

# Reducing chemical use on golf course turf: Redefining IPM

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# Reducing Chemical Use on Golf Course Turf: Redefining IPM

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Cover photo: View of the 2<sup>nd</sup> hole of the Green Course at Bethpage State Park, Farmingdale, NY. Taken by Jennifer Grant at an educational field day.

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## Notice

This handbook was originally published in December 2009. The second printing (January 2011) contains minor corrections for typographical errors and minor style changes. The availability of pesticide active ingredients and products, as well as data on efficacy, has changed in the interim between printings, but is not reflected in the text and tables.

Readers are encouraged to keep abreast of pesticide changes in New York, and EIQ Field Use Ratings, by consulting Cornell University's Pest Management Guidelines for Commercial Turfgrass (Pesticide Management Education Program, Cornell University, Ithaca, NY.) In other states, consult similar publications for legality of specific pesticides. Efficacy data is well summarized annually by Dr. Paul Vincelli at University of Kentucky, <http://www.uky.edu/Ag/ukturf/>. An annual report is presented and can be obtained on the Internet at [www.ca.uky.edu/agc/pubs/ppa/ppa1/ppa1.pdf](http://www.ca.uky.edu/agc/pubs/ppa/ppa1/ppa1.pdf).

## **Purpose**

The New York State Office of Parks and Recreation and Historic Preservation (OPRHP) funded this guide to promulgate strategies for reducing pesticide use on golf courses. The purpose of this handbook is to provide practical guidance for golf turf managers interested in reducing chemical pesticide and fertilizer use.

The strategies outlined in this manual are primarily based on knowledge gained during a nine-year study at the Bethpage State Park in Farmingdale, NY, designed to reduce the use of chemical pesticides and fertilizers. Research results from the turfgrass literature, the experience of numerous superintendents, and the management knowledge and philosophies of the authors were ground-trued on a high-use public golf course. The study at Bethpage is perhaps the best example of research being conducted in the field to adapt institutional research studies and best available practices under real world conditions at a fully operational golf course.

## Executive Summary

There is growing public concern over the use of pesticides and fertilizer on golf courses. At the same time, there is increased demand for immaculate course conditioning from the golfing public. Yet, scientific research, as well as practical field experience on managing golf course turf with fewer pesticides is scarce.

A long-term field research project was initiated at the Bethpage State Park Green Course to investigate cultural and pest management systems designed to be less reliant on pesticides. New research findings, as well as superintendents' experiences, are continually incorporated into the project and evaluated on a typical public golf course. Through this project we have developed environmentally compatible golf turf management programs that are less reliant on chemical pesticides and serve as the core of this handbook.

The project evolved over several years when it was determined that a “zero-pesticide” program in this environment was not feasible for producing acceptable putting green surfaces. The study now compares a “biologically based reduced risk” program with progressive IPM and conventional pest management. An important aspect of the project was the development of alternative cultural management programs such as mowing, fertilization and cultivation practices that results in a more stress tolerant putting surface system.

The Environmental Impact Quotient (EIQ) was introduced during the study to compare the environmental risk of the various pest management systems. The EIQ ranks pesticides using a composite evaluation of toxicity and exposure factors to aide in the selection of products with the least environmental impact. Using EIQ Field Use Ratings as a measure, the environmental impact of IPM and biologically based reduced risk management was 50-95% less than the conventional management. In addition, during the nine years of the project, the quality of the IPM managed areas has equaled that of conventional pest management systems. In addition, annual satisfaction surveys have shown that golfers do not perceive a difference in quality of the IPM managed putting greens.

The Green Course putting surface turf population has adapted to minimal pesticide inputs. This is primarily through reduced annual bluegrass populations—historically more susceptible to pest problems. This finding suggests turf populations can be “weaned-off” pesticides and maintain a playable surface.

The project has helped to reinforce the basic tenants of IPM: Use an interdisciplinary approach to understand the problem; use a series of preventative steps to minimize problems; and use pesticides only when pest pressure and environmental conditions are conducive to severe reductions in playing quality, and then chose the least toxic pesticide option.

This guide is organized to present the fundamental practices underlying the success at Bethpage so they can be customized for success at other courses. Chapters include:

1. Redefining IPM on golf courses
2. Cultural Management Practices
3. Stress Management
4. Pest Management
  - a. Diseases
  - b. Insects
  - c. Weeds

New concepts and tools are provided to forecast potential pest problems, correctly identify signs and symptoms, and to promote the cultural or environmental conditions that affect pest problems. The focus is on encouraging practices that improve growing conditions, and practices that aide in pest prevention. Intervention using pesticides is sanctioned in this guide when conditions such as weather, current infestation levels and site history coincide to predict loss of turfgrass cover or playability. The EIQ is promoted as a critical tool for pesticide selection to be used in addition to the manager's knowledge of effectiveness and cost.

This handbook also provides a new perspective on levels of visual and functional quality. The turfgrass surface should be evaluated based on playability as well as visual quality. In fact, player surveys conducted at Bethpage and on a national basis clearly show that a majority of golfers support programs to reduce pesticide use and value playability over visual appeal. This guide helps golf courses reset their expectations with the environment as a primary consideration.

The Bethpage study was initially funded by the United States Golf Association (USGA), subsequently by the Northeastern IPM Center (USDA-CSREES), and currently by the NYS Office of Parks, Recreation and Historic Preservation (OPRHP). OPRHP and Bethpage State Park in particular have been extremely supportive of this project, and have contributed immeasurable in-kind services. In addition to these organizations, the Golf Course Superintendents Association of America (GCSAA) and their Environmental Institute for Golf (EIFG) dedicate resources to funding scientific research and providing education on best management practices for golf. Amongst all these groups promoting environmental stewardship, New York State's commitment to reducing pesticide use on 29 state operated golf courses may represent the largest environmental leadership initiative in the industry, and paves the way for improving the environmental compatibility of golf.

## ACKNOWLEDGMENT

The authors wish to thank the New York State Office of Parks, Recreation and Historic Preservation and the National Heritage Trust for the opportunity to take science into the field. Cornell has had the unique opportunity to investigate best management practices for nine consecutive years on the Green Course at Bethpage State Park. In particular, we are very grateful for the unwavering support from David Catalano, Craig Currier, and Andy Wilson. Kathie Wegman and Debbie Marvin also played integral roles. We would also like to thank the United States Golf Association (USGA) and the Northeastern IPM Center (USDA-CSREES) for funding and support. The challenges of managing pest pressure under the stresses induced by microenvironments—while hosting over 50,000 rounds per year, and pronounced seasonal variations—has sharpened all our abilities to present the best possible recreational facility with significant reductions in environmental impact.

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## PREFACE

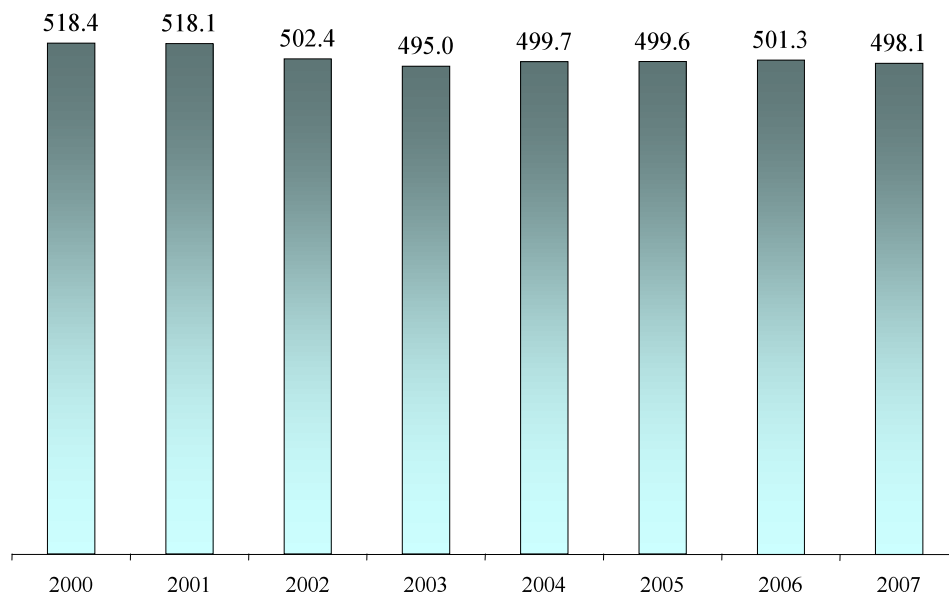
This preface describes the demographics of golf and societal attitudes toward golf and the environment. These business conditions and attitudes are the impetus for the management strategies recommended in this handbook.

### National Trends in Golf:

The Golf Course Superintendents Association of America (GCSAA) recently published a survey of land use encompassed by the game of golf within the United States. Surveying 16,009 golf course superintendents, the GCSAA estimates a total of 2,244,512 acres of land utilized by golf courses (Lyman 2007). This is only 0.2 % of the 938,279,056 acres of agricultural land (NASS 2002). The average 18 hole course maintains 100 acres of turf divided on average into 51 acres of rough, 30 acres of fairway, 3 acres of greens and 3 acres of tees. The balance is divided between practice complexes, clubhouse grounds and nurseries.

The GCSAA also reported that 29% of the 18 hole golf facilities have active environmental stewardship programs and 24% of the respondents participate in the Audubon Cooperative Sanctuary Program. These courses have made significant reductions in the acreage of maintained turfgrass while increasing the acreage of non-turfgrass areas (Lyman 2007).

The National Golf Foundation (NGF) summarizes the status of golf in their 2008 executive summary report. The NGF reports that rounds declined 4.5% in a post 9/11 drop in tourism and overall spending. Rounds played still remain very flat (NGF 2008).

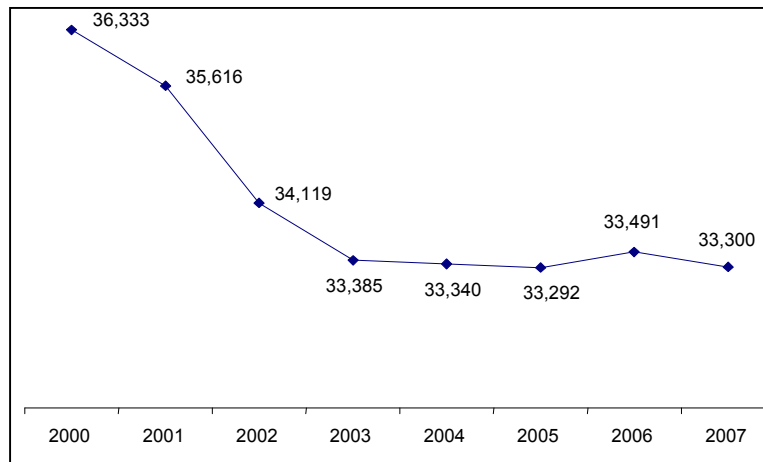


**Figure 1: Rounds Played, NGF, 2008**

	<u>% Change 2007 vs. 2006</u>
U.S.	-0.5
Private	-1.6
Public	-0.3
Premium (>\$70)	0.3
Standard (\$40-\$70)	0.2
Value (<\$40)	-0.5

**Table 1: Rounds by Facility Type, NGF, 2008**

Rounds played per golfer are still significantly down from a high of 40,000 about 20 years ago. The average golfer played 17.5 rounds in 2007.



**Figure 2: Rounds per 18 Hole Equivalent, NGF, 2008**

### **New York State Golf**

New York State was surveyed in 2003 by the New York State Turfgrass Association (NYSTA) and New York State Department of Agriculture and Markets. The report showed 860 courses in the state including public, municipal, semi-private and private courses (NASS 2004). The acreage of managed turf is very close to that reported by the GCSAA. However, the rounds played are approximately 28% lower than the average reported by the NGF for the period of 2003-2007.

**Table 2: General Statistics for NYS Golf Courses**

<b>Item</b>	<b>Unit</b>	<b>Average per Course</b>	<b>Total</b>
Number of Golf Courses	Number	---	860
Total Turf Area	Acres	118	101,480
Property Acres	Acres	220	189,215
Rounds Played	Number	24,071	20,701,180
Paid Labor:			
Full Time Employees	Number	4 per golf course	3,440
Part Time Employees	Number	9 per golf course	7,740
Payroll	Dollars	\$266,700	\$229,362,000
Value of Turf Equipment	Dollars	\$549,500	\$472,570,000

NYS Turfgrass Survey, 2003, NYSTA and NYS Dept of Ag and Markets

The most prevalent problem reported by golf courses was plant disease. Soil problems, notably drainage, are the second highest reported problem. Poor drainage leads to problems in plant health and soil dampness invites disease. Pest management of disease, weeds and insects, collectively, are chronic problems for turf managers.

**Table 3: Turf Management Problems, Percent of Golf Courses Reporting a Specific Turf Problem**

<b>Problem</b>	<b>% Courses</b>
Disease	65 %
Poor Drainage	49 %
Wear and Compaction	34 %
Labor	27 %
Equipment Maintenance.	20 %
Poor Soil	19 %
Insects/Grubs	15 %
Geese / Wild life	15 %
Weeds	13 %
Thatch	13 %
Excessive Shade	7 %
Drought	6 %
Water Availability / Quality	4 %
Erosion	2 %
Other	6 %

NYS Turfgrass Survey, 2003,  
NYSTA and NYS Dept of Ag and Markets

The cost of maintaining golf courses the New York State was also surveyed providing measures of the costs of equipment, staffing, fertility and pest management. The average cost per course includes 9, 18 and 27 hole courses (Table 4).

<b>Table 4: Turf Maintenance Expenses, Golf Courses. 2003</b>			
<b>Type of Expenses</b>	<b>Total Expense</b>	<b>Percent of Total</b>	<b>Avg. Per Course</b>
<b><u>Paid Labor:</u></b>			
Mowing/Trimming	\$111,219,534	47.0	\$129,325
Edging	\$4,277,674	2.0	\$4,974
Clean-up (Spring)	\$8,555,350	4.0	\$9,948
Clean-up (Fall)	\$10,694,186	4.0	\$12,435
Disease Weed, Insect Control	\$17,577,300	7.0	\$20,439
Fertilizer Application	\$6,883,114	3.0	\$8,004
Top Dressing Application	\$4,277,674	2.0	\$4,974
Aerification/Coring	\$6,843,984	3.0	\$7,958
Renovation/Overseeding/Reseed	\$8,010,487	3.0	\$9,315
Dethatching/Raking/Verticutting	\$2,138,838	1.0	\$2,487
Seed/Sod Installation	\$4,510,974	2.0	\$5,245
Irrigation Installation	\$29,281,469	12.0	\$34,048
Irrigation Service	\$4,977,576	2.0	\$5,788
Soil and Tissue Testing/Diagnostic	\$933,203	1.0	\$1,085
Other	\$17,032,437	7.0	\$19,805
<b>TOTAL Paid Labor</b>	<b>\$237,213,800</b>	<b>42.1%</b>	<b>\$275,830</b>
<b><u>Equipment:</u></b>			
New Equipment Purchases	\$34,736,913	48.8	\$40,392
Used Equipment Purchases	\$2,562,559	3.6	\$2,980
Irrigation Equipment Repairs	\$5,196,300	7.3	\$6,042
Equipment Supplies	\$4,840,390	6.8	\$5,628
Equipment Repairs	\$16,229,542	22.8	\$18,872
Equipment Rentals/Leasing	\$7,331,767	10.3	\$8,525
Other Expenses	\$284,729	0.4	\$331
<b>TOTAL Equipment Parts</b>	<b>\$71,182,200</b>	<b>12.7%</b>	<b>\$82,770</b>
<b><u>Supplies:</u></b>			
Seed	\$3,779,081	6.0	\$4,394
Lime	\$503,877	0.8	\$586
Sod	\$1,574,617	2.5	\$1,831

**Table 4: (Continued) Turf Maintenance Expenses, Golf Courses. 2003**

<b>Type of Expenses</b>	<b>Total Expense</b>	<b>Percent of Total</b>	<b>Average Per Course</b>
Top Dressing	\$4,156,990	6.6	\$4,834
Topsoil	\$1,070,740	1.7	\$1,245
Sand	\$2,141,479	3.4	\$2,490
Mulch (straw, hay, peat)	377,908	0.6	\$439
Purchased Irrigation Water	\$1,133,724	1.8	\$1,318
Crop Protectants:			
Herbicides	\$3,149,234	5.0	\$3,662
Insecticides	\$3,653,111	5.8	\$4,248
Fungicides	\$17,005,864	27.0	\$19,774
Biological Pesticides	\$1,763,571	2.8	\$2,051
Fertilizer	\$11,337,242	18.0	\$13,183
Fuel/Lubricants	\$9,195,763	14.6	\$10,693
Other Expenses	\$2,141,479	3.4	\$2,490
<b>TOTAL Supplies</b>	<b>\$62,984,680</b>	<b>11.2%</b>	<b>\$73,238</b>
<b><u>Miscellaneous Expenses</u></b>			
Insurance	\$15,468,003	8.1	\$17,986
Utilities	\$14,895,114	7.8	\$17,320
Travel and Meeting Expenses	\$2,100,593	1.1	\$2,443
Property Taxes	\$44,494,379	23.3	\$51,738
Sales and Use Tax	\$20,242,078	10.6	\$23,537
Building Maintenance	\$8,784,298	4.6	\$10,214
Property Rental	\$2,291,556	1.2	\$2,665
Capital Improvements	\$79,631,571	41.7	\$92,595
Training	\$763,852	0.4	\$888
Other	\$2,291,556	1.2	\$2,665
<b>TOTAL Miscellaneous</b>	<b>\$190,963,000</b>	<b>34.0%</b>	<b>\$222,050</b>
<b>TOTAL EXPENSES</b>	<b>\$562,343,680</b>	<b>100%</b>	<b>\$653,888</b>

NYS Survey, 2003, NYSTA and NYS Dept of Ag and Markets



### **Economic Challenges**

These data give context to the challenges of managing golf courses in today's social, political and economic conditions. While rounds of golf are flat or slightly declining, maintenance costs are higher than ever with record costs for fuel, fertilizers and pesticides. Economic volatility and uncertainty cloud the future. Along with the growing concern for climate change and the on-going debate on chemical use in communities, escalating costs will influence management decisions in the future.

### **Demographics of Golf**

Course management has to recognize the values of their customers adapting course layout and maintenance accordingly. A survey of New York State Parks courses described clientele at these public courses ranging from recreational golfers with the ability to score between 95 and 105 for 18 holes to more skilled players who often shoot within 10 shots of par (Portmess, 2009). Seniors accounted for a significant percentage of play.

The National Golf Foundation (NGF) reported a decrease of 0.5%, in rounds played in 2007 compared to 2006 (NGF 2008). The decline was higher at private courses (-1.6%) vs. public (-0.3%). Clearly, there is increased pressure on golf courses to offer an attractive venue at competitive, if not, reduced rates.

A Golf Digest survey reported well-maintained tees, fairways, bunkers and greens were the most responsible for determining the enjoyment of the game among frequent players (best customers) (Last, 2005). The survey found that among the core and avid golfers, 88% preferred a well maintained course over a more challenging course that was not in good condition. Seventy four percent of these golfers were willing to pay 25% more for a course that was better maintained.

