including the time of year (and ability of the turf to recover from pest activity), tournament schedules, and golfer/traffic demands. In an IPM program, every effort is made to reduce agronomic stresses, thereby enabling turf to survive some pest activity. However, even in the best-maintained golf course environments, pest activity may build to a level that requires some pest-specific action. Normally in an IPM program the order in which management strategies are considered is cultural, then biological, then chemical.

- ***Cultural Practices Designed to Reduce Pesticide/Nutrient Input***

Aeration: Compaction of the underlying soil on golf courses is a major problem, particularly on courses receiving many rounds of golf per day/week/month/year. A compacted soil will promote disease, insect and weed problems and necessitate the overuse of chemical controls as well as increasing fertilizer demands. Compaction also promotes surface run-off of irrigation/rainfall leading to movement of applied chemicals. A program of "aeration" and "topdressing" has been developed according to the soil types and level of play (number of golf rounds) calculated.

At the Wellesley Country Club aeration occurs six times per year on greens (2 cores and 4 "dry-jet"). Core-aeration consist of using equipment which pulls up a plug of soil which washes back into the resulting holes (in the fairways) or which is raked and augmented with sand (top dressed) on the greens and tees. Dry-Jet is an outside service that uses high pressure water to create vertical channels that are then filled with sand. Greens are usually core-aerated during the first week of April, and in late August. Dry-jetting usually occurs in April and August, October and mid-November. Tees are aerated in April, and September. Fairways are aerated in the spring and at the end of September. Since golf greens receive a more "focused" amount of compaction, additional solid tine (5" length) aeration occurs during June, July, and August and 12" tine aeration occurs during the spring and winter. On the tees and aprons (short grass areas around the greens) tine aeration is usually done in November. This progressive program of aeration and topdressing significantly reduces the usage of pesticides in general.

Mowing: A general rule of thumb with regard to turfgrass culture is that the higher the mowing height, the more extensive the root system and the "healthier" the turf will be, particularly with regard to inherent disease/insect resistance. Mowing heights will be maintained at the highest level possible while still maintaining modern golf turf quality demands. Not only will turf be more resistant to pests, but higher mowing heights will result in much less weed infestation due to "shading" of the soil surface and competition for mineral nutrients and water. Mowing equipment is kept in "top notch" condition so that grasses are not scalped or cut poorly which would increase the possibility of disease occurrence.

Irrigation: Appropriate irrigation is considered critical not only to maintaining a proper IPM program but also for economic considerations. The length of time (and hence the amount of water) it takes to adequately water particular areas (i.e. fairways, greens, roughs) is determined by the time it takes to wet the turf to the depth of its root system. Most turfgrass roots extend to four to six inches into the soil. Infrequent and deep watering are preferred to shallow and more frequent events to avoid over usage of water as well as to limit the amount of moisture on surface foliage to inhibit disease infestation. Deep watering also promotes deep rooting. Greens areas will unavoidably be irrigated more since they are mown much lower than fairways and, therefore, will have shallower roots. Proper irrigation is, as mentioned earlier, critical to maintain high quality turfs as well as reduce pest infestations, which will reduce pesticide and fertilizer usage.

At the Wellesley Country Club moisture meters (Spectrum Technologies) are used on a daily basis to measure moisture content throughout the course. There is a weather station at the course and total control over all parts of the irrigation system. The course has a "state-of-the-art" irrigation system which provides adequate irrigation to all areas of the golf course without significant overlapping. There is control of each individual sprinkler head and the heads are set for "head-to-head" coverage. The heads are set on computerized timers and are designed to provide optimum irrigation without excess water waste. In addition, irrigation equipment is kept in proper repair, providing all areas of turf with adequate coverage.

De-thatching: Thatch is a layer of dead turf material (primarily stem tissues) found at the surface of the soil and can build-up to unacceptable levels if not removed. A deep layer of thatch tends to intercept irrigation water keeping disease susceptible crowns of grasses too wet and impeding flow of water to the root zone. A thick layer of thatch will also tie up insecticides and other pesticides at the surface not allowing for control of root-feeding insects or root diseases. Conversely, a minimal level of thatch is necessary for organic matter deposition as well as promoting the proper "cushioning" necessary for fine turfs. All tees and fairways are de-thatched five times a year. Greens are dethatched four times a year.