A multiple year survey, conducted as part of the reduced chemical management project at Bethpage State Park, revealed that 50% of golfers prefer "putting greens be kept at reasonably good quality, using pesticides judiciously only when needed". The survey is a clear statement for the need to realign management priorities (see Chapter 8).

### **Environmental**

New York State has been proactively establishing a leading position on environmental issues driven by several external factors including:

- Public pressure is growing to reduce chemical inputs that are harmful to human health and the environment.
- Rising concern about global warming and Greenhouse Gases (GHG's).

Already, the Governor has issued Executive Order #4 to define and implement sustainability guidelines for New York State Parks. Several counties, towns and cities have passed legislation restricting pesticide and/or fertilizer use to safeguard water quality, human health and the environment. Future legislation could further restrict or ban the use of certain chemicals.

The objective of this handbook is to provide a template for managers to implement alternative practices with the intention of reducing chemical dependency, selecting alternative products with low environmental impact, and improving the environmental compatibility of their courses. Specifically, this handbook emphasizes three major concepts:

1. Redefining Integrated Pest Management (IPM)
  - (a) Establishing preventative steps to minimize pest problems
  - (b) Anticipating the risk periods of pest problems
  - (c) Recommendations to effectively deal with pests in a cost effective and environmentally sensible manner.
2. Substitution of traditional synthetic pesticides with cultural practices and the use of reduced-risk and biologically-based products.
3. Introducing the use of the Environmental Impact Quotient (EIQ): Superintendents will be able to select pesticides based on the environmental impact of each alternative.

This handbook is intended to build the framework for reducing chemical inputs while maintaining a functional, attractive and challenging golf facility. The integration of these recommendations with the experience of the superintendents and staff can lead to significant environmental improvements.

## Chapter 1

### Re-Defining Golf Course Integrated Pest Management

Many courses across the country have implemented various aspects of Integrated Pest Management (IPM). Misconceptions and the lack of a comprehensive IPM program often hamper their success in reducing the use of chemical inputs. Therefore, it is vital to directly address persistent misconceptions and redefine IPM in an effort to advance the process of reducing risks of golf course management.

#### **IPM is an effective tool:**

IPM has many documented success stories in agriculture and within the golf industry. No study underlines the potential success as well as the nine year project on the Green Course at Bethpage State Park designed to assess various approaches to reducing pesticide use (Rossi and Grant, 2008). The study showed that IPM and biologically-based strategies using alternative cultural practices reduced the environmental impact by 50-95 % while maintaining acceptable turfgrass quality and meeting golfer satisfaction.

#### **IPM doesn't take more time:**

The adage of “working smarter, not harder” would be appropriate in defining the labor requirements to implement and maintain an effective IPM program. The Bethpage study concluded that, ultimately, the alternative management regime using IPM based strategies ended up taking less time than conventional practices. While the alternative cultural practices will introduce new elements, adding labor to some maintenance routines, there are reductions as well. The task is to rebalance the routine and reallocate labor on the course to adopt these new practices. IPM identifies the problem areas, focusing activity on long term solutions that will reduce labor requirements over time.

#### **IPM does not have to cost more:**

In terms of immediate measureable cost reductions, implementing IPM can provide notable reductions in the following areas:

- Alternative weed strategies can reduce herbicides by as much as 50%.
- Better insecticide timing can reduce insecticide use by as much as 50%.
- Fungicide applications of conventional chemicals may be reduced using alternative cultural practices and by substitution with reduced risk and biological formulations. Applications may also be reduced by timing the schedule to coincide with high risk periods.
- Site specific management recommendations can also lower the cost of nutrient inputs.

Indirect savings are realized in the improved environmental compatibility of the course.

**IPM does not require extensive training:**

The foundation of IPM is knowledge-based versus traditional product-based management. Maintaining healthy plants, recognizing potential stress and then measured intervention can be established with minimal training.

**IPM engages staff:**

Enlisting staff participation is critical to course monitoring. An IPM program will be empowered by the watchful eyes and attention of many concerned participants already engaged in other aspects of maintenance. An IPM program will foster team building, provide development opportunities for personnel, and will likely generate new energy and enthusiasm. These practices may be beneficial:

- Conduct periodic refreshers on pest identification and the characteristics associated with each pest during high risk times.
- Emphasize areas, like putting greens, with a lower tolerance for pests and areas that have a history of chronic problems.
- Inform staff of all management activities so they can contribute to observations and results.
- Encourage and reward staff for detecting and sharing information on pest and turf issues.

**IPM will reduce your reliance on pesticides:**

The early years of the Bethpage Project demonstrated the effect of the ecological dependence of pesticides. Specifically, when pesticides were withheld, the turf that had been sustained for more than 60 years with pesticides failed. Over time the project has shown that the putting surfaces, once reliant on pesticides, can be maintained with significantly fewer inputs. The IPM program helps reduce the reliance on pesticide use by:

- Improving growing environments through tree removal, improved air circulation and soil amendments.
- Implementation of a series of cultural management programs that remove stress on turf and promote healthy plants.
- Intervening when indicated by risk period, site conditions and tolerance levels.

**IPM reduces risk:**

Beyond the concerns of regular pesticide use, the implementation of IPM is directed at the improvement in the environmental compatibility of the golf course. The first step in this process is through reduced reliance on chemical pesticides and when possible, selecting pesticides based on reduced risk. The Bethpage study was the first project to implement the use of the Environmental Impact Quotient (EIQ) in a turfgrass system (Kovach et al. 1992).

**IPM will NOT reduce quality:**

IPM does not require acceptance of a reduction in quality of the playing surfaces. In fact, many definitions of IPM include a reference to adjusting practices so there is no reduction in quality (Bajwa and Kogan 2002). The Bethpage study showed that once the putting surfaces stabilized following implementation of reduced risk programs, playing conditions, as measured by visual quality and ball roll, almost always met golfer satisfaction. As strategies have been implemented on tees and fairways, there have been similar performance responses.

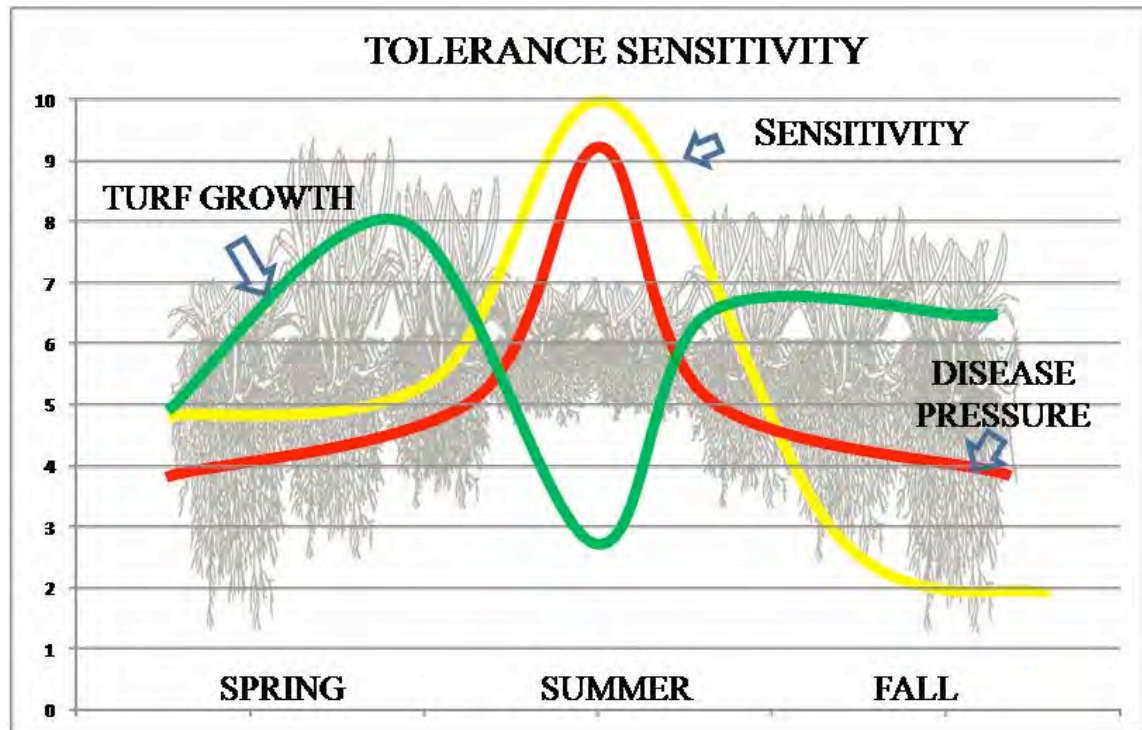
The golf course manager is usually the person most critical of the course appearance. Communicate with golfers and management to form a consensus of expectations. Recalibrating your standards to what is generally acceptable will alleviate any anxiety over the appearance of the course. Take measured steps forward. Define high and low priority areas. Make sure to establish an effective communications program with your members. Involve them in the goals and progress of the program.

**IPM should be based on adaptive Tolerance Thresholds:**

The potential for damage from insects, diseases, and weeds is always present. The turf can tolerate these pests up to some threshold point. This point, when the pest damage or turf injury exceeds the tolerance for the quality standard set for the course is defined as the “Tolerance Threshold” or “Action Threshold”.

The superintendent is always sensitive to the conditions and changes on the course. As the risk of pest problems increases, the sensitivity and attention level also increase. Special attention should be given to the level of the threshold and the period of risk. Two or more pest problems and the overall condition of the turf can interact to create “cross-thresholds”. Compounding problems can lead to rapid decline or destruction.

The turf manager will also adapt thresholds to the seasonal patterns (Figure 3). Turf has a strong growth surge in the spring. Conditions may increasingly favor pests, but vigorous turfgrass health offsets some of the concern. The sensitivity should be at about level 5. There may be signs of pests on the course, but the tolerance is higher knowing that the turf has good health and the ability to fend off or tolerate the pests. However, as temperatures increase in the summer, root and shoot growth decline. During this peak summer period, as temperatures and humidity factors are at play, turf is more susceptible to pest pressure. The superintendent’s sensitivity will peak at 10. The course should be on high alert scouting for symptoms or signs of pests. The tolerance level for pests is much lower knowing that the turf is in its weakest condition. Tolerance thresholds are lowered. As temperatures decline moving into fall, the turf recovers, sensitivity is relaxed and tolerance thresholds can be raised. This is the concept of adapting the sensitivity and tolerance thresholds to the conditions and risks on the course.



**Figure 3: Tolerance Sensitivity to Seasonal Changes**

This handbook contains sections on each of the major pests typical to golf courses in New York State. In each section, recommended thresholds are offered. These thresholds may vary by the time of year, the site, turf health, golfer or membership demands, and location in the state. For instance, there are relatively low spring thresholds for annual bluegrass weevils because common treatments target adults before laying their eggs. However, the threshold is raised later in the summer when adult weevils present a much smaller threat to turf. In another example, experience at Bethpage has determined that for some diseases, control is very difficult once the disease sets in. In these cases, the tolerance or threshold level is “detection” and treatment for these diseases is recommended where there is a history of past outbreaks and during the periods when conditions favor disease development.

### **IPM focuses on prevention**

Proper cultural management was essential to the success of the IPM treatments in the Bethpage study. The alternative cultural practices maximized plant health and minimized plant stress, particularly during the peak summer stress period of June, July and August. Some key concepts underlining the success at Bethpage include:

- Assessing growing conditions.
- Identifying and remediating chronic stress and pest areas.
- Implementing tree removal to reduce shading and other means improving air circulation.

- Amending the soil to maximize plant health.
- Scouting to discover early signs of pests.
- Proper identification of pests and separation of pest induced problems from turf problems.

Conducting a site assessment will help identify the problem areas. There is never enough time or money in the budget to fix all the problems right away. However, formalizing a list will help outline the priorities on the course. Work on the items one at a time with whatever time and resources are available. Make sure club management is up-to-date with these priorities and the importance of accomplishing the overall goals of maintaining healthy turf and how that will help reduce chemical inputs.

## Chapter 2

### Cultural Practices

Turf growth varies from course to course based on conditions that are dictated by climate, landscape features, and soil. Management programs vary depending on these conditions and the unique history for each course. Building a management plan on a sound philosophy of IPM and implementing cultural practices designed to maximize plant health are the foundation for improved environmental stewardship and reduced chemical inputs.

It is easy to be skeptical of a new routine of alternative cultural practices and even critical that such practices will take more labor. The experience at Bethpage has provided a solid ground-proofing of alternative management practices. While labor is higher for the new mowing and cultural practices, the IPM alternative management program ultimately was not any more time intensive than conventional management. Overall, there is a broad consensus that the IPM alternative practices on the Green course have met course standards for turf quality, playability, and golfer satisfaction.

The most important contribution to the success of the program was a measure of the people involved, their dedication to the goal of reducing chemical inputs, and their ability to adapt and refine ideas into workable solutions. Some of the key elements to the program included:

- Identifying treatments that created healthy turf and produced improvements in visual quality.
- Adjusting cultural practices to maintain playability.
- Significantly reducing soil pH resulting in a major reduction in *Poa* populations.
- Improving the irrigation coverage on greens.

The combined IPM process, including the evaluation of alternative practices, the adoption of thresholds, and the critical selection of reduced risk pesticides, contributed to making a significant reduction in chemical inputs. While the work at Bethpage was concentrated on the management of the greens, the lessons learned are being adapted to the rest of the course.

Using the experience from Bethpage coupled with the science learned from other research, this handbook is presented as a compilation of best management practices. The cultural practices focus on greens, but are easily applicable to tees and fairways. Pest management and reduced chemical inputs starts with maintaining healthy turf to withstand the rigors of play, environmental stress, and pest pressure. This handbook divides cultural practices into those practices that promote ideal soil conditions and healthy turf. Environmental stress and pest pressure are considered in subsequent sections.



## **Keys to Effective Soil Management**

### **Background:**

Soil is a matrix of air, water, organic material and minerals that provides the medium for plant roots. The soil is a complex system where microorganisms break down plant debris and organic material, build structure and provide essential plant nutrition. The soil holds other essential macro and micronutrients that are released to the plant. The soil can hold water and provide needed oxygen to the roots. If the soil does not have adequate amounts of air and water, or has excessive amounts of surface organic matter plant health will suffer.

There are three aspects of the soil: physical, chemical and biological. Soil physical properties involve soil texture and water movement. Chemical properties determine nutrient availability. Biological properties are the least understood and are largely governed by microbial activity. While there are critical management recommendations of physical and chemical properties, there is little known about how to manipulate soil biology to directly benefit turf health.

### **Problems with Soil Physical Properties:**

There are many characteristics used to describe a soil. In the context of managing turfgrass with foliar fertilizers and irrigation systems, two properties are critical for reducing chemical inputs: drainage and organic matter.

### **Poor Drainage:**

A poorly drained soil or saturated soil will have less oxygen and negatively influence soil microbial activity leading to poor root growth.

- Wet soils promote many root related diseases.
- Persistently wet soils increase turf stress and lead to loss of turf.
- Common causes of poor drainage are fine textured soils such as clays or layered soils.

The recommended saturated hydraulic conductivity of a USGA green is between 6-12 in  $\text{hr}^{-1}$  and a minimum of 2 in  $\text{hr}^{-1}$ . A drainage problem is easily diagnosed by pouring water and saturating the soil. If the water puddles and takes too long to percolate into the soil, then the soil has an internal drainage problem. Cutting a slice from the turf, or pulling a core sample, may indicate some underlying problems with buried organic and intermittent soil layers.

### **Management Options:**

- If soil layering is beyond the reach of typical cultivation equipment then deep tine cultivation would be required. This can also provide effective soil shattering in the case of a heavily compacted clay soil.
- Improving surface drainage by altering surface contours and removing mounds.
- Installing a slit subsurface drain system.

- The use of Drill and Fill procedures can connect surface water with underlying porous material such as gravel or sand with a sand channel.

**Surface Organic Matter Accumulation:**

Organic matter is vital for sustaining a dynamic microbiological community.

Microorganisms are essential in decomposing surface organic matter, especially the thatch layer. Problems with organic matter occur when the accumulation exceeds microbial degradation or topdressing rates, and, when organic matter with a high water holding capacity becomes saturated. The saturated condition will limit root growth and promote soil borne pathogens and disease.

If the organic matter is too high, typically meaning the thatch layer is too thick (generally > ½ inches), the turf will feel spongy. Impressions will be left after walking on the turf, or the turf will still be soggy and moist well after a rain or irrigation event.

**Management Options:**

- Severe problems will require intense physical organic matter removal with hollow tine cultivation, core removal and aggressive sand topdressing to fill core holes.
- Various forms of vertical mowing, grooming or aggressive scarification using a device such as the Graden have been shown to provide an effective means of reducing surface organic matter.

Many courses may have originally constructed greens from native soil often referred to as push-up greens. And, some courses have renovated greens utilizing a USGA specified sand mix. The differences in these greens will mandate adapting particular practices for each.

**Chemical Properties:**

The two most important factors that describe the chemical properties of the soil are the Cation Exchange Capacity (CEC) and the pH of the soil. The CEC is a measure of the soil's ability to hold nutrient cations. The pH determines how well nutrients are released to the plants.

**Management Options:**

- Download a soil survey to determine the variation of soil types across the course. (See appendix 3).
- Obtain a soil nutrient analysis to describe the CEC, pH, and nutrient availability. Different areas of the course may vary considerably as indicated in the soil survey. Management of the areas will need to be adapted to the specific assessments. Recognize there are limitations in the nutrient analysis with respect to macronutrient recommendations for potassium and phosphorous and all of the micronutrients. Focus management on nitrogen (See appendix 2).
- Understand and manage pH. In addition to the soil analysis, identify the pH of your water source and topdressing.

### **Keys to Effective Turf Management:**

Turfgrass commonly found on golf course putting greens in NYS are mixed stands of creeping bentgrass and annual bluegrass (often referred to as *Poa*). Putting greens comprise the smallest area of any playing surface, involve more than 70 percent of all the shots in a round, are maintained at very low cutting heights, and are the most intensely managed areas on a golf course. Management programs often focus on the visual and playing requirements of these surfaces. These programs are chemically intensive.

### **Key Properties of Turfgrass found on Greens:**

- Creeping bentgrass is highly adapted to acidic, infertile soil.
- Annual bluegrass initially invades putting greens as a frequent flowering, winter annual weed and then persists as a dense, sparsely flowering perennial.
  - a. A very large seedbank of annual bluegrass persists in the soil.
  - b. Surface disruption associated with play allows for invasion from seedlings.
  - c. Seasonal seedhead formation is disruptive to play and adds to the seedbank.
  - d. During and following seedhead formation, annual bluegrass is increasingly susceptible to pest infestations due to its weakened condition.
  - e. Annual bluegrass is susceptible to winter injury, especially ice damage.
  - f. Annual bluegrass is also susceptible to severe summer decline and a number of plant diseases and insects.
  - g. Annual bluegrass has higher demands for fertilizer, water and pesticide use.