Tree Pruning and Removal: On parkland style courses like the Wellesley Country Club trees play an important role in helping to define golf holes and hazards, and by providing a natural visual context. Trees also provide important habitat for various avian and mammal species. Trees growing adjacent to turf can also negatively affect wind movement and available sunlight to the turf. When trees impinge upon the turf areas disease (such as fungal outbreaks) become more common and require remediation to return the turf to a healthy condition. Therefore, as part of the IPM/TM program tree growth is monitored and where necessary trees are either pruned or removed to increase airflow and sunlight to the turf resulting in a healthier turf that requires less chemical input.

- ***Chemical Practices Designed to Reduce Pesticide/Nutrient Inputs***

Fertilization: A lack of soil nutrient levels promotes weed infestation as well as reduces overall vigor resulting in increased pesticide usage. All greens are tested twice a year before aeration for soil pH levels and cation exchange. In addition tissue samples from the turf are also tested every six weeks. All tees and fairways are tested on a three year rotating basis or more frequently if conditions warrant. Fertilization practices are modified to optimum levels according to soil tests. Slow release and organic fertilizer materials are used extensively throughout the course. The use of these materials results in much more efficient use of applied nutrients and also greatly reduces the leaching and runoff losses of nitrogen. Slow release and organic sources of nitrogen also encourage a steady and controlled growth habit as well as reduce the extent of disease infestation, which results in much lower usage of pesticides. Use of organic fertilizers also greatly encourages soil microbial activity, which enhances production of beneficial organic matter/soil nutrients as well as promoting the breakdown of residual pesticides.

Pesticides: If a pest population exceeds tolerance levels and no reliable cultural control strategies are available, a pesticide may be necessary to suppress the pest. In an IPM program, it is understood that applications are made only to areas that have populations that exceed the tolerance level, or can reasonably be expected (based on observations in previous years, current populations, and expected weather patterns) to exceed that level. Pesticides are selected to minimize impact to non-target organisms (e.g., predatory insects, earthworms) whenever possible.

- ***Record Keeping & Evaluating Results***

Until recently, documentation of IPM-related activities proved to be difficult, but in the past few years several handbooks and recording forms have been developed. These forms provide a means by which a superintendent can scout the property and file the results of the scouting information in a filing system easily reviewed. State and federal regulations mandate that records of pesticide applications be kept and filed for review. A similar filing system can be developed to track the application of cultural techniques. A detailed record keeping system is in place at the Wellesley Country Club. This system enables the superintendent to review efforts from previous years and determine which techniques were most effective.

WEED CONTROL

In an IPM program, the turf management staff should try to identify the underlying conditions that predispose areas to weed infestation and address those causes. However, some weed activity will always be present on a golf course.

- ***Monitoring Weed Populations***

While it is easy to notice the presence of weeds on a finely maintained turf such as a golf course, it is not so easy to quantify the number of weeds present or the annual recurrence of weed populations. At the Wellesley Country Club a log of areas prone to outbreak, and the specific type of outbreak, are kept on an annual basis. These logs help the superintendent develop a program to address areas experiencing repeated outbreaks and help to determine the efficacy of treatment methods.

- ***Cultural Strategies***

Many weeds serve as indicators of agronomic imbalances. Any cultural activity which encourages vigorous turf should ultimately make weed survival more difficult. Mowing heights typical of golf courses put some weeds at a competitive disadvantage, and providing adequate fertilizer usually makes it more difficult for some weeds to compete.

- ***Chemical Strategies***

Several herbicides are labeled for use against turf weeds, with a variety of characteristics. Some are specific against grassy weeds, others are specific against broadleaf weeds, and a few are effective against both kinds of weeds. There are many different chemical classes, and a range of environmental characteristics.

Pre-emergence Weed Control: These chemicals provide effective control of crabgrass and other annual grass weeds for several weeks or months, depending upon dosage and products. The effectiveness of these materials is based upon their ability to provide control without turf injury. The best approach is application before annual seeds germinate and, as such, timing is important. These herbicides are applied at least two weeks prior to expected weed seed germination – usually late April to early May. These chemicals need to be watered-in immediately after application. Only one or two of these compounds would be used once or twice yearly. The primary products that will be considered for use are:

- Siduron (Tupersan)
- Dithiopyr (Dimension IEC)

At the Wellesley Country Club areas affected by crabgrass and annual weeds are mapped throughout the year and then the following year the trouble spots are treated with a pre-emergent herbicide as appropriate.

Post-emergence Weed Control: These chemicals control emerged grassy weeds and broadleaf weeds. These herbicides are applied after weed seeds germinate and are the most utilized materials for weed control. As such, there are many products available for use which have similar efficacy. Selection of materials is primarily up to the experience and judgment of the superintendent who bases the decisions on efficacy, economics and environmental impact. The primary products that will be considered for use are:

- 2, 4D (Millennium, Banvel, 4 Speed)
- Quinchlorac (Drive)

- Sethoxydin
- Imazosulfuron (Celero)
- Fenoxaprop-p-methyl, Fluroxpyr MHE, Dicamba (Last Call)
- Carfentrazone (Quicksilver)
- Dimethylamine (Diablo)

♦ ***Actions by the Grounds Staff***

The Wellesley Country Club staff has developed a management plan that concentrates on key pests (crabgrass, annual bluegrass, and various broad-leafed weeds) and identifies some of the underlying conditions that could predispose the area to weed encroachment. They:

- monitor weed activity daily on greens and tees when weeds are most likely to occur, and as needed on fairways and roughs;
- quantify weed activity on greens and tees at least once a year, using random area search or transect lines;
- developed a record keeping system so scouting records can be traced from year to year;
- set and refine action thresholds regularly.

PLANT GROWTH REGULATORS

Turf Management occasionally calls for the regulation of the growth of grasses. Research ahs shown that growth regulators compact turf growth and increase the density of a turfgrass stand. Growth regulators are also used to balance the mowing frequencies of adjacent turfgrass areas that normally would have significantly different height regimes, watering regimes, and mowing frequencies.

♦ ***Chemical Strategies***

Several growth regulators may be used at the Wellesley Country Club. These include:

- Ethephon (Proxy)
- Fluprimidol (Cutless, Legacy)
- Trixapac-ethyl (Primo)
- Prohexadione calcium (Anew)

Other products that may be developed in the future which have similar properties will be considered for use on the course.

INSECT PEST CONTROL

There are relatively few species of insects that pose problems on golf courses, but those insects are fully capable of destroying substantial areas of turfgrass if left unmanaged. In general we expect the golf course to experience relatively minor outbreaks but management and staff must be prepared to respond to pest populations as they develop.

The only insect pests known to be serious problems on golf courses are white grubs, sod webworms and cutworms, hyperodes weevils, and bluegrass billbugs. Biological control strategies are an important part of IPM and greatly complement chemical control.

- ***Monitoring Insect Populations***

White grubs can be monitored by taking a series of soil samples with a cup cutter. A core of turf is removed to a depth of about 4 inches, and the entire core placed on a small piece of plywood or cardboard. Any grubs that are present will be very apparent. Each sample is 0.1 sq. ft., so determining the number of grubs per square foot is very straightforward.

Black turfgrass ataenius larvae (grubs) can be sampled in the same manner. Cup cutter cores are taken from areas where activity is suspected. Adults can be forced to the surface by an irritating drench (such as lemon-scented liquid dish detergent in water). Adults also can be seen walking on the surface of greens and fairways and may be observed in baskets of greens mowers.

Annual bluegrass weevil larvae can be sampled using a cup cutter or by cutting a triangular wedge in the turf. Larvae (and pupae) will be visible near the crowns of the plants and in the thatch. Adults can be forced to the surface by an irritating drench (lemon-scented liquid dish detergent in water), and often are observed in baskets of greens mowers, especially in late June and early July.

Cutworms and webworms can be sampled by using an irritating drench. Smaller stages (less than 0.25 inch) may not reach the surface, but larger stages will wriggle to the surface quickly. Adult moths are attracted to blacklight traps.

Turfgrass ants are most easily quantified by counting the number of visible mounds in a known area. This can be accomplished by marking out (or visualizing) a series of squares ten feet on a side or by constructing a square frame, two or three feet on a side, and randomly tossing the frame onto the area to be surveyed. The number of mounds are counted and recorded from several such samples to estimate an overall activity level.