### **Cultural Objectives on Greens:**

- Blend a set of management practices to favor bentgrass and reduce the amount of annual bluegrass.
- Management practices should be designed to maximize plant health in spring and fall in an effort to reduce stresses during high temperature, high humidity summer conditions.

### **Key Properties of Turfgrasses found on Tees and Fairways:**

- Mixed stands of turf will provide flexibility to a range of environmental conditions.
  - a. Kentucky bluegrass will provide a dense, wear tolerant stand.
  - b. Perennial ryegrass will germinate and fill in faster.
  - c. Creeping bentgrass should be managed with an emphasis on low pH.
  - d. Fescues will have greater drought tolerance, lower nutrient requirements, and better shade tolerance, but reduced cart traffic tolerance if not managed properly.
- Annual bluegrass will be most susceptible to pests and diseases. Annual bluegrass will exhibit the same characteristics and demands as found on greens.

### **Cultural Objectives on Tees and Fairways:**

- Management practices must reduce turf stress especially during peak summer conditions.

### **Keys to Effective Mowing:**

Mowing height has a significant influence on plant health. It is vital to establish a mowing height consistent with the optimal range of the turfgrasses you are managing.

#### **Cultural Recommendations on Putting Greens:**

- Determine minimum amount of mowing required to provide acceptable visual quality and playability. Mow as little as 3 times a week but no more than 5 times per week and alternate with rolling. Avoid excessive rolling on soil-based greens that have not established a sand-based surface from topdressing.
- Do not mow below 0.130 inches and never double mow. If you need additional speed perform additional rolling.
- Mowing heights below 0.130 should only be used for tournament play and on adequately topdressed greens.
- Use Trinexapac-ethyl (Primo) 0.1 to 0.2 oz/1000 every two weeks to enhance turf health, turf density and maintain consistent ball roll measurements.

#### **Cultural Recommendations on Tees and Fairways**

- Maintain heights between 0.5 and 0.75 inch.
- Mow at least twice per week and never more than three times per week.

## **Keys to Effective Fertilization**

### **Greens:**

- Promote an acid pH on the putting green with a target pH of 5.0 – 6.0. This favors the bentgrass and puts annual bluegrass at a disadvantage, and over time will reduce annual bluegrass populations.
- Apply ammonium sulfate/Urea (2.5-3.0 lbs N/1000/yr) in 0.1 lb N increments every 7 to 10 days in the spring and fall. Water lightly (approx. ¼ inch). Avoid applications during peak summer periods to avoid burning the turf.
- Supplement with Iron (Fertilizer mixes with iron in the range of 2-5%).
- Several amendments help improve plant and soil health including products such as Panacea, Soil Life, Rhapsody and Converted Organics. Another product, Civitas, an OMRI approved organic mineral oil supplement has demonstrated improved nutrient efficiency and plant resistance to disease. Refer to product labels for more information. Only use amendments with scientifically proven benefits.
- No other micronutrients unless pH falls below 5.0, then consider liming.

### **Tees and Fairways:**

- Apply slow release nitrogen (SRN) (2.5 -3.0 lbs N/1000/yr) on a four to six week release schedule.
- Alternatively, use products with longer release times, if limited in the ability to apply fertilizer.

Records should be maintained for all the fertility management inputs with the same attention to detail used in reporting the use of registered pesticides. The logs will provide an important agronomic reference to the timing and variations in your fertility plan. Additionally, public concern is mounting on the environmental problems associated with off-site movement of nutrients via runoff and leaching. In fact, some counties in New York are already evaluating nutrient management programs on golf courses to understand and control the effects on the environment.

### **Keys to Effective Irrigation:**

Proper irrigation is essential for maintaining healthy turf. There are a number of aspects of irrigation decision-making that are often overlooked due to the ease of automatic watering. Additionally, many courses do not have the ability to deliver water to the turf in a consistent and uniform fashion. This can create additional problems that might require synthetic pesticides. Therefore, the key to establishing an effective irrigation program is to focus on precision and efficiency, i.e., how much water does the plant need and what is the most effective means to supply it.

The first step in determining plant water needs is to understand evapotranspiration (ET). ET is the amount of water evaporated from the soil and transpired by the plant. If ET exceeds the amount of precipitation in your area, the turf will be in a water deficit.

When determining irrigation requirements, the soil must be considered as a water bank. The soil, depending on its physical properties will act as a reservoir of water. At saturation, the soil is at “field capacity”, i.e., where all water that will be lost downward to gravity has drained. As the soil water is depleted, there is a point at which the plant cannot extract water from the soil. This is the wilting point of the soil. At this stage, you will observe drought stress in the turf.

- Track ET for your area. The Northeast Regional Climate Center (NRCC) and your local extension services provide the daily ET rates for your area. Irrigation management dictates that the soil water be replenished to sustain the turf.
- Light and frequent irrigation will not promote strong rooting by the plants. Long and deep irrigation cycles will tend to over-saturate the soil. The best practice is somewhere in between. Deficit irrigation (60-80% of ET) has been shown to effectively balance the needs of a bentgrass green.
- Conduct routine irrigation audits to verify the distribution uniformity of your system. Adjust, repair, or replace heads to correct problems. If you are using roller heads, measure the water distribution the same way as you would on a fixed head system. Understand the pattern and delivery of the heads to determine the best placement of your sprinklers and your irrigation interval.
- If labor allows, before wilting occurs, use careful hand-watering to make up any deficits and irrigate trouble spots. This can be one of the most effective means of reducing stress that leads to pest problems.

## Chapter 3

### Stress Management

A number of stressful conditions may exist or develop that reduce plant health. The effect of any one of these conditions can be significant. In combination, stresses can have a devastating effect on the quality and condition of the course. Most of the problems, unchecked, will lead to increases in pest pressure, especially diseases. Managing these conditions is an integral part of reducing chemical usage.

#### **Black Layer:**

Sulfur by-products can accumulate forming a “black layer”. The layer becomes impervious to water (perched water table) exacerbating problems.

#### **Appearance:**

Yellow to brown areas with irregular patterns of thinning turf.

#### **Conditions:**

- Waterlogged soils
- Rotten egg smell

#### **Cultural options:**

- Maintain good drainage – deep tine aerification to break up layers.
- Use wetting agents to increase infiltration and percolation.
- Avoid compost amendments and organic fertilizers.
- Reduce sulfur component on fertilizers.
- Fertilize at light and frequent intervals.

#### **Layered Soil**

Irregular topdressing sometimes accompanied by excess thatch accumulation and improper management can create layers of soil.

#### **Appearance:**

Turf will develop patches or streaks of wilt typically accompanied by weeds.

**Conditions:**

- The change in particle densities create perched water tables, leading to poor drainage.
- Sub-layer zones are dry and will not support root systems.

**Cultural options:**

- Deep tine aerification to break up layers.
- Resume regular topdressing programs.
- Manage thatch accumulation.

**Soil Compaction**

Excessive traffic can compress the soil structure increasing the bulk density of the soil. Some soil types, particularly clayey soils are more prone to compaction. In some soil types, drought conditions create hard pan soil layers.

**Appearance:**

Bare areas or areas with thinly developed turf. Soil will often have a “crusted” appearance. Areas may be infested with weeds.

**Conditions:**

- Compression breaks up aggregate structure of the soil reducing porosity.
- Air and water infiltration is reduced, creating poor rooting conditions.

**Cultural options:**

- Use needle tine aerification to loosen the soil.
- Use water injection aerification during peak summer conditions instead of needle tines.
- Manage traffic patterns.
- Reduce mowing frequency and clean up passes.
- Restrict cart and equipment access.



### **Poor Drainage**

If the soil is too wet, the turf root system will have insufficient air exchange. Wet soils will promote many root related diseases. Poor soil drainage produces wetter soils that favor *Poa* over bentgrass.

#### **Appearance:**

Turf will be completely yellow or tan indicating loss of plants.

#### **Conditions:**

- Layered soils
- Compacted soil
- Poor percolation in the parent soil material.
- Insufficient depth in the soil profile limits water capacity of the soil.

#### **Cultural options:**

- Deep needle tine (Vertidrain).
- Drill aerification.
- Reshape contours and remove mounds to eliminate ponding and redirect water flow.
- Install sub-surface drains.

### **Dry Soil /Localized Dry Spots**

Dry soil will create drought stress on turf and will not support good rooting.

#### **Appearance:**

Irregular patches of dead or stressed turf.

#### **Conditions:**

- Topographical profile such as a high spot on a green or a sloping fairway.
- Poor irrigation coverage.
- Organic acid or fungal coating of soil particles that increase water repellency.

#### **Cultural options:**

- Needle tine affected areas to loosen soil.
- Application of surfactants.
- Hand water to assist recovery.
- Check irrigation coverage.

### **Turf Conditions that Create Stress:**

Ideal growing conditions are essential for maximizing plant health and reducing reliance on chemical pesticides. Light, air, and water are the three vital aspects of plant growth and must not be in deficit.

### **Low Light, Poor Air Movement**

Shade areas inhibit turf growth and are typically denoted by thinning turf and chronically wet soil profiles. Areas around greens and tees are typically boxed in with thick stands of trees and heavy underbrush. The conditions imposed will always lead to weakened turf not simply from light deficits but from a lack of air movement that extends periods of leaf wetness and leads to increased fungal disease. In addition, annual bluegrass has a competitive advantage over other cool season turfgrass in low light and poor air movement environments. It is essential to have at least 4-6 hours of direct sunlight with as much of the light on the turf in the morning and maintain a minimum of 3 mph wind speed across the surface.

#### **Appearance:**

Thin, pale green leaf blades, shallow rooting, often with weeds or moss.

#### **Conditions:**

- Thin turf
- Poor root density
- Thin cuticles

#### **Cultural options:**

- Thin trees to maximize light levels in the morning hours.
- Create air flow through understory to provide 3 mph wind or consider a fan.

### **Low Soil Infiltration**

Aside from soil conditions that restrict air or water infiltration, poor conditions may be associated with the density of the turf.

#### **Appearance:**

The turf will have a high uniformity in color and appear to be relatively healthy. On closer inspection, it will be difficult to comb or separate plants.

**Conditions:**

- Turf density is so dense that water puddles on the surface.
- Air penetration will also be limited, thereby restricting plant root functions.

**Cultural options:**

- Verticut greens to thin turf and thatch.

**Summer Stress**

Seasonal growth of cool season grasses starts with a strong spring surge. As summer temperatures rise, there is a summer decline in growth of both roots and shoots. As temperatures decline, there is a renewed growth in the fall. The effect is dependent on both soil and air temperatures. Summer is a period of stress and vulnerability to turf loss. The period of decline coincides with peak risk periods for insects and diseases. Managing summer decline is the most important factor to successfully managing the course.

**Appearance:**

Reduced shoot and root growth accompanied by wilted appearance or yellowing.

**Conditions:**

- Decline is highest when both soil and air temperatures approach 85° F. Damage is significant after 7-14 days exposure to extreme conditions.
- Weakened plants are susceptible to insects and plant diseases.
- Thinned turf is exposed to weed germination.

**Cultural options:**

- Raise mowing heights and reduce the number of clean up passes.
- Avoid excessive irrigation and root zone saturation.
- Minimize leaf wetness.
  - a) Irrigation at sunrise
  - b) Dew removal
- Needle tine aeration on regular basis unless temperatures exceed 90°F.
- Maintain adequate fertility. High nitrogen fertilization can complicate the turf's decline by promoting shoot growth at the expense of root growth.
- Avoid herbicide applications.
- Use seaweed extract based products containing cytokinin to enhance heat stress tolerance.

### **Thatch**

When the accumulation of organic material is faster than the rate of decay, an excessive thatch layer will develop. The crowns end up above the soil in the thatch layer where there is no water or nutrient retention. The crowns are exposed and subject to desiccation. Greens, due to the intensity of management, can accumulate a lot of thatch. Bentgrass produces more thatch than other turf species.

#### **Appearance:**

A layer of dead or decomposing plant material between the turf and the soil.

#### **Conditions:**

- High nitrogen fertilization
- Excessive watering
- Low pH

#### **Cultural options:**

- Manage fertility and irrigation to control thatch to be less than ½ inch.
- Verticut to remove excess thatch. Thinning the density will open the thatch layer and accelerate decay.
- Topdressing is essential. Topdressing fills in the gaps reproducing a soil matrix. The firmness of the green will also be improved.
- Minimizing pesticide inputs helps maintain an active microbial population.

### **Root Interference:**

Roots from adjacent shrubbery and trees can compete for available nutrients and water. Typically, the turf and adjacent plants will be weakened.

#### **Appearance:**

Turf will develop symptoms of drought stress and have an undernourished growth habit demonstrated by reduced shoots, thin stands and poor recovery.

#### **Cultural options:**

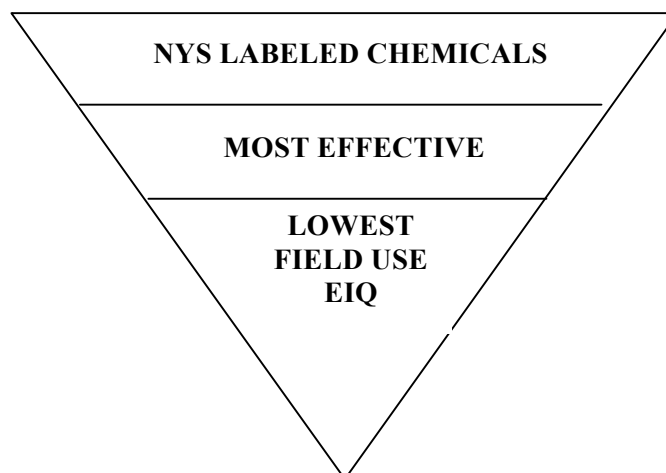
- Maintain buffer zones around trees and ornamentals using mulches.
- Prune roots as necessary using caution not to create another problem by chopping off a tree's root system. Consult with arborists as the situation dictates.

## Chapter 4

### Pest Management and Chemical Selection

There are many synthetic pesticides registered for use on turfgrass in New York. The *Pest Management Guidelines for Commercial Turfgrass*, published by Cornell University provide references to many of the pest problems, the pesticides registered, and their classifications. The Pesticide Ingredient Manufacturer System (PIMS) (<http://pims.psur.cornell.edu>) provides a complete listing of the trade names registered for each of the recommended pesticides. PIMS also provides an electronic copy of the NYS and EPA labels for each pesticide. It is the best reference for ensuring a product is registered in New York.

Pesticide selection is best accomplished by considering the three E's: efficacy, economics and environment. The Bethpage project provided some unique insight into product usage and performance. However, due to the systems nature of the study it is difficult to determine direct effectiveness of any one pesticide. The success at Bethpage was determined to be the result of a combination of management practices, biological treatments and soil amendments, and the combination of products. Therefore, this handbook features chemical treatments for pests that have been field tested by university researchers to determine the most effective treatments. The pesticides with the best efficacy are then evaluated for their environmental compatibility using the Environmental Impact Quotient (EIQ) and the EIQ Field Use Rating. From a list of choices, the turf manager can then compare and select the most economical.



**Figure 4: Pesticide Selection Criteria**

The EIQ is a value assigned to a pesticide that is calculated based on 13 different criteria. The factors account for persistence in the soil, the potential for leaching or run-off, and the toxicity to humans, wildlife, and non-target organisms. The EIQ is a quantitative assessment of the ecological impact of a pesticide. However, the EIQ, by itself, is only an index of the active ingredient of the pesticide. Calculations must take into account the percent active ingredient and the rate of application. Therefore, the Field Use Rating for a particular pesticide product is calculated from the EIQ of the active ingredient, the percent active ingredient, and the application rate. The Field Use Rating can be summed for a series of applications or a pest management strategy. Selecting a pesticide with the lowest Field Use Rating is the basis of chemical substitutions to lower the environmental impact of pest management. Appendix 6 provides additional information on the EIQ and Field Use Ratings.

In several cases, biological controls are recommended. The efficacy of biological control programs is often not as effective under periods of high pest pressure but they may still allow for reduced rates of application or longer intervals between applications of traditional pesticides. In addition, new technology is becoming available each year that will reduce our reliance on traditional pesticide chemistry. Commonly used biological and biologically-based controls include:

*Bacillus licheniformis* (Ecoguard)  
*Bacillus subtilis* (Rhapsody)  
*Trichoderma harzianum* (Turfshield)  
*Pseudomonas aureofaciens* (Spotless)  
Spinosad (Conserve)  
Boscalid (Emerald)  
Mineral Oils (Civitas)

This handbook divides pest management into three groups: Plant Diseases, Insects, and Weeds. Each section reviews keys to the identification of pest problems, the conditions that cause or accompany these problems, cultural recommendations and suggested chemical and biological controls. Pest management is dynamic. Conditions vary from course to course, and factors, specific to your course, may dictate modifications.

This handbook provides information and recommendations on alternative management practices and reduced-risk controls that have proven successful in the field studies at Bethpage. The work at Bethpage resulted in several significant milestones:

- IPM greens received 66% fewer traditional chemical pesticide applications than the unrestricted (conventional) greens.
- Although the IPM and conventional greens received a similar number of fungicide applications, over two thirds were reduced-risk products in the IPM treatments.
- The IPM greens received 75% fewer chemical insecticides than the conventional greens, and only limited area herbicide applications were required in any treatment.
- The overall environmental impact was reduced by 50-95% based on Field EIQ ratings.

## Chapter 5

### Pest Management

#### Plant Diseases

The most prevalent disease pathogens in golf turf are fungal agents. Fungi are generally present in the soil matrix throughout the year, but competition with other soil organisms and healthy plant defenses can keep infection low or non-existent. Certain environmental conditions promote infection and rapid colonization of plant tissue. The process can be very fast and the damage can accelerate within a few days of the first signs of symptoms.

As reported in a survey of NYS Park golf courses, five diseases were commonly reported problems. Two of the most reported disease problems in NYS are Dollar spot and Pink Snow Mold. Anthracnose is also a chronic problem for *Poa* on greens. Brown Patch and Summer Patch were also noted. These diseases are presented in each of the following sections. A brief description includes characteristics for identification, environmental conditions that favor the disease formation and management options. Additional references can be obtained from Cornell's *Pest Management Guidelines for Commercial Turfgrass* and from the *Compendium of Turfgrass Diseases* (Smiley 2005).

Reviewing each of the individual disease profiles, some factors are recurring themes:

- Drainage:** Improved drainage is critical to promoting the correct soil conditions and minimizing leaf wetness.
- Irrigation:** Irrigation schedules and the uniformity of coverage are important factors.
- Fertility management:** Consistent nitrogen fertility helps a plant fend off disease.
- Stress management:** Turf is more susceptible to disease under stress conditions.
- Timing:** Disease incidence coincides with specific seasonal or climate conditions. A pest FORECAST is provided by the NRCC. (<http://www.nrcc.cornell.edu/grass/>).

Successful disease management can then be achieved by adopting proper cultural practices to insure the best possible conditions for maintaining plant health, implementing preventative practices using seasonal indicators to identify high risk periods, and adopting a series of biologically-based amendments to fortify the plant and soil to ward off disease. There are times when signs of pathogens may be seen and some symptoms may surface. Some of these times will occur as result of unusual weather patterns. The incidence is typically below the thresholds. Healthy turf can withstand minor outbreaks and rebound quickly as conditions return to normal.

At other times, conditions that favor disease development may continue. These conditions may coincide with noted high risk periods for the disease. The signs and symptoms continue to increase extending above threshold levels. This triggers the need for intervention and treatment using chemical control.

The *Pest Management Guidelines for Commercial Turfgrass* list a variety of possible chemical treatments. The University of Kentucky compiles research reports and evaluates treatments for efficacy (Vincelli 2008). This handbook presents only those treatments with high efficacy ratings and low EIQ Field Use Ratings. Many of the suggested alternatives are classified as reduced risk chemicals. Some biological controls are also shown.

Using recommended NYS label rates, the EIQ Field Use Ratings are calculated. Where applicable, the values are shown for the low (preventative) rate and the high (curative) rate. Some chemicals are stipulated at only one preventative rate. These are shown as the median Field Use Ratings. Any recommendations in this handbook are not a substitute for pesticide labeling. Read the label before applying any pesticide.

There is a growing trend of fungicide resistance limiting the effectiveness of chemical control. Chemicals should be rotated by class and mode of action. Information on the resistance classification of chemicals can be obtained from the Fungicide Resistance Action Committee (FRAC) at [www.frac.info](http://www.frac.info). Each fungicide presented in this handbook is identified with its corresponding FRAC code.



**Dollar spot:****Agent: *Sclerotinia homoeocarpa*.****Species Affected:**

All cool-season turfgrass except perennial ryegrass

**Appearance:**

On greens, the early symptoms are small spots of blight measuring 2-3 inches. In early morning dew, they will be covered with white cottony patches. Unchecked, the spots will coalesce into large areas of tan-colored turf. On greens, the spots will eventually sink forming a pitted surface. Higher cut turf will exhibit much larger blighted areas measuring from 6 inches to 12 feet.

**Signs:**

On closer inspection the leaves have yellow-green blotches that progress to a water soaked or hourglass appearance. These progress to a yellow tan spot with reddish brown borders.

**Ideal Conditions for Disease Development:**

- Warm days (60-90°F) and cool nights (above 50°F)
- Prolonged leaf wetness, dew and high humidity (>85%)
- Dry soils with low nitrogen fertility

**Cultural Management Options:**

Dollar spot has been shown to be most virulent on sand-based greens and less virulent on push-up greens - possibly due to more consistent surface moisture that prevents drying that leads to increased dollar spot.

- Rolling three times a week has reduced dollar spot infestation.
- Remove dew as early in the morning as possible (mowing, rolling, whips).
- Maintain adequate and consistent N fertility.
- Reduce compaction and minimize surface organic matter accumulation.
- Water to avoid drought stress. Avoid nighttime irrigation that prolongs leaf wetness.
- Remove grass clippings.
- Check FORECAST model to assess risk level.

**Intervention:**

There are many products labeled to treat dollar spot. The following pesticides have been identified to have good efficacy in field tests.

<b>Table 5: Pesticide Recommendations for Dollar Spot</b>					
<b>Fungicides</b>	<b>FRAC Code</b>	<b>Some Trade Names</b>	<b>EIQ Field Use Rating*</b>		
			<b>Low Rate</b>	<b>Median Rate</b>	<b>High Rate</b>
Boscalid	7	Emerald	7	8	9
Fenarimol	3	Rubigan AS	4	6	9
Iprodione	2	Chipco 26019, Lescro 18, ProTurf Fluid, Iprodione Pro	50	58	66
Propiconazole	3	Banner MAXX, Spectator, Dorado	6	15	25
Thiophanate-Methyl	1	Cleary's 3336, Fungo Flo, Cavalier	65	97	130
Triadimefon	3	Bayleton, Granular Turf	18	28	37
Vinclozolin	2	Curalan, Touché	-	24	-
<b>Biocontrols</b>					
<i>Bacillus licheniformis</i>	NC	Ecoguard	0	0	1
<i>Bacillus subtilis</i>	NC	Rhapsody	1	2	3
<i>Pseudomonas aureofaciens</i>	NC	Spot-less	<1	<1	<1
* EIQ Field Use Ratings can vary by mfg label % AI and/or application rates NC: Material of biological origin is not classified by FRAC					

**Additional Notes:**

- Early season applications of vinclozolin have been shown to delay onset of dollar spot and reduce overall chemical use for dollar spot control over the season.
- Note that the use of azoxystrobin or flutolanil to treat other diseases has led to an increase in dollar spot incidence.
- Treatments made after the dew was removed have been found to be more effective.
- The use of a wetting agent has also been noted to reduce disease severity.

**Recommendations based on effective management at Bethpage:**

- Intensive applications of *Pseudomonas aureofaciens* and *Bacillus licheniformis* as biocontrols have been shown to reduce dollar spot infestations.
- Propiconazole and Triadimefon
- Vinclozolin

**Tolerance Threshold:** 0.2 patches per square foot (= 1.8 / sq yd)

**Summer patch:**

**Agent: *Magnaporthe poae***

**Species Affected:**

- Kentucky bluegrass and annual bluegrass are highly susceptible.
- Fine fescues are moderately susceptible.
- Creeping bentgrass and perennial ryegrass are highly resistant.

**Appearance:**

- First appears as a gray-green wilted 4-6 inch patch.
- Grows in a outward, radial pattern. Progresses to yellow to straw colored circular patches (up to 20 inches in diameter), rings and crescent patterns. Patches may blend together. Unaffected bentgrass or ryegrass may occupy the center of the patch.
- Turf leaves wither and die. Roots and crowns are often blackened.

**Signs:**

Dark black-brown translucent strands running along in parallel with crowns and roots.

**Ideal Conditions for Disease Development:**

- Hot humid weather, most severe when air temperatures are between 85-95°F followed by rain.
- Most active when soil temperatures reach 65-70°F at a 2 inch depth.
- Common in poorly aerated or compacted soil.
- Too frequent watering, high soil pH (>6.0) and low mowing height may increase severity.

**Cultural Management Options:**

- Maintain adequate soil fertility with pH 5.5-6.0 and use acidifying fertilizers such as ammonium sulfate in the spring.
- Improve drainage and irrigate to prevent drought stress.
- Aerate to loosen compaction.
- Increase height of cut.
- Once infected, light and infrequent watering increases the disease severity and amount of root rot. *M. poae* has a competitive advantage over the turf root system, even in drought conditions. While the pathogen population may be lower, the pathogen has adapted to lower soil water content. The plant under drought stress loses its disease resistance.

- Without adequate levels of nitrogen, chemical treatment will be ineffective. Nitrogen levels have to be maintained, even in peak summer conditions, to defend against summer patch.

**Intervention:**

In areas with summer patch history, when soil temperatures reach 55°F at 2 inch depth for five consecutive days, begin preventative fungicidal treatment.

<b>Table 6: Pesticide Recommendations for Summer Patch</b>					
<b>Fungicides</b>	<b>FRAC Code</b>	<b>Some Trade Names</b>	<b>EQ Field Use Rating*</b>		
			<b>Low Rate</b>	<b>Median Rate</b>	<b>High Rate</b>
Azoxystrobin	11	Heritage	7	11	15
Propiconazole	3	Banner MAXX, Spectator, Dorado	-	25	-
Triadimefon	3	Bayleton, Granular Turf	37	55	73
Trifloxystrobin	11	Compass	8	9	10

\* EQ Field Use Ratings can vary by mfg label % AI and/or application rates

**Recommendations based on effective control at Bethpage**

Cultural management has kept this disease in check and when plants have shown symptoms additional fertilizer and water are used to nurse the weakened root systems.

**Tolerance Threshold:** 2 patches/green

## **Brown Patch**

**Agent: *Rhizoctonia solani***

### **Species Affected:**

All cool season turfgrass species

### **Appearance:**

- First appears as dull tan leaf lesions, enlarging with reddish brown margin, expanding to the entire leaf surface. The leaf browns with a dry brittle texture, but usually retains its shape in contrast to other disease symptoms where wilting disfigures the leaf.
- Initial patch formation is irregularly shaped and purplish green. In hotter weather, purplish smoke rings often border the circular patches. The rings expand outward.
- A musky odor often can be detected 12-24 hours before the disease appears.
- As the disease progresses, leaf death causes the patches to become brown. Algae may form over the affected area complicating identification and recovery.
- On higher cut turf, the turf develops large blighted areas with no distinct margins.

### **Signs:**

- At warmer temperatures, masses of fungal threads are typical and may be seen later in the season as hardened nodules on the plant.
- Dark brown to black or off-white and pale spores are often embedded in the plant tissue or on the surface of the soil.

### **Ideal Conditions for Disease Development:**

- Growth is initiated when air temperatures reach 65° F, accelerating as temperatures increase.
- At 90° F, infection ceases.
- Rainy, humid conditions and prolonged leaf wetness.
- Increased severity at excessive levels of nitrogen.

### **Cultural Management Options:**

- Use moderate nitrogen fertilization during environmentally conducive weather. Disease is more likely when excess nitrogen is applied, particularly quick release nitrogen.
- Reduce leaf wetness by dragging or mowing.
- Improve drainage.
- Reduce thatch where fungus lays dormant.
- Air circulation can help reduce soil moisture and leaf wetness while also lowering the surface and soil temperatures that are conducive to disease formation.

**Intervention:**

- There is a considerable latent period between infection and the demonstration of symptoms.
- Turf loss associated with brown patch is rare, and while some thinning may occur, persistent warm night time temperatures have not proved problematic.
- Increase air movement, as persistent leaf wetness is a major factor.
- Check FORECAST website for disease risk levels.
- Insecticides and herbicides have been shown to increase the disease severity.

<b>Table 7: Pesticide Recommendations for Brown Patch</b>					
<b>Fungicides</b>	<b>FRAC Code</b>	<b>Some Trade Names</b>	<b>EQ Field Use Rating*</b>		
			<b>Low Rate</b>	<b>Median Rate</b>	<b>High Rate</b>
Azoxystrobin	11	Heritage	7	11	15
Flutolanil	7	Prostar	66	81	97
Iprodione	2	Chipco 26019, Lescro 18, ProTurf Fluid, Iprodione Pro	-	66	-
Phosphite Salts	33	Alude, Vital, Kphite	32	49	65
Polyoxin D	19	Endorse	-	7	-
Trifloxystrobin	11	Compass	4	7	10
<b>Biocontrols</b>					
<i>Bacillus licheniformis</i>	NC	Ecoguard	<1	<1	1
<i>Bacillus subtilis</i>	NC	Rhapsody	1	2	3
<i>Pseudomonas aureofaciens</i>	NC	Spot-less	<1	<1	<1
* EQ Field Use Rating can vary by mfg label % AI and/or application rates					
NC: Material of biological origin is not classified					

**Recommendations based on effective management at Bethpage:**

*Pseudomonas aureofaciens*

*Bacillus licheniformis*

Azoxystrobin

Polyoxin D

Alude

**Tolerance Threshold:**

2 patches/green

**Additional Notes:**

Another species, *Rhizoctonia cerealis*, is separately identified as causing Yellow Patch in cool weather conditions. It survives in the soil and thatch. It is particularly aggressive with annual and Kentucky bluegrass by infecting the crowns and the roots. Infection and colonization of the leaves will also occur in cool (50-65° F) and wet conditions. The symptoms are distinctive foliar chlorosis (yellowing) that begins at the tips and moves downward. If conditions persist, the crown and roots may become brown or black. If weather warms, the turf may fully recover. It produces straw colored patches up to 3 feet in diameter, the patches often merge forming a mosaic and the turf in the center of the patches may recover giving the patch a “frogs eye” appearance. The patch will often be sunken as thatch in the center is decomposed. *R. cerealis* is evident as fungal threads around the crown or lower leaf. Cool season brown patch rarely results in turf loss.

**Species Affected:**

All cool season turfgrass can be affected, but severe outbreaks are most likely on annual bluegrass putting green turf or turf weakened by another pest or stress.

**Appearance:**Basal Root Rot Anthracnose:

- During cool wet weather, plants will develop a basal rot seen as a dark brown discoloration at the bases of leaf sheaths and stems.
- Patches develop from ½ to 20 inches turning from yellow to red to brown.
- The leaf stem lesions appear to be water soaked. The shoot base easily detaches and is discolored, usually blackened.

Foliar Blight Anthracnose (*C.cereale*):

- Reddish brown then yellow lesions on the leaf blade and sheath.
- During warm weather, annual bluegrass will yellow from the tips down. Under extreme temperatures, the entire leaf will yellow.
- The turf takes on a blotchy appearance from yellow-green, to yellow and finally to brown in irregular patches ranging from a couple of inches to several feet across.

**Signs:**Basal Root Rot Anthracnose:

There are grayish-brown to black fungal structures covering the stem bases. These structures appear to have small black spines protruding.

Foliar Blight Anthracnose:

The spiny fungal structures will be noted on the leaf as well as the stem bases.

**Ideal Conditions:**

Both conditions only occur when the turf is highly stressed. Anthracnose will usually accompany other pathogenic diseases that have themselves induced stress on the plant. Many of those diseases are also foliar blight diseases. Separating the pathogens on foliar symptoms alone can be difficult.

Basal Root Rot Anthracnose:

- Conditions are usually prevalent in late spring and early fall.
- Temperatures of 55-70°F accompanied by wet weather.

Foliar Blight Anthracnose:

- Conditions are usually prevalent in mid-summer.
- Warm temperatures (>78°F).
- Wet and humid conditions.



**Cultural Management Options:**

- Reduce compaction.
- Reduce mowing frequency and increase rolling.
- Raise mowing height.
- Maintain adequate fertility (N>3 lbs/1000/yr).
- Minimize leaf wetness, but syringe as necessary to remove heat stress.
- Water to avoid drought stress.
- Improve drainage.
- Limit thatch to less than 0.50 inch.
- Frequent and light topdressing.
- Utilize plant growth regulators\*.

\* Growth regulators and some fungicides that act like growth regulators should be avoided in peak summer time. The use of mefluidide or ethephon alone has resulted in increased severity. However, using mefluidide with trinexapac-ethyl for seedhead suppression consistently reduced anthracnose.

**Intervention:**

Preventative applications of fungicides should start in mid-April and continue to mid-October. Prevention is often attained by selecting an early season Dollar spot control that is also labeled for Anthracnose.

<b>Table 8: Pesticide Recommendations for Anthracnose</b>					
<b>Fungicides</b>	<b>FRAC Code</b>	<b>Some Trade Names</b>	<b>EIQ Field Use Rating*</b>		
			<b>Low Rate</b>	<b>Median Rate</b>	<b>High Rate</b>
Azoxystrobin	11	Heritage	7	11	15
Fludioxonil	12	Medallion	8	12	16
Phosphite Salts	33	Alude, Vital, Kphite	32	49	65
Polyoxin D	19	Endorse	-	7	-
Thiophanate-methyl	1	Cleary's 3336, Fungo Flo, Cavalier	65	130	195

<b>Table 8: Pesticide Recommendations for Anthracnose</b>					
<b>Fungicides</b>	<b>FRAC Code</b>	<b>Some Trade Names</b>	<b>EIQ Field Use Rating*</b>		
			<b>Low Rate</b>	<b>Median Rate</b>	<b>High Rate</b>
Trifloxystrobin	11	Compass	6	8	10
<b>Biocontrols</b>					
<i>Bacillus licheniformis</i>	NC	Ecoguard	0	0	1
<i>Bacillus subtilis</i>	NC	Rhapsody	1	2	3
<i>Pseudomonas aureofaciens</i>	NC	Spot-less	<1	<1	<1
* EIQ Field Use Rating can vary by mfg label % AI and/or application rates					
NC: Material of biological origin is not classified					

**Recommendations based on effective management at Bethpage:**

This disease was rarely a serious problem, because mowing heights had been increased.

**Tolerance Threshold:**

detection

**Pink snow mold (Fusarium Patch)**

**Agent: *Microdochium nivale***

**Species Affected:**

All cool season turfgrass. Annual bluegrass is highly susceptible. Creeping bentgrass is also more susceptible than the other species.

**Appearance:**

- First appears as 2-3 inch circular spots with reddish-brown then tan centers.
- Leaves appear water-soaked and mat together with a pink outer margin.
- On turf with a high population of annual bluegrass, the edges will appear reddish brown.
- The patches may expand up to 12 inches within 72 hours of symptom development.

**Signs:**

- Under conditions of prolonged leaf wetness and low temperatures, pink spore clusters may develop on the leaves.
- White or dull pink fungal masses may develop at the edges of the patches and are typically seen early in the morning. Fungal threads are pale salmon colored.

**Ideal Conditions for Disease Development:**

- Usually associated with snow covered turf. Infection and disease can occur without snow cover under wet cool temperatures (32-45°F). Typically associated with late fall to early spring.
- Wet, moist soil conditions.

**Cultural Management Options:**

- Apply moderate nitrogen levels in late fall, avoiding late season growth.
- Maintain a low soil pH (5.7-6.3).
- Avoid mowing when disease is active, as streaking can occur.
- Turf should not be left uncut in the fall, and mulches of fallen leaves should be removed.
- Drifting snow should be controlled. Prevent compaction or physically remove snow.

**Intervention:**

On established turfgrass that consistently experiences the disease, apply a preventive fungicide in November and repeat in mid to late January if snow cover melts and unusually temperate weather prevails.

<b>Table 9: Pesticide Recommendations for Pink Snow Mold</b>					
<b>Fungicides</b>	<b>FRAC Code</b>	<b>Some Trade Names</b>	<b>EIQ Field Use Rating*</b>		
			<b>Low Rate</b>	<b>Median Rate</b>	<b>High Rate</b>
Iprodione	2	Chipco 26019, Lescro 18, ProTurf Fluid, Iprodione Pro	66	99	132
Propiconazole	3	Banner MAXX, Spectator, Dorado	25	37	49
Thiophanate-methyl	1	Cleary's 3336, Fungo Flo, Cavalier	65	97	130
Trifloxystrobin	11	Compass	-	10	-
* EIQ Field Use Rating can vary by mfg label % AI and/or application rates					

**Tolerance Threshold:**

10 patches/green

## Chapter 6

### Pest Management

#### Insects

There are many insects that can potentially be damaging to turf. The damage may be confined to specific stages of their lifecycle and only when populations exceed damage thresholds. Seasonal patterns of turfgrass insects are presented in the appendix.

Scouting the course to monitor for insects is an essential step of IPM that will allow you to quantify how abundant the insects are by location and to determine the life stage of those insects. In addition to a visual inspection there are two scouting methods that can be used.

1. Pour a **disclosing solution** over and around the area of inspection. (The solution is made of two tablespoons of dishwashing detergent with 1 gallon of water). The solution will agitate insects and cause them to move to the surface where they can be collected, identified and counted. Disclosing solutions are useful techniques for weevils and caterpillars. A variation of this method is called the flotation method which uses a canister open on both ends. Driving the canister into the ground and filling it with water will cause adults and nymphs to float to the surface. This variation is used for hairy cinch bugs.
2. The second method, **digging soil samples**, is primarily used to scout for grubs. Using a flat shovel, peel back one square foot of sod. Sifting through the top 4-6 inches of soil, collect and identify any grubs found. A cup cutter is an easier way to extract samples. A cup cutter is about 1/10 of a square foot.