Monitoring should be scheduled to coincide with insect development. Grub populations can be mapped in April and May, and distribution maps subsequently used to predict "hot spots" in August. Annual bluegrass weevil adults can be seen in spring and summer (on warm sunny days), while larvae may be present from mid May through late August. Peak larval activity usually will be in late June and again in early August. Black turfgrass ataenius larvae usually occur from early June through mid August, with peak populations in late June and again in early August. Black cutworms and webworms can damage turf from mid May through mid September, and will be present in all stages (small, medium, and large caterpillars) throughout the growing season. Turfgrass ants are active from early May through late summer, with greatest activity in July and August.

- ***Setting Thresholds***

As with any pest, action thresholds or tolerance levels will depend on many external factors, many of which relate to turfgrass vigor (e.g., availability of water, drainage, local weather conditions (heat stress), mowing height, compaction, and recuperative potential of the turfgrass). Thresholds must be site-specific and often vary from one part of a golf course to another or within a growing season. The following table presents some general guidelines for action thresholds that can be used as starting points for determining threshold populations for pest insects. Thresholds should be refined each year, incorporating observations of pest activity and response to weather conditions in previous years.

Table 1: Common Turfgrass Insect Pests

Common Name	Turf Area Affected	Suggested Threshold (per sq.ft. unless otherwise noted)
Annual bluegrass weevil	Greens, Tees, Collars	10 to 20 larvae/adults (spring) 10 to 20 larvae/adults (summer)
	Fairways	10 to 20 larvae/adults (spring) 10 to 20 larvae/adults (summer)
Black cutworm	Greens and Tees	5 to 10 pockmarks per green/tee
Bluegrass billbug	Fairways Roughs	10 to 15 larvae 15 to 20 larvae
Hairy chinch bug	Roughs (irrigated) Roughs (un-irrigated)	30 nymphs 15 to 40 nymphs
Turfgrass ant	Fairways Greens/Tees	0.5 to 1 mounds 0.1 to 0.2 mounds
Webworms	Greens/Tees Fairways	15 to 30 grubs 30 to 60 grubs
Black turfgrass ataenius	Greens, Tees, Collars Fairways	15 to 30 grubs 30 to 60 grubs
European chafer	Fairways Roughs (irrigated) Roughs (un-irrigated)	4 to 8 grubs 5 to 10 grubs 4 to 8 grubs
Japanese beetle	Fairways Roughs (irrigated) Roughs (un-irrigated)	6 to 12 grubs 8 to 15 grubs 4 to 8 grubs
Oriental beetle	Fairways Roughs (irrigated) Roughs (un-irrigated)	6 to 12 grubs 8 to 15 grubs 4 to 8 grubs

- ***Cultural Strategies***

Most insects that are pests on golf courses in Eastern Massachusetts have a wide range of conditions in which they can thrive, so very few cultural strategies will reduce populations. General good agronomic practices will enhance turf vigor and enable it to tolerate more insect damage than stressed turf, but there are few specific, cultural techniques that will reduce insect populations directly.

Turfgrass Species and Cultivars: The annual bluegrass weevil strongly prefers to feed on annual bluegrass, so the establishment of the golf course becomes critically important. All possible steps should be taken to ensure that the golf course has minimal annual bluegrass - e.g., use of plant growth regulators as needed after establishment to reduce annual bluegrass incidence. Cultivars of fine fescues and perennial ryegrasses that contain endophytes will reduce sod webworm, chinch bug, and billbug survival, but have little effect on cutworms and white grubs.

- ***Biological Control***

There are several biological control agents and "biopesticides" available on the market but few of them perform reliably enough to be used with confidence on golf courses in Massachusetts. Some of the options that are available commercially or are under development include:

- Milky Spore: A natural bacteria that causes a disease of the digestive system of Japanese beetle grubs. It is non-toxic to humans and other non-target organisms.
- Bacillus Thuringiensis (BT): A bacteria that causes disease in several kinds of insects. Recently several new strains of BT have been identified which are quite specific in the kinds of insects they attack. The strains that are available are effective to varying degrees on cutworms and sod webworms.
- Entomopathogenic Nematodes: Small microscopic worms which attack certain insects such as cutworms and sod webworms and to some degree, white grubs.
- Neem: A derivative of the neem tree which grows in India and other tropical settings. The compound is natural and repels several kinds of insects and often caused them to stop feeding. Neem also acts as an insect growth regulator preventing some insects from molting normally from one stage to another. Neem controls cutworms and sod webworms in turf.