There are many beneficial species of insects on golf courses. These non-target organisms can be knocked out by broad spectrum insecticides. Therefore, extra care and caution should be exercised when considering the use of chemical controls.

There is a growing trend of insecticide resistance limiting the effectiveness of chemical control of insects on golf courses. Chemicals should be rotated by class and mode of action. Information on the resistance classification of chemicals can be obtained from the Insecticide Resistance Action Committee (IRAC) at [www.iraconline.org](http://www.iraconline.org). Each insecticide presented in this handbook is identified with its corresponding IRAC code.

Descriptions of several common turfgrass insect pests are presented with identification features, cultural management options and control products. The pesticides were selected from efficacy reports published by the University of Kentucky (Potter 2002, 2005), Ohio State University (Shetlar 2008), Rutgers University (Buckley et al 2008) and the USGA (Murphy et al 2008).

**Alert:**

There is a New York State warning on the European Crane Fly (*Tipula oleracea* and *Tipula paludosa*). Areas infested include zones around the southern shore of Lake Ontario and a few locations on the eastern shore.

More information may be obtained at:

[www.agmkt.state.ny.us/caps/pdf/European%20Crane%20Fly%20Pest%20Alert.pdf](http://www.agmkt.state.ny.us/caps/pdf/European%20Crane%20Fly%20Pest%20Alert.pdf).

Contact your local extension agent if you suspect the presence of either of these crane flies on your course.

## **Annual bluegrass weevils (ABW)**

It is generally accepted that the larval stages cause damage to turf. The adults lay their eggs in *Poa annua* stems. The first instars will bore into the stems disrupting the plants vascular system. After the 3<sup>rd</sup> instar, the larvae emerge from the stems and drop down where the final two instars feed on the crowns. The fifth instar will pupate in the soil leading to the second generation. There can be as many as 2-3 generations per year.

### **Species Affected:**

*Poa Annua*

### **Appearance:**

The turf will have a wilted, yellow appearance generally occurring at the peripheral edge of the fairway and first intermediate cut. Typically, when tugged, the plant will break off where larvae have fed.

### **Identification:**

Adults are small, dark grayish brown to black beetles approximately 0.1 inch in length with a broad, short snout. Fifth instar larvae are approximately 0.2 inches in length. The bodies are cream colored with a distinctive brown head capsule. The ABW larvae are distinguished from other grubs by the absence of legs.

### **Cultural Management Options:**

- Minimize stress on the perimeter of the fairway.
- Maintain sufficient soil moisture (e.g. check irrigation coverage).
- Maintain proper fertility levels.
- Keep surrounding woodlands floor clean of debris.

### **Treatment:**

There are 2-3 generations of weevils each year. The over-wintering adults move out from wooded areas next to fairways and greens. Studies are finding that this migration typically occurs in two distinct waves. Treating too early will miss the second wave. Monitoring and timing treatments is critical to control. Treat adults before they lay their eggs or while larvae are in the fourth and fifth instar outside of the stem.

- Preventative treatment at the late blooming stage of forsythia will catch the first wave of adults before they lay their eggs.
- Many reports are indicating ABW's increasing resistance to pyrethroid control. You can test for resistance by obtaining a test kit from the Connecticut Agricultural Research Station ([www.ct.gov/CAES/](http://www.ct.gov/CAES/)) or your county cooperative extension agent.
- Treating only the peripheral areas will reduce overall chemical application while providing control.

<b>Table 10: Pesticide Recommendations for Annual Bluegrass Weevil</b>					
<b>Insecticides</b>	<b>IRAC Code</b>	<b>Some Trade Names</b>	<b>EQ Field Use Rating*</b>		
			<b>Low Rate</b>	<b>Median Rate</b>	<b>High Rate</b>
Bifenthrin	3A	Talstar	4	7	9
Halofenozide**	18	Mach2	30	36	41
Imidacloprid	4A	Merit	15	17	19
Imidacloprid + Bifenthrin**	4A/3A	Allectus	11	14	18
Indoxacarb	22	Provaunt	1	2	3
Lambda-cyhalothrin	3A	Battle, Scimitar GC	3	3	3
Trichlorfon	1B	Dylox	107	124	141
<b>BioControls:</b>					
Spinosad	5	Conserve	5	5	5
* EQ Field Use Rating can vary by mfg label % AI and/or application rates					
** Not for use on Long Island					

**Thresholds:**

		<u>larvae / ft<sup>2</sup></u>
Spring Damage		30-80
Summer Damage		10-40



## **White Grubs**

White grubs are scarab beetle larvae that feed on turf roots. Most damage is caused by third instar larvae in late summer and fall, as they feed prior to overwintering. There are eight common species in New York, including the Japanese beetle, European chafer, Oriental beetle and the Black turfgrass *Ataenius* beetle. Lifecycles vary by species, but most have a one year cycle with eggs being laid in June or July. The beetles are quite adept at flying, so controlling the adult beetle does not typically control grub populations.

### **Species Affected:**

All cool season turfgrass species

### **Appearance:**

- Thinning turf, often with a wilted appearance.
- Spongy, soft surface.
- Heavily damaged turf peels back from the soil easily because roots have been severed. Damage is often seen where animals roll back the turf to feed on grubs.

### **Identification:**

- The white grub is characteristically described as a “C-shaped”, often bulbous scariform larva.
- Larvae have six pro-legs and well developed mandibles.
- Each of the species can be determined by a unique raster pattern at the end of the abdomen. For more information:  
[http://www.umassturf.org/publications/fact\\_sheets/insects/white\\_grub\\_ID.pdf](http://www.umassturf.org/publications/fact_sheets/insects/white_grub_ID.pdf).
- Disclosing solutions will not work on white grubs. Sampling is accomplished by digging a sample and sifting through the soil.

### **Ideal Conditions:**

- Moist but not wet soil.
- Adults prefer certain host plants and trees. For example, Japanese beetles favor roses, grapes, lindens, oaks and fruit trees. Host plants near high maintenance turf areas may encourage grub problems.
- Moderate to high cut turf. Putting greens are rarely infested.

### **Cultural Management Options:**

- Maintaining a healthy turf with a good root system will mask damage, even when thresholds are exceeded.
- Good aerification.

- Remove excessive thatch.
- Deficit irrigation during egg laying and early instars (July and early August).
- Maintain adequate soil moisture in the fall to encourage turf growth and recovery.
- Maintain adequate fertility but do not apply excessive nitrogen.
- Raise cutting heights to encourage deep rooting and recovery.
- Frequent topdressing increases abrasion.

**Treatment:**

With healthy root systems, treatment is rarely required. Research has shown that chemical treatment was only required 20% of the time on healthy turf in upstate New York. However, high profile areas could be designated for treatment once thresholds levels are observed. Putting greens rarely have high grub populations and therefore rarely warrant treatment with pesticides. Generally, the third instars – the easiest instar to detect – is most resistant to chemical treatment.

- The best period for preventative control is from mid June thru the end of July.
- Spinosad is not effective against grubs.

<b>Table 11: Pesticide Recommendations for White Grubs</b>					
<b>Insecticides</b>	<b>IRAC Code</b>	<b>Some Trade Names</b>	<b>EIQ Field Use Rating*</b>		
			<b>Low Rate</b>	<b>Median Rate</b>	<b>High Rate</b>
Chlorantraniliprole**	28	Acelepryn	2	3	4
Halofenozide**	18	Mach2	30	35	40
Imidacloprid	4A	Merit	15	17	19
Trichlorfon	1B	Dylox	141	141	141
<b>Biocontrols</b>					
Entomopathogenic nematodes***	NA		NA	NA	NA
* EIQ Field Use Rating can vary by mfg label % AI and/or application rates					
** Not for use on Long Island					
*** Results vary and are inconsistent					

**Thresholds :**

Species	Number of grubs per	
	sq. ft	core <sup>1</sup>
Asiatic garden beetle	18-20	2
Black turfgrass ataenius	30-50	3-5
European chafer	5-8	Any
Green June beetle	5	Any
Japanese beetle	8-10	Any
Oriental beetle	8	Any
Northern masked chafer	8-12	Any
May and June beetle	3-4	Any
<sup>1</sup> 4.25-inch diameter soil core of the standard golf course cup cutter		
NYS Guidelines for Commercial Turfgrass		

**Table 12: Threshold levels for White Grubs**

These thresholds are based on damage to turf caused directly by larvae feeding on the roots. Some situations exist where animal populations are high enough that the primary damage is caused by animals digging up the turf. In these cases where damage is widespread, there may be no tolerance for grubs. Measure your situation and select the appropriate action considering the degree of the problem and the environmental impact of your insecticide application.

Even though threshold levels may be observed in the springtime, there is no justification for treatment. This spring population has overwintered from the prior season. This population will not create substantial damage. The majority of their feeding was in the fall. And pesticide treatments are not very effective on 3<sup>rd</sup> instar larvae.

## **Cutworms**

### **Species Affected:**

All cool season turf grasses except Kentucky bluegrass

### **Appearance:**

- The moths lay eggs on the blades of grass. Larvae bore hole into the thatch and soil. They come to the surface at night, chew off the grass plants and pull the plants into the hole for feeding. Cutworms are capable of 2-3 generations a year.
- Damage is a small round discolored turf spot about the size of a ballmark with a small pencil sized burrow hole in the center.

### **Identification:**

- Caterpillars have three pairs of legs at the front and five pairs of prolegs on the back.
- Dark grey with brown and black coloring on their backs. They can be up to 1.75 inches in length.

### **Ideal Conditions:**

The black cutworm moth invades from the south coming in on storm fronts in mid to late spring.

### **Cultural Options:**

- Pheromone traps are a good tool for detection of adult moths. Begin sampling greens for caterpillars with a disclosing solution two weeks later.
- Maintaining healthy turf minimizes damage.
- Collect clippings (with eggs) and dispose of them at least 200 feet away from greens.
- Cutworms shun Kentucky bluegrass. Maintaining 30 foot wide buffers around greens is a good control.
- The most effect control is early morning mowing (12-4 am) for 3-4 days in a row when the cutworms are moving about the surface of the green.
- Frequent topdressing increases abrasion and discourages cutworms.

<b>Table 13: Pesticide Recommendations for Black Cutworm</b>					
<b>Insecticides</b>	<b>IRAC Code</b>	<b>Some Trade Names</b>	<b>EIQ Field Use Rating *</b>		
			<b>Low Rate</b>	<b>Median Rate</b>	<b>High Rate</b>
Deltamethrin	3A	Deltaguard	1	1	1
Halofenozide **	18	Mach2	-	20	-
Indoxacarb	22	Provaunt	1	2	3
Lambda-cyhalothrin	3	Battle, Scimitar GC	1	2	3
<b>Biocontrol:</b>					
Spinosad	5	Conserve	5	5	5
* EIQ Field Use Rating can vary by mfg label % AI and/or application rates					
** Not for use on Long Island					

**Thresholds:**                      Cutworms    3-8 larvae / yd<sup>2</sup>

## Chapter 7

### Pest Management

#### Weeds

Ralph Waldo Emerson described weeds as plants whose virtues have not yet been discovered. The Weed Science Society of America (WSSA) defines weeds as plants growing where they are not wanted. These perspectives emphasize a very important concept in managing weeds on a golf course. When is a weed a problem that requires management, intervention, and control? A weed is a problem when it disrupts the function of the site and substantially reduces visual quality.

#### **Thresholds:**

Weed management on a golf course should include tolerance thresholds for weeds for distinct areas of the course: greens, tees, fairways, rough, clubhouse lawns and the practice range.

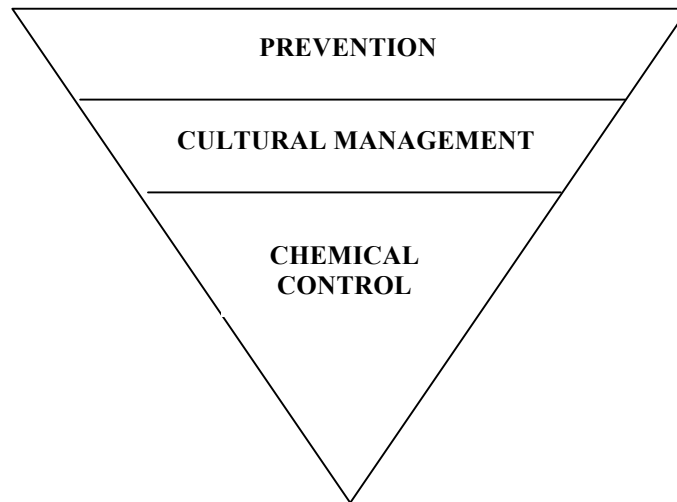
Aesthetic Thresholds: On high value turf, the threshold may be zero. A green and the immediate surround may be designated to have a threshold where no weeds are acceptable on the basis of their appearance. It may be tolerable to have some weeds on tees and fairways, depending on the species and the density of the weeds.

Functional Thresholds: Any weed that will disrupt play is interfering with the function of the game. Obviously, there is no tolerance for weeds on a green. Weeds could affect the lie of the ball on a fairway, suggesting that the tolerance be adjusted. There should be some acceptance of weeds in the rough outside of normal play areas.

#### **Weed Management:**

Herbicides are not the cure to weed problems. If the conditions that allowed for a weed problem continue without correction, the weeds will return soon after the herbicide treatment. The most effective control of weeds on your course is prevention. By implementing cultural practices that maintain healthy, vigorous and dense turf stands, weed populations will generally be low. Herbicides should only be considered after implementing preventative cultural practices (figure 5).

There is a growing trend of herbicide resistance limiting the effectiveness of chemical control. Chemicals should be rotated by class and mode of action. Information on the classification of chemicals can be obtained from the Herbicide Resistance Action Committee (HRAC) at <http://www.hracglobal.com>. HRAC works closely with the WSSA. Herbicide labels may be identified by an HRAC classification or a WSSA group number. Each herbicide shown in this handbook is identified with its corresponding WSSA group number.



**Figure 5: Weed Management Strategy**

**Considerations:**

- Weed identification. Determine the species.
- Classification: Annual or Perennial, Grassy weed (GRS) or broadleaf weed (BLW).
- Identify typical timing of germination, seedling stage, and flowering period.
- Weeds are fierce competitors for water and nutrients.
- Annual weeds can be classified as summer annuals, winter annuals or both.
- Annual weeds are very prolific at seed production and seed dispersal across wide areas.
- The soil has thousands of seeds creating a weed seed bank.
- Perennials can also produce large amounts of seed.
- The vegetative growth of perennials through rhizomes, stolons, and creeping stems can quickly colonize an area.

**Ideal Conditions for Weeds:**

A weed problem indicates weak turf conditions:

- Poor growing conditions (light, water, air movement).
- Low mowing heights and scalped turf.
- Inadequate nitrogen.
- Excessive traffic causing wear and soil compaction.

- Improper cultural management.
- Damage or stress from insect or disease or physical disruption.

Some weed species have a niche in particular conditions. For instance:

Algae and Moss:	Excessive surface moisture, poor light, low mowing heights.
Goosegrass:	Soil compaction, low soil aeration.
Clover, Chickweed:	Low soil nitrogen levels.
Plantains:	Compacted areas, high soil pH.
Sedges :	Poor drainage, overwatering.
Sorrell:	Low soil pH.
Quackgrass:	Depleted and/or sandy soil.

### **Cultural Control**

- Buy certified weed free seed.
- Topdressing should be sterilized or verified to be weed free.
- Manage boundary areas to eliminate seed proliferation.
- Thin turf: Fertilize, raise mowing height, and over seed with perennial ryegrass for fast grow in.
- Poorly drained soils: Aerify and install sub-surface drainage if necessary.
- Mechanical Control
  1. Hand pulling: particularly effective for spot problems with annual broadleaf weed species.
  2. Hot Water: Equipment that applies scalding water or steam to weed effectively killing plant cells. Aquacide and Waipuna are two brand names of machinery that can be purchased.
  3. Tilling: In particularly heavily infested areas, tilling may be required to kill the weed and then renovate the area. A method commonly practiced with annual weed species.
  4. Fallowing: Similar to tilling, this method is used for heavy infestations of perennial weeds. The method relies on repeatedly cutting the propagating weed parts to deplete them of their stored resources. This practice is best accomplished in late fall to expose and desiccate the weeds to colder air temperatures.



### **Post Emergence Weed Control Strategy**

Herbicides can be picked based on their selectivity and control. Some herbicides are effective for broadleaf weeds while others are only useful for grassy weeds. In a few cases, some herbicides have good to excellent efficacy across both groups and certain weed species. Among these choices, efficacy tests show better choices for specific weed problems, i.e. sedges, dandelion, or crabgrass. Identification of the weed species and the problem area will help in selecting the specific herbicide. Alternatively, some problem areas may require a non-selective herbicide to “burndown” the weed problem then reseed.

#### **Post Emergent Control of Annuals**

1. Monitor the course to assess weed development and correlate observations with a published germination calendar. Develop a weed map to identify chronic problem areas.
2. Time treatment to target seedlings. Most herbicides lose their effectiveness the older the weed. Timing is critical.
3. In high priority areas:
  - a. Mechanically remove weeds (e.g. greens and tees).
  - b. apply post emergent application with systemic herbicide that is translocated.
  - c. Use spot applications where weed densities permit.
  - d. Broadcast spray only those areas that are widely affected.
4. On medium priority areas, no herbicide is required.
5. Renovate to correct soil compaction and drainage issues.
6. Correct any shade or air restrictions.
7. Over-seed.
8. Maintain adequate fertility and irrigation.

#### **Post Emergent Control of Perennials**

1. Monitor course to assess weed development and correlate observations with published germination calendar.
2. Apply a post emergent systemic herbicide if perennial weed populations are very high.
3. Correct soil compaction and drainage issues and renovate if necessary.
4. Correct any excessive shade conditions and air restrictions.
5. Overseed.
6. Maintain adequate fertility and irrigation.

### **Pre-emergence Control Strategy**

Do not use pre-emergence herbicides routinely; there is no way to determine if there is a weed problem. The tools of monitoring and site assessment are negated if herbicides are applied on a repeated schedule.

Herbicides pose risks of surface water contamination. Indiscriminate use of pre-emergence herbicides is not environmentally compatible.

Dense turf can crowd out weeds and block weed seed germination. Correct any site problems that restrict growth. Renovate and reseed severely thinned areas before considering herbicides.

### **Recommended practice for courses applying pre-emergent herbicides:**

Courses that routinely apply pre-emergent herbicides should reconsider their management options. A significant portion of the pesticide inputs on the course are most likely pre-emergent herbicides. The area treated is probably the largest of any pesticide application. Adopting an alternative strategy can reduce pesticide use and generate economic savings.

### **Greens:**

The alternative strategy for greens emphasizes promoting healthy turf. Tracking weed problems using a map will help assess the problem areas. Focus attention on these problem areas. There is no reason to intervene with herbicides on greens without any problems.

Try hand pulling problem weeds. If intervention is required, consider using a post emergent herbicide in spot applications. Compare the difference in EIQ Field Use Ratings for spot treatments of post-emergent herbicides against blanket treatments of pre-emergent herbicides.

If the weed problem persists after correcting all of the site and cultural management options, and the problem exceeds tolerance thresholds, a pre-emergent application may be warranted. Do not exceed more than one application every three years.

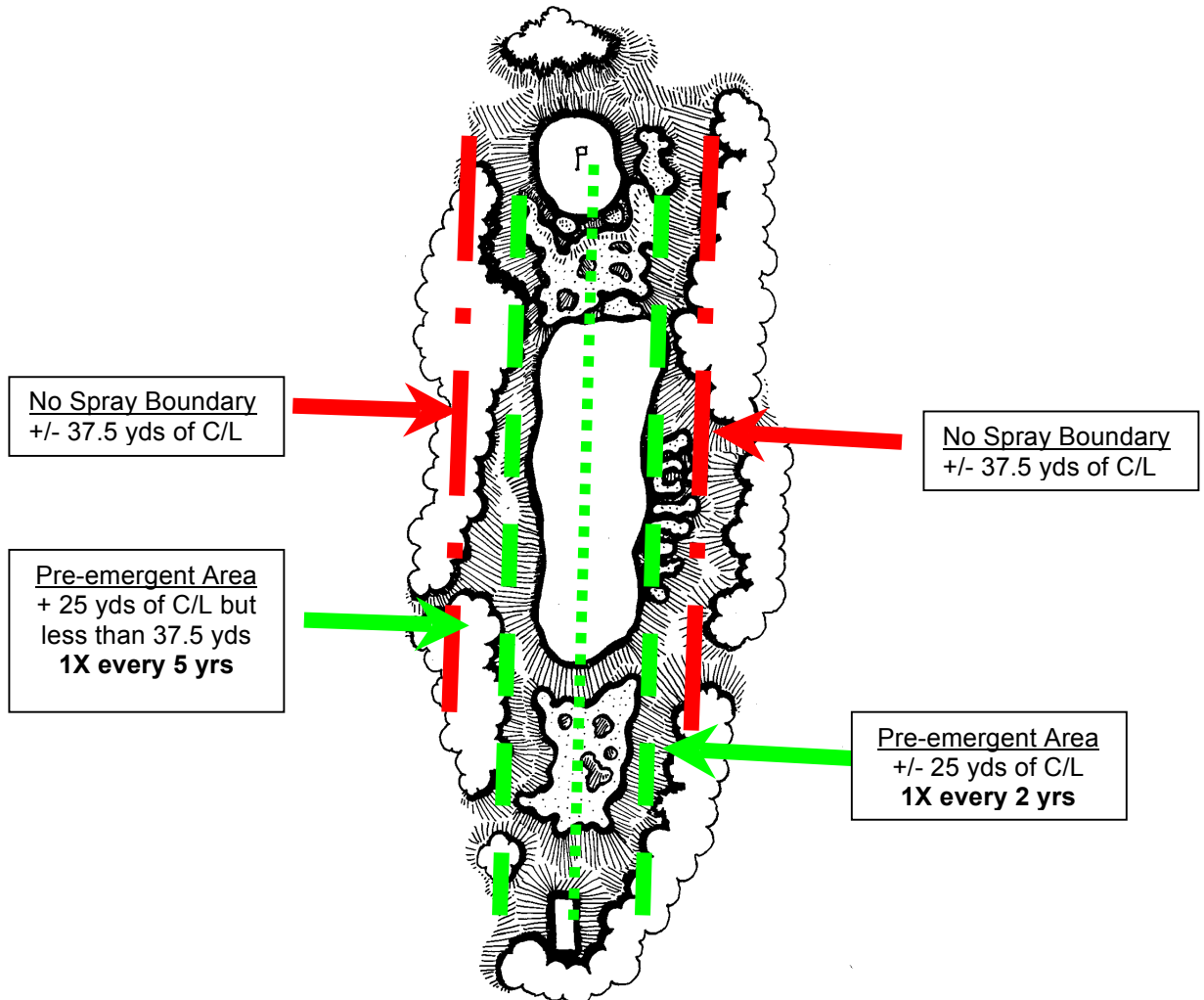
### **Tee to Green:**

Managing the course for weeds from tee to green adopts many of the same points. Monitor the course to identify and map problem areas, correct site conditions, renovate and reseed problem areas. Compare and utilize spot treatments of post emergent herbicides where weed problems are developing.

If herbicides have been routinely applied over the years, the weed seed in the surface layer has probably been depleted. Only significant soil disturbance will bring up additional weed seed. A particular area may also be affected by seed dispersal from an area adjacent to the course. Consider mechanical weed control to cut these weeds before the weeds flower.

If a weed problem exceeds the tolerance thresholds established and intervention is warranted using a pre-emergent herbicide, consider adapting these limits for the area treated and frequency of treatment:

- Within +/- 25 yds of fairway centerline (C/L): No more than 1 application every 2 yrs.
- Within the intermediate area that is outside of 25 yds of the centerline but within 37.5 yds: No more than 1 application every 5 yrs.
- Treat only problem areas.



**Figure 6: Pre-Emergent Herbicide Control Strategy - Tee to Green Application Zones determined by distance from Centerline (C/L)**

(Drawing Courtesy of Renaissance Golf)

**Herbicide EIQ Field Use Recommendations:**

There are many herbicides labeled in New York. Based on efficacy testing provided by Cornell University in the *Pest Management Guidelines for Turfgrass*, only those herbicides that provided “excellent” control (>85%) were selected. These herbicides were then evaluated for their EIQ Field Use Rating. The NYS label will often stipulate a range for the application rates. The EIQ Field Use Rating is shown for the low, median and high rates given. In some cases, the recommended application is a set figure. All of the Field Use Ratings are for only one application. Where labels advise repeat applications, The Field Use Rating would be a cumulative sum.

<b>Table 14: Registered chemical control products for grassy weeds in New York State</b>						
Weed	Strategy <sup>1</sup> (WSSA)	Common Name	Examples of Trade Names	Field Use EIQ*		
				Low Rate	Median Rate	High Rate
Crabgrass, goosegrass and other annual grassy weeds	PRE -3	Pendimethalin	Pre-M, Pendulum	40	48	55
	PRE -14	Oxadiazon	Ronstar, Quali-Pro	89	134	179
	PRE -3	Prodiamine	Barricade	4	8	11
	PRE/EPO -3	Dithiopyr <sup>2</sup>	Dimension 2EW	3	4	5
	POST -1	Fenoxaprop	Acclaim	1	4	7
	PRE/EPO -27	Mesotrione	Tenacity	2	3	4
	POST -17	MSMA	MSMA 6	-	23	-
Yellow Nutsedge	POST -6	Bentazon	Basagran T/O, Lescogran	17	17	17
	POST -2	Halosulfuron	Sedgehammer	27	41	55
Perennial grassy weeds (Quackgrass, Tall fescue, Orchardgrass, etc).	POST -17	MSMA	MSMA 6	-	23	-
	POST -2	Sulfosulfuron	Certainty, Outrider	5	10	15
	NSPOST -9	Glyphosate	Round up, Touchdown	2	2	2
* FIELD USE EIQ varies by mfg label % AI and/or application rates						
<sup>1</sup> Strategy code: PRE= pre-emergence control; EPO= early post emergence (3-5 leaf stage); POST= post emergence; NSPOST= nonselective post emergence control						
<sup>2</sup> Product use restrictions when used on Long Island.						

Weed	Strategy <sup>1</sup> (WSSA)	Common Name	Trade Name	Field Use EIQ*		
				Low Rate	Median Rate	High Rate
Broadleaf weeds (Annuals including: chickweeds, henbit, speedwells.)	PRE -3	Dithiopyr <sup>2</sup>	Dimension	3	4	5
	PRE -14	Oxidiazon	Ronstar	89	134	179
	PRE -3	Pendimethalin	Pre-M, Pendulum	40	48	55
	PRE -27	Mesotrione	Tenacity	2	3	4
	PRE -3	Prodiamine	Barricade	4	8	11
	POST -6	Bromoxynil	Buctril	6	9	12
Broadleaf weeds (Perennials including: dandelion, clover, ground ivy and plantain) (Perennials including: dandelion, clover, ground ivy and plantain)	POST (4+3)	2,4-D + Triclopyr	Chaser, Turflon	14	21	28
	POST -4	Dicamba + Acetic Acid	Cool Power	25	31	37
	POST -4	2,4-D + Clopyrlid + Dicamba	Millennium Ultra <sup>3</sup>	14	18	22
	POST -3	Fluroxypyr + Acetic Acid	Spotlight <sup>3</sup>	7	15	23
	POST (4+14)	MCPA + Carfentrazone + Dicamba + MCPP	Power Zone	40	48	56
	POST (4+14)	2,4-D + Carfentrazone + Dicamba + MCPP	Speed Zone	18	23	29
	PRE -27	Mesotrione	Tenacity	2	3	4
Silvery thread moss	POST -14	Carfentrazone	Quicksilver	2	2	2
* FIELD USE EIQ varies by mfg label % AI and/or application rates						
<sup>1</sup> Strategy code: PRE= pre-emergence control; EPO= early post emergence (3-5 leaf stage); POST= post emergence; NSPOST= nonselective post emergence control						
<sup>2</sup> Product use restrictions when used on Long Island.						
<sup>3</sup> Not for use on Long Island						

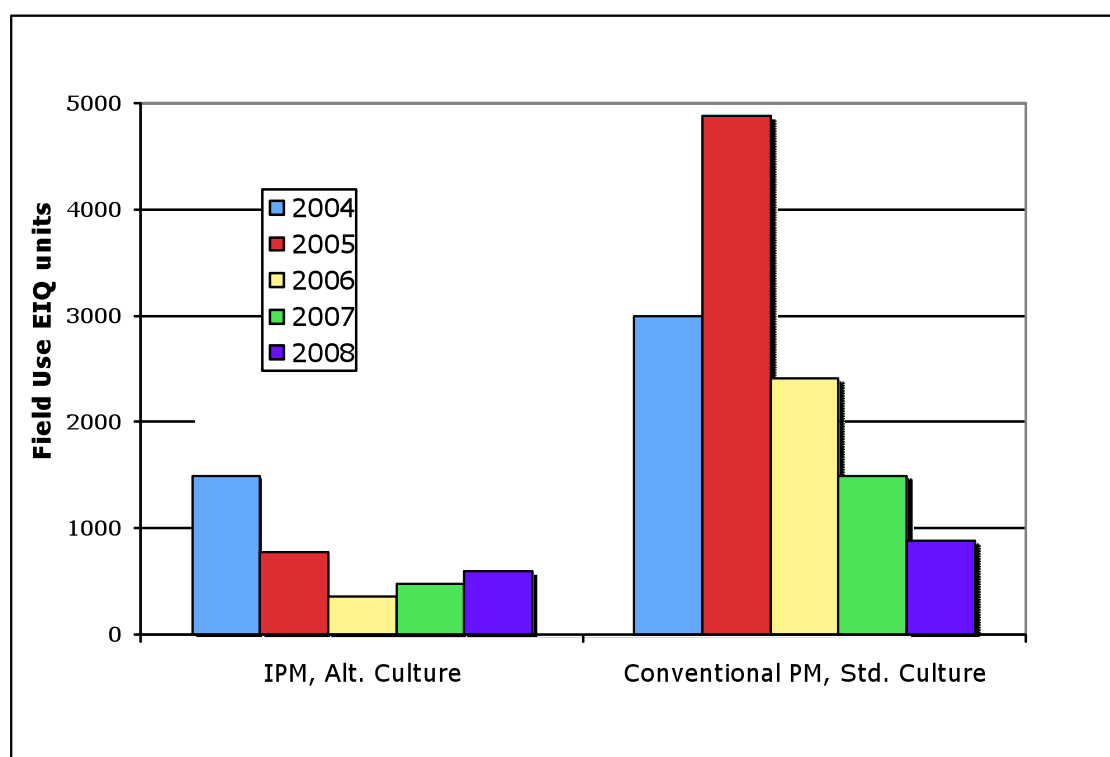


## Chapter 8

### Summary of Results from Bethpage Study to Reduce Chemical Inputs

Work at Bethpage State Park has provided experience to define IPM principles and management practices necessary to sustain a course for the rigors of play while using fewer chemical inputs (Grant and Rossi 2009).

Comparing alternative cultural practices using IPM based pest management with conventional cultural practices using conventional chemical pest management, the environmental impact, as measured by the EIQ (see Appendix 5) was reduced 43-85%, depending on the year.

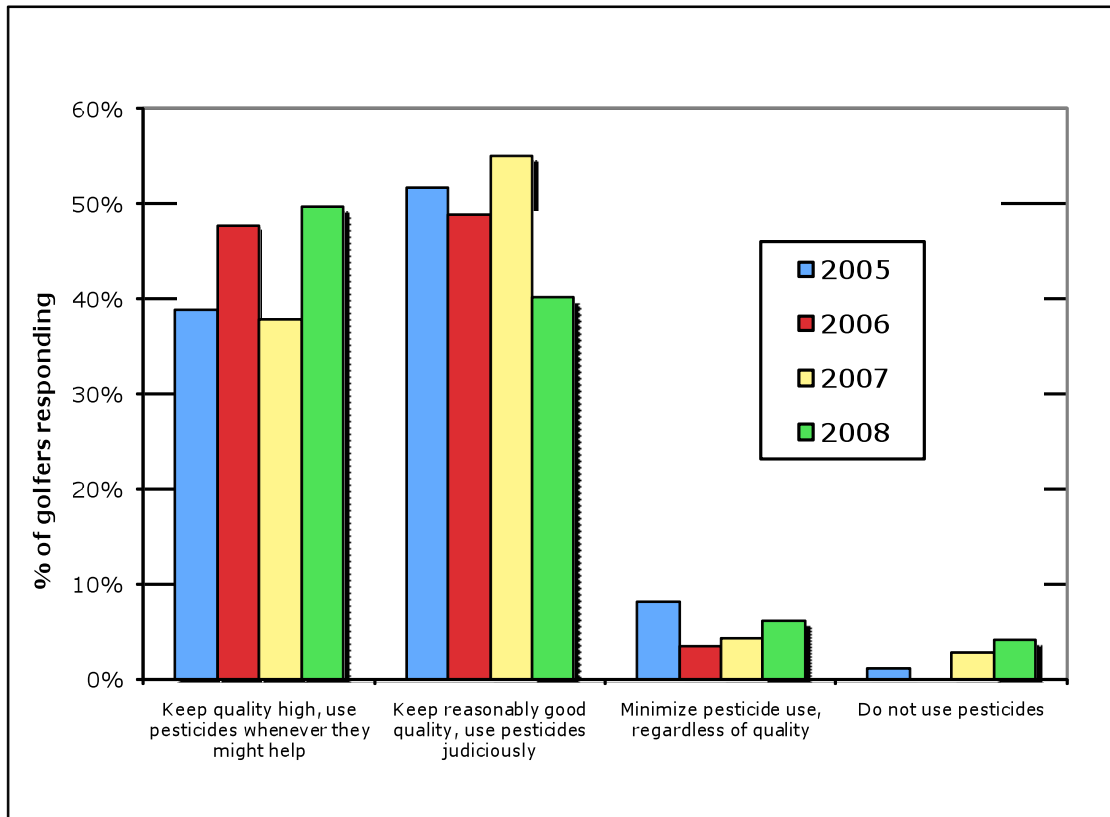


**Figure 7: Comparing Cumulative EIQ Field Use Rating between Alternative Cultural Practices using IPM Pesticide Control and Conventional Cultural Practices using Conventional Management**

Even in peak pressure years, the IPM /Alternative Cultural Management program was able to maintain relatively low total Field Use Ratings. Refinements in the program and new product introductions have aided in improving the results. The EIQ Field Use Rating has steadily declined with experience. It is also notable that some practices and product substitutions have worked into the Conventional PM and Standard Cultural management

program. This is partially due to positive changes industry-wide and partially due to the inevitable transfer of knowledge of successful practices among the staff at Bethpage State Park.

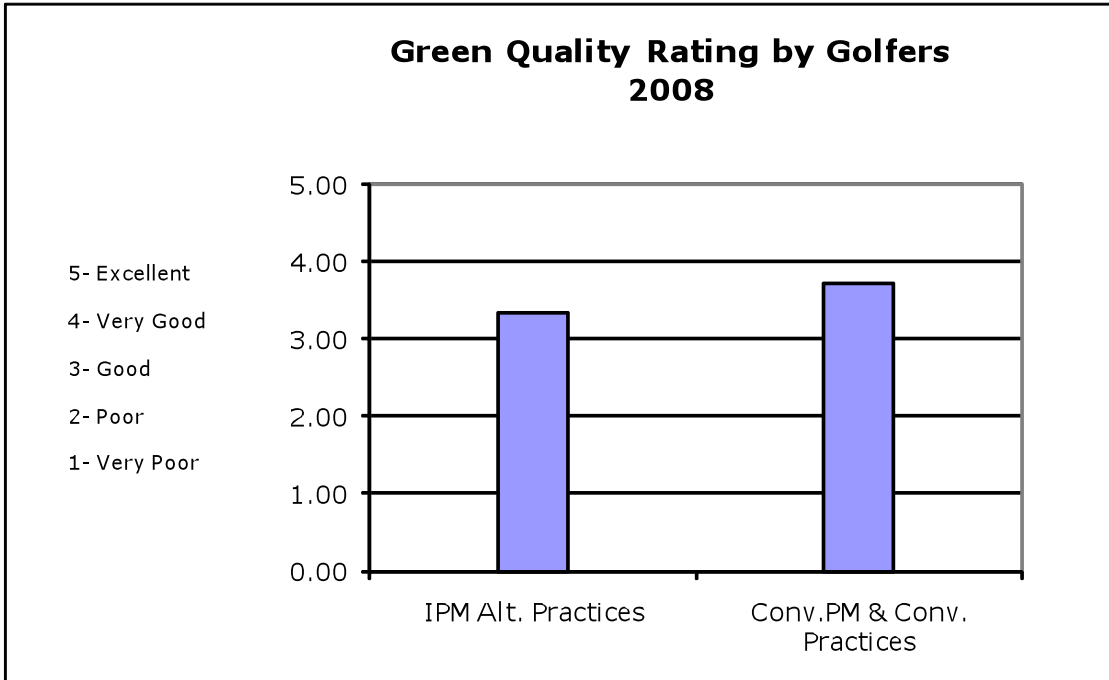
Golfer surveys over a four year period provide insight into golfer perceptions of the course and their expectations for the use of pesticides. When asked about their attitude on pesticide use in general, a clear majority is willing to accept “reasonable quality” using pesticides sparingly.