♦ ***Chemical Controls***

Several insecticides are labeled for use against turf insects, with a variety of characteristics. Some insecticides are mobile and can penetrate thatch, and so are appropriate to use against white grubs in the soil. Others are less mobile and remain in thatch, and are appropriate to use against surface and thatch insects like annual bluegrass weevils and black turfgrass ataenius adults.

Chemical control methods will be utilized only as specified in the IPM plan and only as a last alternative method. Materials known to be comparatively safe with regard to soil mobility, half-life properties and ground water contamination will be used. The following is a list of insecticides being considered for use:

- Imidacloprid (in Merit and Triple Crown) for grubs
- Bifenthrin (in Aloft and Triple Crown) for weevils, cinch bugs, black turfgrass antaenaus
- Chlorpyrifos (in Dursban) for weevils, cinch bugs, black turfgrass antaenaus
- Spinosad (Matchpoint) for weevils
- Clothianidin (in Aloft) for weevils, cinch bugs
- Trichlorfon (Dylox) for white grubs
- zeta Cypermethrin (in Triple Crown) for grubs, cinch bugs, weevils

Other products that may be developed in the future which have these properties will be considered for use on the course.

♦ ***Actions by the Grounds Staff***

The Wellesley Country Club staff has developed an insect management plan that concentrates on key pests (white grubs, annual bluegrass weevil, black turfgrass ataenius, cutworms, and ants). They monitor insect activity daily on greens and tees during the seasons when that activity is likely to occur (Table 1), and as needed on fairways and roughs. They track actual insect population measurements when activity is greatest so evaluation of control strategies can be made). They have developed a record keeping system so scouting records can be traced from year to year and so that action thresholds can be evaluated. Good housekeeping practices such as removing clippings from greens, tees, and collars, and disposal of those clippings at least 50 feet away from the nearest green or tee help to reduce reinvasion by black cutworm caterpillars. They use endophytic cultivars of perennial ryegrass or fescues in rough areas if those cultivars also meet the needs of disease management.

DISEASE CONTROL

- ***Cultural Strategies***

Most of the grasses used on the primary playing areas (greens, tees, and fairways) are cultivars of bentgrass and bluegrass, and these provide some inherent tolerance to some diseases. However, disease resistance is very specific so no single cultivar or species is resistant to all turf diseases, and some cultivars that are resistant to certain diseases are also more susceptible to others. In New England we can assume that pathogens will find at least some turf areas that have susceptible hosts.

Environmental conditions are the primary factor in determining how severe a disease outbreak may be. Some diseases (e.g., snow molds) thrive in cool conditions, while others (e.g., pythium blight and brown patch) are very damaging at high temperatures and high humidity. Most diseases are more active in moist conditions, whether following heavy rains or in areas where soils drain poorly. When summer temperatures and high humidity prevail, watering practices can be amended slightly to avoid extending the period of leaf wetness.

Several other cultural strategies can put the turf at a competitive advantage or the disease at a disadvantage. Fertilizing with sources of nitrogen and other nutrients that provide precise delivery of those nutrients to the plant reduces the lush plant growth that sometimes induces greater activity of certain pathogens (e.g., brown patch, leaf spots) while nutrient deficiency may lead to increased activity of other diseases (e.g., dollar spot, red thread). Every effort will be made to provide optimum fertility throughout the growing season to minimize or delay onset of disease activity.

While low mowing heights sometimes provide a level of stress that leaves a turf stand more vulnerable to disease, golfer expectations are such that there will be little latitude for raising mowing heights. However, other techniques should be explored for providing fast, consistent ball roll on the putting greens while allowing some flexibility in mowing height - e.g., double cutting, topdressing regularly, or using rollers. In addition, any area with known active leaf disease should be mowed last in a daily rotation and mowers should be cleaned thoroughly at the end of the day to reduce the spread of pathogens from an infested area to an uninfested area.

- ***Biological Controls***

There area few biological control agents available on the market for fungus control. Some that perform reliably enough to be used with confidence on golf courses in Massachusetts are:

- Extract of Reynoutria sachalinensis (Regalia)
- A mixture of vinegar, salt, and dish soap in water

- ***Chemical Control Strategies***

In an IPM program, scouting and monitoring can detect the presence of conditions that will lead to disease outbreaks, and every effort is made to reduce disease severity by refining cultural strategies. However, it is impossible to eliminate disease activity with cultural and/or biological control strategies alone. Every effort will be made to minimize the use of fungicides, by monitoring weather conditions, using predictive models to determine when outbreaks are most likely, and

regularly scouting the agronomic conditions of the course (including thatch thickness and density) and adjusting practices as appropriate to enhance turf vigor and put pathogens at a disadvantage.

Fungicides can be used as a tactic to protect plants from being infected by pathogens. Many fungicides protect the plant from within, and must be applied before a pathogen becomes active. While some people believe this preventive application is contrary to an IPM program, such applications can be justified. First and foremost, in some cases the preventive (and systemic) applications are the only effective alternative for a given disease. In many cases, there are no fungicides that will reduce disease incidence after infection has incurred. Furthermore, when such applications are made in conjunction with weather monitoring and predictive models, they are made only when disease outbreak is likely. Intervals between applications can be extended when using predictive models, thereby further minimizing use of fungicides.

To complicate matters, many turfgrass diseases (most notably, Pythium blight and dollar spot in New England) have developed resistance to one or more fungicides. Once resistance develops subsequent applications of the same material or closely related compounds are ineffective. The result is that a turf manager must manage fungicide use very carefully: minimize the number of applications by using predictive models and extending the interval between applications, keep good records of evaluations of applications, and avoid using compounds to which a pathogen has developed resistance.

A turf disease can only develop if three factors are present: the causal organism (usually a specific fungus), a susceptible host, and favorable environmental conditions. The fungi causing turf diseases normally are present throughout the year, and can be recovered from turf samples even when no obvious symptoms are apparent, so we can assume the organism is virtually always present, even on a newly established golf course.

Fungicides kill or inhibit the growth of fungi and there are two general types of fungicides: contact (or protectant) and systemic. Contact types cover the plant surface and prevent infections while systemic types are absorbed into plant tissues and may provide some curative action. Turfgrass management requires the use of several pest-specific fungicides to treat for a variety of diseases (snowmold, patch disease, pythium blight, basal rot anthracnose, summer patch anthracnose, etc.). The following is a list of possible choices of fungicides to treat for these diseases:

- Azoxystrobin (Heritage)
- Cyazofamid (Segway)
- Fludioxonil (Medallion)
- Fluoxastrobin (Fame)
- Fosetyl (Signature)
- Iprodione (Rovral)
- Isofetamid (Kubota)
- Mandestrobin (Pin Point)
- Mefenoxam/Metalaxyl (Subdue)
- Metaconaziole (Tourney)
- Metalaxyl (Subdue)
- Polyoxyn (Endorse)
- Propamocarb (Banol, ProPlant)
- Propiconazole (Banner)
- Tebuconazole (Clearscope)
- Thiophanate (TM 4.5)

- Thiram (Spotrete)
- Zinc ion/manganese ethylenebisdithiocarbamate (Protect DF)

As newer products are developed, they will be considered for use.

- ***Actions by the Grounds Staff***

The grounds staff will adjust irrigation schedules during periods of peak disease activity to minimize the period of leaf wetness. Normally this means irrigation would be avoided in early evening or early morning hours when dew has just begun to form (evening) or is beginning to evaporate (morning). In warm humid weather dew and/or guttation water should be removed from greens, tees, and fairways early in the morning. Mowing schedules will be amended as necessary so that diseased areas are mowed last in a daily rotation. Mowers will be cleaned thoroughly to avoid transporting pathogens to new locations. Fungicide or plant protective applications will be made based on predictive models where they exist and have been validated in the field. Intervals between applications will be extended as much as possible (based on weather conditions and normal persistence of each product). The plant protective program focuses on the issue of disease resistance and avoids repeated applications of the same product targeting diseases that are known to develop resistance to that product in New England.