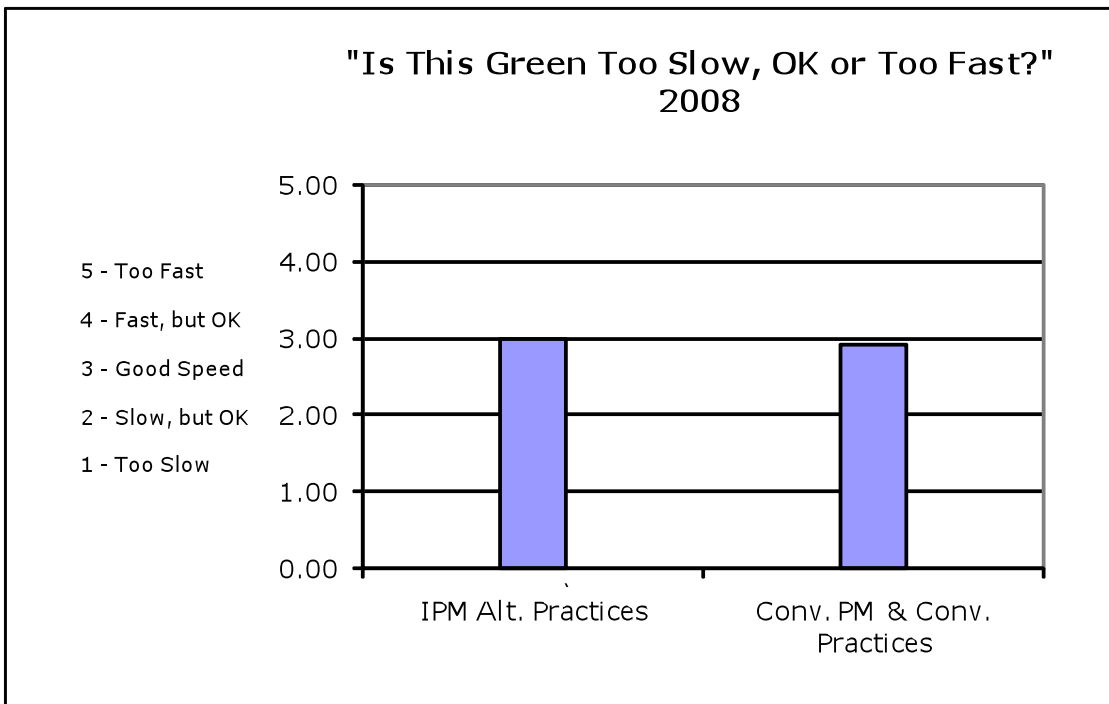
**Figure 8: Bethpage State Park Golfer Surveys for Pesticide Use Preference**

There is also a sizeable group that favors quality and the use of pesticides to keep that quality high. Most importantly, when ranking overall quality and speed of the greens (Figures 9 & 10), the golfers cannot discern a difference between the two management practices.

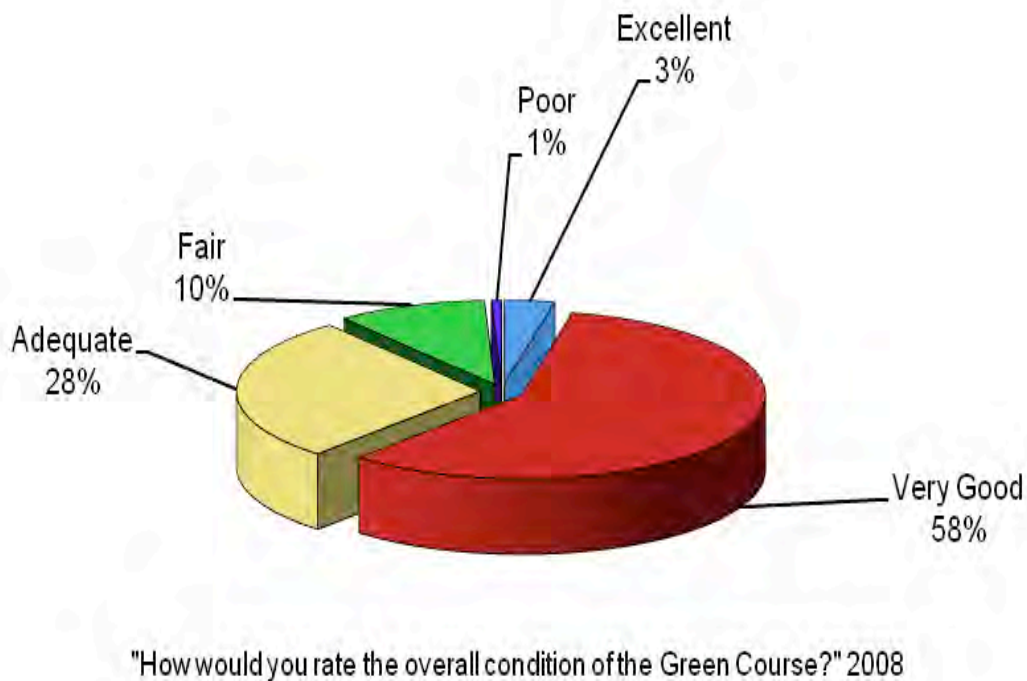




**Figure 9: Bethpage State Park Golfer Surveys for Overall Quality of Greens**



**Figure 10: Bethpage State Park Golfer Surveys for speed of Greens**



**Figure 11: Bethpage State Park Golfer Surveys Overall Condition of the Course**

Eighty six percent of the golfers were satisfied with the overall condition of the course.

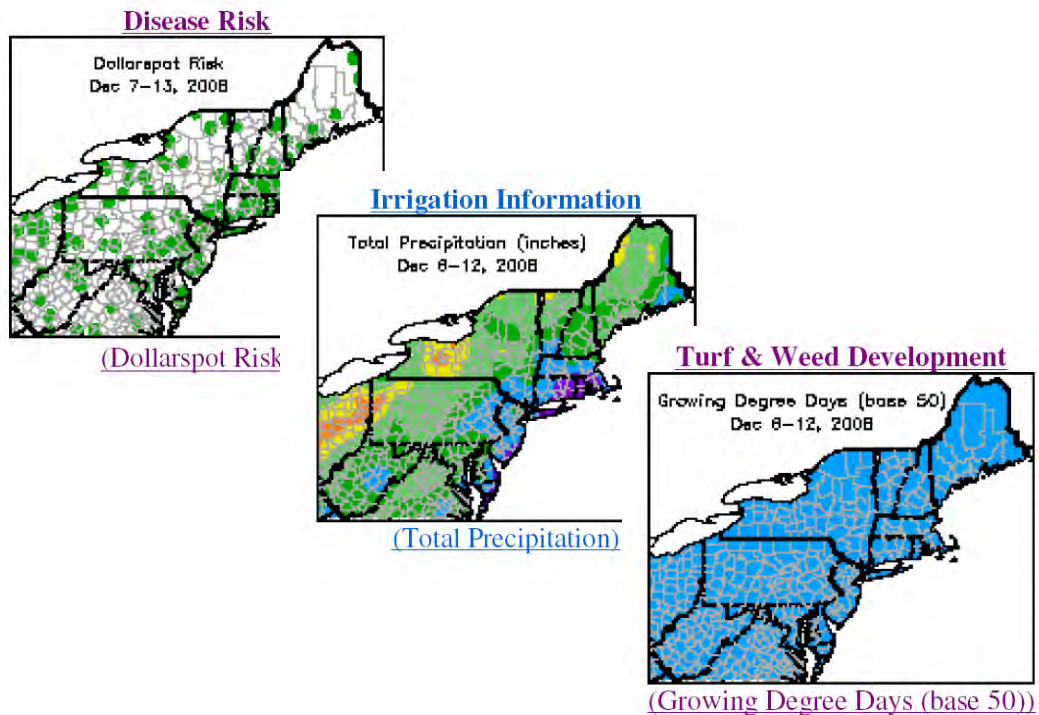
The fieldwork has put science to the test to show that a public golf course can practically implement a program to reduce chemical inputs while maintaining the quality of play. Many courses in New York are already providing examples of eco-friendly practices. New York State's Office of Parks and Recreation and Historic Preservation is poised to make a notable shift in golf management by implementing the IPM, Alternative Practices program on all their state courses. Creating this initiative to reduce chemical inputs, demonstrates leadership to the industry and raises the bar on environmental stewardship in golf management.

## Appendix 1: Forecasting Risk Periods

All pest problems have specific conditions that foster their development and colonization. There are often seasonal or phenological patterns to pest threats. New York State offers a variety of climatic settings ranging from the more temperate Long Island region to harsher northern settings in upstate New York. Significant differences arise in the microclimates for growing degree days, amount of rainfall, snow and ice. Climatic factors and the accumulation of Growing Degree Days (GDD) are well documented guides to pest patterns. Indices for temperature and humidity are leading indicators for predicting pest problems.

FORECAST, managed by the Northeast Regional Climate Center (NRCC), provides useful web-based information for turf managers (<http://www.nrcc.cornell.edu/grass/>).

NRCC provides data for temperature, humidity, evapotranspiration and precipitation. There are links to regional weather stations located throughout New York. The information has also been extrapolated and presented as pest forecasts. Integration of these information networks into course management is essential to management. Preventative and curative treatments can be better timed and managed to minimize unnecessary pesticide applications.



**Figure 12: Forecasting Tools at the Northeast Regional Climate Center**

Page Number	Group Weed	Season Temperature Range Month(s)	Winter < 32°F	Early Spr. 32-60°F	Late Spr. 61-80°F	Summer > 80°F	Early Fall 80-61°F	Late Fall 60-32°F	Winter < 32°F
			Jan Feb	Mar Apr	May Jun	Jul Aug	Sep Mid-Oct	Mid-Oct Nov	Dec
			142	<b>Perennial, Broadleaf</b>					
142	Broadleaf Plantain								
144	Buckhorn Plantain								
146	Common Blue Violet								
148	Creeping or Slender Speedwell								
150	Dandelion								
152	Ground Ivy								
154	Hawkweed								
156	Mouse-Ear Chickweed								
157	Red or Sheep Sorrel								
158	White Clover								
159	Yellow Woodsorrel								
160	<b>Perennial, Grasses or Grasslike</b>								
160	Annual Bluegrass								
162	Nimblewill								
164	Quackgrass								
166	Yellow Nutsedge								
168	<b>Annual, Winter</b>								
160	Annual Bluegrass								
168	Common Chickweed								
170	Corn Speedwell								
172	Henbit								
174	<b>Annual, Summer</b>								
174	Barnyardgrass								
176	Black Medic								
178	Goosegrass								
180	Knotweed								
182	Large Crabgrass								
184	Prostrate Spurge								
185	Smooth Crabgrass								

**Key** ■ Flowering ■ Nonflowering

**Table 16: Seasonal Weed Calendar**  
 (Courtesy of Natural Resource, Agricultural, and Engineering Service, Ithaca, NY)

**Appendix 1.2 Insect Management Risk Periods**

Category Insect	Season Temperature Range Month(s)	Winter	Early Spr.	Late Spr.	Summer	Early Fall	Late Fall	Winter
		< 32°F	32-60°F	61-80°F	> 80°F	80-61°F	60-32°F	< 32°F
		Jan Feb	Mar Apr	May Jun	Jul Aug	Sep Mid-Oct	Mid-Oct Nov	Dec
<b>Surface</b>								
Annual Bluegrass Weevil ( <i>Listronotus</i> ) *Damage caused by Larvae		Grub/Larva	Grub/Larva	Grub/Larva	Grub/Larva	Grub/Larva	Grub/Larva	Grub/Larva
Bluegrass Billbug *Damage caused by Grub and Adult		Grub/Larva	Grub/Larva	Grub/Larva	Grub/Larva	Grub/Larva	Grub/Larva	Grub/Larva
Hairy Chinch Bug *Damage caused by Nymphs & Adults		Grub/Larva	Grub/Larva	Grub/Larva	Grub/Larva	Grub/Larva	Grub/Larva	Grub/Larva
Sod Webworm Complex *Damage caused by Larvae		Grub/Larva	Grub/Larva	Grub/Larva	Grub/Larva	Grub/Larva	Grub/Larva	Grub/Larva
<b>Subsurface</b>								
Asiatic Garden Beetle *Damage caused by Grub		Grub/Larva	Grub/Larva	Grub/Larva	Grub/Larva	Grub/Larva	Grub/Larva	Grub/Larva
Black Cutworm *Damage caused by Larva		Grub/Larva	Grub/Larva	Grub/Larva	Grub/Larva	Grub/Larva	Grub/Larva	Grub/Larva
Black Turfgrass Ataenius *Damage caused by Grub		Grub/Larva	Grub/Larva	Grub/Larva	Grub/Larva	Grub/Larva	Grub/Larva	Grub/Larva
European Chafer *Damage caused by Grub		Grub/Larva	Grub/Larva	Grub/Larva	Grub/Larva	Grub/Larva	Grub/Larva	Grub/Larva
Green June Beetle *Damage caused by Grub		Grub/Larva	Grub/Larva	Grub/Larva	Grub/Larva	Grub/Larva	Grub/Larva	Grub/Larva
Japanese Beetle *Damage caused by Grub		Grub/Larva	Grub/Larva	Grub/Larva	Grub/Larva	Grub/Larva	Grub/Larva	Grub/Larva
May or June Beetles *Damage caused by Grub		Grub/Larva	Grub/Larva	Grub/Larva	Grub/Larva	Grub/Larva	Grub/Larva	Grub/Larva
Northern Masked Chafer *Damage caused by Grub		Grub/Larva	Grub/Larva	Grub/Larva	Grub/Larva	Grub/Larva	Grub/Larva	Grub/Larva
Oriental Beetle *Damage caused by Grub		Grub/Larva	Grub/Larva	Grub/Larva	Grub/Larva	Grub/Larva	Grub/Larva	Grub/Larva

Key:  Adult     Grub/Larva

**Table 17: Seasonal Insect Calendar**  
(Courtesy of Natural Resource, Agricultural, and Engineering Service, Ithaca, NY)



Page Number	Season Disease	Season Temperature Range Month(s)	Winter < 32°F	Early Spr. 32–60°F	Late Spr. 61–80°F	Summer > 80°F	Early Fall 80–61°F	Late Fall 60–32°F	Winter < 32°F
			Jan Feb	Mar Apr	May Jun	Jul Aug	Sep Mid-Oct	Mid-Oct Nov	Dec
47	<b>Late Fall to Early Spring</b>								
47	Pink Snow Mold		High	High	Low			High	High
50	<i>Typhula</i> Blight/Gray Snow Mold		High	High	Low			High	High
53	<b>Spring and Fall</b>								
53	Basal Rot Anthracnose			High	High	Low	Low	High	
55	Cool-Season <i>Pythium</i> Root and Crown Rot			High	High	Low	Low	High	
57	Dollar Spot			High	High	High	High	Low	
59	Fairy Rings			High	High	Low	High	High	
61	Necrotic Ring Spot			High	High	Low	High	High	
63	Pink Patch			High	High	Low	High	High	
65	Powdery Mildew			High	High	Low	High	High	
67	Red Thread			High	High	Low	High	High	
69	Spring/Fall Leaf Blight			High	High	Low	High	High	
72	Spr./Fall Leaf Spots/Melting Out			High	High	Low	High	High	
75	Yellow Patch			High	High	Low	High	High	
77	Yellow Tuft (Downy Mildew)			High	High	Low	High	High	
79	<b>Summer</b>								
79	Brown Patch			High	High	High	High	Low	
57	Dollar Spot			High	High	High	High	Low	
82	Foliar Anthracnose			High	High	High	High	Low	
84	Gray Leaf Spot			High	High	High	High	Low	
61	Necrotic Ring Spot			High	High	High	High	Low	
86	<i>Pythium</i> Blight			High	High	High	High	Low	
89	Rusts			High	High	High	High	Low	
91	Stripe Smut			High	High	High	High	Low	
93	Summer Leaf Spots			High	High	High	High	Low	
95	Summer Patch			High	High	High	High	Low	
98	Take-All Patch			High	High	High	High	Low	

**Key**  High disease potential  Medium disease potential  Low disease potential

**Table 18: Seasonal Disease Risk Calendar**  
 (Courtesy of Natural Resource, Agricultural, and Engineering Service, Ithaca, NY)

## **Appendix 2: Nutrient / Fertility Management**

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Understand the basis of your soil fertility. The Natural Resources Conservation Service (NRCS) offers a web based soil survey analysis for your area of interest (<http://websoilsurvey.nrcs.usda.gov/app/>). As an example, see appendix 5 for a soil report generated for Montauk Downs State Park on Long Island. The soil survey will identify the soil series and structure for your soils. A golf course has many variations of soils. The survey report also provides a capabilities analysis for nutrient and irrigation management specific to turfgrass. The information will be particularly useful for fairway management.

Conducting a physical survey of areas of your course will provide specific location perspectives. Undisturbed core samples can be studied to see the uniformity of your soil, the texture, and layers including thatch that might create impervious water boundaries.

Soil samples should be collected and analyzed for nutrient analysis. The reports are created with respect to managing turf. Soil nutrient levels, Cation Exchange Capacity (CEC) and pH are provided along with recommendations for all the macronutrients (nitrogen, phosphorous and potassium) and the essential micronutrients (sulfur, magnesium, calcium, molybdenum, manganese, copper, zinc, boron, iron and chlorine).

The relationship of macronutrient levels is dynamic. Growth as measured by clipping yields and evapotranspiration rates have been shown to vary at different levels of N, P and K. There is typically enough potassium and phosphorous in the soil to support plant growth. Phosphorous additions are generally only needed as start-up doses for grow-in. Recent research has shown that turfgrass performs well across a wide variety of soil potassium levels and that additions did not improve turf performance.

Nitrogen is the most essential element of the macronutrients (NPK). Insufficient N will limit the formation of carbohydrates and stunt root growth. With a weaker root system and lower reserves, the plant will not be as fit for periods of stress. Too much N, on the other hand, can lead to excessive shoot growth and weaker plant structure. Some pests prefer N deficient plants, while others favor N rich plants. Dollar spot is one disease that attacks N deficient plants. Continually balancing nitrogen nutrition is essential in pest control.

There are many forms of nitrogen fertilizer. The water soluble type, including inorganic N and organic urea, are released quickly into the soil and run the risk of burning the turf and leaching. Losses due to volatilization may also be high. Inorganic sources include ammonium nitrate, ammonium sulfate and calcium nitrate. There are organic sources and synthetic organics. Both of these, unlike the inorganic sources, contain carbon (C). Carbon is an essential element in supporting soil microbial activity.

The natural organics tend to be low in the % N, are slow release and rely on soil microbes to break down the fertilizer. Therefore applications must be made when soil temperatures are greater than 50° F. These natural organics, as by-products of other industries, may be readily available at lower pricing compared to synthetics.

Urea is the only commercially viable fast release synthetic N fertilizer: The other products are slow release. Urea contains 46% N and is soluble in water. Typically the total cost per pound of N delivered will be lower than the lower percentage products. Urea can burn turf but it has a lower burn potential than the inorganics. Urea is also available coated in either sulfur or a polymer for slow release.