MANAGEMENT GUIDELINES

- ***Reduced Frequency of Pesticide Usage***

IPM procedures radically reduce the frequency and rates of pesticide usage in general. The selection of less toxic, less mobile and less persistent pesticides coupled with the use of alternate strategies such as biological control and recommended cultural practices will reduce potentially adverse environmental effects. Controlling the timing and amounts of a particular pesticide application in relation to local environmental conditions, especially rainfall, will reduce offsite movement and enhance degradation characteristics of utilized compounds. This is especially effective when determining Action Thresholds of each target pest so that pesticides are used only when populations become economically critical and in need for control.

- ***Selection Criteria and Usage of Pesticides***

Only pesticides specifically labeled for usage in Massachusetts will be used, and only by properly registered, certified and trained personnel. Selection criteria for the type of pesticide will include consideration of the target species or disease, pesticide characteristics and site characteristics. Important pesticide characteristics such as efficacy; solubility; formulation; degradation rate; volatility; adsorption; potential toxicity to natural pest enemies and toxicity to wildlife or non-target species will be carefully considered prior to usage or development of a timing program. Selection of less toxic, less mobile and less persistent pesticides or use of alternate control strategies will reduce potentially adverse environmental effects. Proper equipment maintenance and calibration coupled with the selection of formulations that reduce mobility will enhance pesticide efficacy as well as degradation. Application methods such as incorporation or placement below the soil/thatch surface and "watering-in" will reduce exposure to runoff and enhance soil adsorption.

- ***Handling, Storage and Disposal***

Pesticides are stored in a state- and federally-approved storage locker to ensure complete safety and security of all utilized materials. All applicators are required to use protective clothing, gloves, shoes and respirators when recommended and all unused chemicals and containers are properly stored or disposed of by State and Federal guidelines. The application of a pesticide is made under the direction of a licensed applicator, and in accordance with all state and federal laws and in accordance with all label specifications. The golf course superintendent is licensed in the proper Pesticide Control categories. Records are kept of all pesticide use and reports are prepared and submitted to the state regarding all pesticide usage at the course.

- ***Alternate Pest Control Strategies***

A significant component of an IPM/TM plan includes the use of non-pesticide approaches toward pest control. The most fundamental approach will be the maintenance of an actively growing and competitive turfgrass environment, which is well known to out-compete weed species, promote active soil microbial activity and reduce the inoculum of soil borne disease organisms. Whenever possible, turfgrass species selections will focus upon the use of endophyte-enhanced varieties which are extremely effective in biological resistance to almost all above ground insect pests.

Endophyte enhanced species of turfgrass are also much more disease resistant as well as having increased environmental resistance to drought and heat stresses. The use of natural biological control species such as parasitic nematodes, pathogenic bacteria as well as natural insect predation of pest species will be incorporated into the overall pest management plan. Commercially available insect attractants and traps will also be strategically placed throughout the course when active thresholds are determined.

- ***Maintenance of Secondary Rough***

Maintaining fairway margins as unsprayed rough will serve as a buffer between the more intensively managed turf and adjacent wildlife habitat. Communities of native insects and other arthropods will be able to use edge habitat, without impact from drift or short distance leaching of insecticides and fungicides and native plants will not be impacted by herbicides. This area also serves as a reservoir for natural biological controls such as Tiphia wasps which prey on white grubs.

- ***Soil, Sediment, and Water Quality Monitoring***

IPM programs are designed to reduce the input of chemicals into the environment by using them in a curative rather than preventative fashion where appropriate. There is still a need to use fertilizers and pesticides so that the turf remains healthy and less prone to disease. Because of that, the IPM program is backed up by a routine monitoring program which provides information on the fate of these chemical in the environment.

Several of the pesticides listed were chosen for low mobility in ground and surface waters, which means that they may persist in soil. Because of this it is recommended that areas treated with more persistent chemicals be tested occasionally for build-up of these chemicals.

The Wellesley Country Club has instituted a voluntary groundwater and surface water monitoring program to test for nutrient and pesticide runoff. Throughout the property is a network of deep

wells, shallow wells, piezometers, and surface water monitoring stations which are placed so that comparisons to upslope (background) and downslope samples can be made. In addition, the club has tested the sediment in several of the ponds onsite to see if materials have entered these systems. The details and results of the sampling program are forwarded to the Wellesley Board of Health, Wellesley Water Department, and the Wellesley Natural Resources Commission.