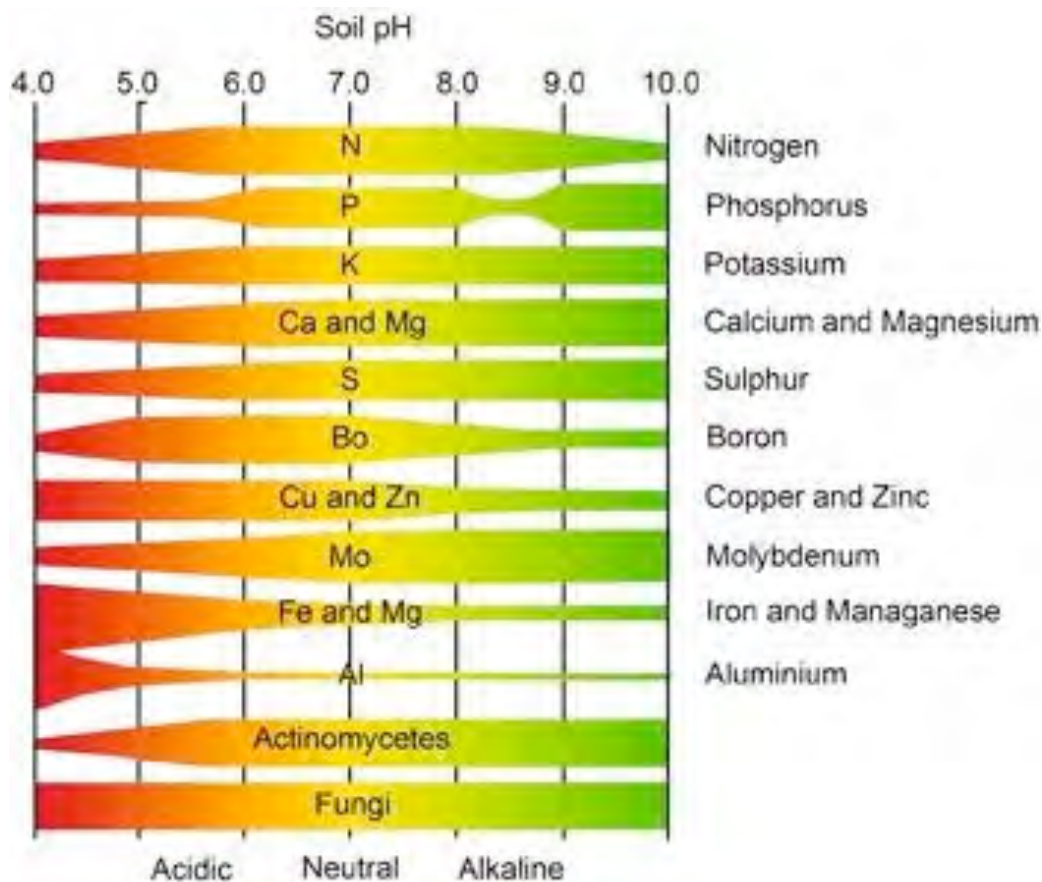
Other forms of urea include ureaformaldehyde (UF), methyleneureas (MU), triazone, and isobutylidene diurea (IBDU). The UF and MU fertilizers are available in long chain or short chain C-H or methyl links. Shorter chains will increase the burn potential. The long chain formulations release over a long period of time with low burn potentials. The UF and MU fertilizers require microbial activity to release their N. Like the organic sources, little N will be released unless the soil temperature is over 50° F. As the soil warms, and activity increases, more N will be released.

Triazone is typically 28% N, is generally used in tank mixes, and is also broken down by microbes. IBDU, typically 31% N, does not require microbes. It is slowly hydrolyzed by water. Be careful to consult with the manufacturer to determine the specific release rates for the products considered.

Slow release products are useful for applications to tees, approaches and fairways. The slow release provides the ability to make just a few applications for the entire season. Some companies are offering greens-grade granular products. These products should be evaluated first to insure you can provide uniform coverage. Foliar sprays on greens provide consistent coverage. With so many choices and factors, it is important to consider the application carefully to select the right material at the proper rate and application interval to meet your plant requirements.

Micronutrients are also generally available in the soil. One of the most significant factors in soil and nutrient management is the pH of the soil. As shown in the chart below, pH can limit the nutrient availability by binding cations or anions to the soil exchange sites depending on whether the soil is acidic or alkaline. Typically, iron is the key micronutrient that is deficient at high pH, Magnesium is typically deficient at low pH. At the other extreme, care must be taken to not oversupply nutrient elements. Plants have toxicity levels for each of the nutrients. The key is to balance nutrient supply.





**Figure 13: Nutrient availability across the pH range**  
[http://www.terragis.bees.unsw.edu.au/terraGIS\\_soil/sp\\_soil\\_reaction\\_ph.html](http://www.terragis.bees.unsw.edu.au/terraGIS_soil/sp_soil_reaction_ph.html)

After the design and implementation of your fertility management program, the plan can be checked by taking samples of leaf tissue and sending them for a tissue analysis. The lab report will identify all the key nutrients in the tissue test verifying plant uptake and identifying any deficiencies. Small adjustments can then be made to balance your fertility plan. This careful planning and verification insures that operating costs are not wasted on unnecessary elements and that the plant receives enough, but not too much, of the essential nutrients.

Four tools will be very effective in setting up and managing a fertility plan.

1. A **soil thermometer** to determine the right time for your first spring fertilizer application and your last fall application.
2. A **pH kit** to measure the pH of your soil, topdressing and your irrigation water.
3. A **soil survey** to understand the variation of soil types and conditions across your course.
4. A **soil chemical analysis** completed by a qualified soil nutrient lab.

**Appendix 3: NRCS Soil Survey**  
**Montauk Downs State Park Golf Course, Montauk, NY**

The NRCS Web Soil Survey is an online tool to obtain specific soil descriptions for your property. The underlying soil characteristics will vary considerably across the course and are denoted by the taxonomic soil series name and description. These variations will help to identify specific areas of management. For example, areas with soils that have poor drainage or poor cation exchange capacity can be identified.



**Figure 14: NRCS Soil Survey Map**

Reports can be custom generated to list a number of soil properties and land use characteristics. Each soil area can be detailed. Some of the important parameters for turf management are listed below:

- Depth to the upper and lower boundaries of each layer is indicated.
- Cation-exchange capacity is the total amount of extractable bases that can be held by the soil. Soils having a low cation-exchange capacity hold fewer cations and may require more frequent applications of fertilizer than soils having a high cation-exchange capacity. The ability to retain cations reduces the hazard of ground-water pollution.

- Particle size is the effective diameter of a soil particle. The broad classes are sand, silt, and clay, ranging from the larger to the smaller. The content of sand, silt, and clay affects the physical behavior of a soil.
- Bulk density is the weight of soil (oven-dry) per unit volume. Bulk density data are used to compute available water capacity, total pore space, and other soil properties. The bulk density of a soil indicates the pore space available for water and roots. As soil compaction increases, the bulk density will increase.
- Saturated hydraulic conductivity ( $K_{sat}$ ) refers to the ease with which pores in a saturated soil transmit water.
- Available water capacity refers to the quantity of water that the soil is capable of storing for use by plants. The capacity for water storage is given in inches of water per inch of soil for each soil layer. The capacity varies, depending on soil properties that affect retention of water. The most important properties are the content of organic matter, soil texture, bulk density, and soil structure. Available water capacity is an important factor in the design and management of irrigation systems.
- Organic matter is the plant and animal residue in the soil at various stages of decomposition. Organic matter has a positive effect on available water capacity, water infiltration, soil organism activity, and tilth, the overall health of a soil. It is a source of nitrogen and other nutrients for turf and soil organisms.

## **Appendix 4 : *Poa annua* Control**

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Long considered a weed, *Poa annua* (*Poa*) or annual bluegrass is a species of turfgrass by default. Some courses may still seek to control *Poa* on their greens. Others have adapted it as a mix with their bentgrass or have successfully created a monoculture of *Poa* on the greens. *Poa* management is distinctly different from bentgrass management and raises special considerations for chemical management.

There are classically two types of *Poa*. There is a winter annual biotype identified as *Poa annua* L. var. *annua* Timm, or simply *Poa annua* L. The other is a perennial biotype designated as *Poa annua* L. *reptans*.

*Poa annua* L, the winter annual, is very competitive at taking resources such as water and nutrients, growing rapidly and crowding out surrounding turfgrass. The plant produces large quantities of seed that typically germinate in the fall. However, any disturbance in the soil, such as ball marks, will stimulate seed germination. The seedlings overwinter. Cold induced vernalization triggers flowering, leading to the production of seedheads. Flowering can occur throughout the season but there are pulses that are strongly correlated with GDD indicators. Research indicates that soil temperatures need to be above 13° C (55°F) and the peak flowering period will occur between 363-433 GDD<sub>55</sub>. The seedheads can reduce turf quality and disrupt ball roll. There are growth regulator programs that can effectively reduce seed head formation.

During seedhead development, the plant redirects all of its energy to seed formation. During this period, growth and root development is interrupted. At this point, the plant is very susceptible to plant disease. Upon the completion of the reproductive cycle, the mature plant will senesce and die, often producing a yellow specking to a greens surface.

*Poa annua* L. *reptans*, as a perennial, is a colonizing species: tillering and expanding as patches within a stand. This perennial type evolves on greens as a result of intraspecific hybridization and natural selection. It is more persistent and highly competitive.

The competitive advantages of *Poa* over bentgrass is that it performs better in poorly drained and compacted soils and has a faster growth rate at higher photoperiods. It performs well at low cutting heights. However, *Poa* requires higher rates of nitrogen and phosphorous and needs a higher soil pH (6.5). *Poa* is generally more susceptible to disease pressure in peak summer conditions.

### ***Poa* Stress**

If stressed, *Poa* can be more prone to disease and insect pressure. Several practices should be adapted to minimize potential damage.

- Deficit irrigation should lead to root extension in search of water. Light and frequent watering is preferred.
- Heat induces root senescence. Water during the day as heat stress increases. Avoid saturation. Daytime syringing for stress relief, as required.

***Poa* Control:**

Chemical control of *Poa* on greens is not discussed in the handbook. If attempted, it should only be done in combination with cultural practices that favor bentgrass and with care not to create any phytotoxicity problems for the bentgrass. Also, be aware that effective treatment may leave large voids in the turf coverage requiring immediate reseeding.

The cultural management practices at Bethpage State Park were designed to favor bentgrass over *Poa*. The pH of the soil was driven down using ammonium based fertilizers. No phosphorous was added. Over the span of the project, bentgrass populations have increased. The reduction in *Poa* population has reduced the pest incidence on greens.

## **Appendix 5: Environmental Impact Quotient (EIQ)**

The turf manager is confronted with hundreds of choices of chemical formulations for pest control. The formulations vary by class, mode of action, percent active ingredient, proprietary inert ingredients and application rates. Many are available as mixtures with fertilizer applications. There are increasing reports of pesticide resistance and there are changing regulations on chemical use. The responsibility rests squarely on the turfgrass manager to make informed choices. Typically choices are based on the “3 E’s”: Efficacy (Effectiveness), Economics, (Cost), and Environmental impact. University extension services provide essential evaluation reports on chemical efficacy for specific pest treatments. Appendix 6 lists important links to the NYS Pesticide Management Education Program (PMEP) and the NYS Pesticide Product, Ingredient and Manufacture System (PIMS). Managers should always check PIMS to ensure a product is legal to use in New York State.

The Environmental Impact Quotient (EIQ) model was developed to combine multiple environmental and health aspects of pesticides. The EIQ rates chemicals by looking at many factors in terms of health, ecology and the environment (Kovach et al, 1992) (<http://www.nysipm.cornell.edu/publications/eiq/>). Table 19 lists the EIQ values for the active ingredients of most turfgrass pesticides referenced by Cornell’s *Pest Management Guidelines for Commercial Turfgrass*. Note that the EIQ is based on the active ingredient only. Ideally, all ingredients in a formulation would be included, however, these data are largely unavailable.

### **EIQ Field Use Rating:**

Products should be compared based on the EIQ Field Use Rating not by the EIQ of the active ingredient. The environmental assessment of a product cannot be measured by the active ingredient alone. The evaluation must also consider the rate of application of the active ingredient (AI) (e.g. lbs AI per acre) and ultimately, the total area treated.

The EIQ Field Use Rating is a term expressed as a measure of the environmental toxicity of a product per area treated. This handbook and the EIQ Calculator on the NYSIPM website convert application rates to lbs per acre. Field Use Rating are therefore presented on a per acre basis. The calculation of the EIQ Field Use Rating is shown below:

$$\text{FIELD EIQ} = \text{EIQ} \times \% \text{ Active Ingredient} \times \text{Rate of Application} *$$

\* Rate should be standardized to the same units, usually lbs/acre

To convert ounces or fluid ounces per 1000 ft<sup>2</sup>, divide the rate by 16 and multiply by 43.56  
(lbs/a = [(oz/1000) / 16] x 43.56)

Some pesticides are considered “reduced risk” if classified as such by the EPA. They include polyoxin D zinc salt (Endorse), mono and di-potassium salts of phosphorus acid (e.g. Alude), boscalid (Emerald), azoxystrobin (Heritage), Mineral Oil (Civitas) and spinosad (Conserve). The FIELD USE EIQ for these products is typically much lower than traditional pesticides.

Biological controls or *biopesticides* are often recommended treatments. The efficacy of biological controls is often not rated as high as traditional pesticides. However, biological controls are very compatible with the environment and are often successful in delaying the onset of diseases, decreasing severity, and lengthening the interval between applications of traditional pesticides. Commonly used biological controls include:

- Bacillus licheniformis* (Ecoguard)
- Bacillus subtilis* (Rhapsody)
- Trichoderma harzianum* (Turfshield)
- Pseudomonas aureofaciens* (Spotless)
- Bacillus thuringiensis* (Dipel, Javelin)

**EIQ Field Use Ratings for Comparing Management Strategies:**

By calculating the individual and cumulative pesticide Field Use Rating, various management strategies can be compared. For example, Daconil Ultrex Turf Care (EPA Reg Num: 50534-202-100) has 82.5 % of the active ingredient chlorothalonil and a recommended application rate of 3.7 -5.0 ounces of product per 1000 ft<sup>2</sup> for curative treatment of Dollar Spot, perhaps the most common disease on NYS golf courses. The EIQ for this chemical is 37.4. The Field Use Rating for daconil is computed as follows:

$$\begin{aligned}
 \text{Field Use Rating} &= \text{EIQ} \times \% \text{ active ingredient} \times \text{Rate of Application (3.7 oz/1000 ft}^2\text{)} \\
 \text{(Daconil)} &= 37.4 \times 0.825 \times 10.07 \\
 &= \mathbf{310.7 / acre}
 \end{aligned}$$

For treatment of Dollar Spot, treatments of triadimefon, propiconazole, and iprodione can be compared at preventative rates to aid in the selection of which pesticide to use:

TRIADIMEFON BAYLETON 50% CONCENTRATE EPA Reg Number: 432-1360	$  \begin{aligned}  &= \text{EIQ} \times \% \text{ active ingredient} \times \text{Rate (0.5)} \\  &= 29.96 \times 0.50 \times 1.36 = \mathbf{18.3 / acre}  \end{aligned}  $
PROPICONAZOLE BANNER MAX EPA Reg Num: 100-741	$  \begin{aligned}  &= \text{EIQ} \times \% \text{ active ingredient} \times \text{Rate (0.5)} \\  &= 31.63 \times 0.143 \times 1.36 = \mathbf{6.2 / acre}  \end{aligned}  $
IPRODIONE CHIPCO 26019 EPA Reg Num: 432-889	$  \begin{aligned}  &= \text{EIQ} \times \% \text{ active ingredient} \times \text{Rate (1.5)} \\  &= 24.25 \times 0.50 \times 4.08 = \mathbf{49.5 / acre}  \end{aligned}  $

All three of the chemicals noted above have moderate risk for resistance. Triadimefon and propiconazole are from the same DMI class of fungicides. Rotation between the two chemicals would increase the probability of developing resistance. Iprodione is a good alternative in the dicarboximides class and has been rated with good efficacy.

Alternatively, another rotation might consider using Boscalid, a “reduced risk” treatment:

BOSCALID	
EMERALD	= EIQ x % active ingredient x Rate (0.13)
EPA Reg Num: 7969-196	= 26.44 x 0.70 x 0.4 = <b><u>6.6 / acre</u></b>

In the selection process, Field Use Ratings for a single application that are below 50 are considered low rates. Field Use Ratings in the range of 50-100 are medium. Any ratings that are over 100 are considered high; another strategy should be considered. In the example above, the preventative control of any of the three alternatives are good choices. Each of the treatments is substantially lower than even one curative application of daconil. This underscores the impact of choosing the right chemical treatment program and the implicit value of using good management practices to avoid the onset of disease.

Table 19 gives the EIQ values for turfgrass pesticides. Remember that these EIQ values should not be compared. Instead, calculate the EIQ Field Use Rating for each product with its respective application rate, comparing alternative treatment strategies. Refer to the NYSIPM website (<http://www.nysipm.cornell.edu>) and the online EIQ calculator (<http://www.nysipm.cornell.edu/EIQCalc?input.php>).

The screenshot displays the 'EIQ Calculator' interface. On the left, the input fields are: Step 1: 'boscalid'; Step 2: '%AI (the value must be >0 and <=100)' set to 70; Step 3: 'Rate of Application' set to 0.13. Under 'Select a Volume/Mass', 'oz' is selected. Under 'Select an Area', '1000 ft. sq.' is selected. A 'Submit' button is at the bottom left. On the right, the 'EIQ Calculator Output for boscalid' is shown. It includes a warning: 'Use the Field Use EIQ for comparisons, not the base EIQ Value.' The 'USER INPUT' section lists: Active Ingredient: boscalid, % AI: 70, Rate of Application: 0.13 oz/1000ft2. The 'REFERENCE VALUE' section lists: EIQ Value for Active Ingredient boscalid: 26.4, Source: NYS IPM EIQ Database. The 'RESULTS' section lists: Field Use EIQ: 6.6, Field Use EIQ Components: Consumer: 5.3, Worker: 3.0, Ecological: 11.4.



**Table 19: EIQ Values for NYS Turfgrass Pesticides**

Type	Chemical Name	EIQ	Resistance Classification		
			FRAC	IRAC	WSSA
Fung	Acibenzoler S-methyl (ASM)	20.7	P1		
Fung	Azoxystrobin	26.92	11		
Fung	Bacillus licheniformis 3086	7.33	NC <sup>1</sup>		
Fung	Bacillus subtilis QST713	10.28	F6		
Fung	Boscalid	26.44	7		
Fung	Cloroneb	17.83	14		
Fung	Chlorothalonil	37.40	M5		
Fung	Copper hydroxide	33.20	M1		
Fung	Cyproconazole	38.03	3		
Fung	Etridiazole	34.86	14		
Fung	Fenarimol	18.10	3		
Fung	Fludioxinil	23.87	12		
Fung	Fluopicolide	26.00	28		
Fung	Flutolanil	23.07	7		
Fung	Fosetyl-al	12.00	33		
Fung	Iprodione	24.25	2		
Fung	Mancozeb	25.72	M3		
Fung	Mefenoxam, metalaxyl	19.07	4		
Fung	Metconazole	24.00	3		
Fung	Mineral oil	NC <sup>1</sup>	NC <sup>1</sup>		
Fung	Mono and Di-potassium salts	11.33	33		
Fung	Myclobutanil	24.01	3		
Fung	Phosphite Salts	7.33	33		
Fung	Polyoxin D	24.60	19		
Fung	Propamocarb	23.89	28		
Fung	Propiconazole	31.63	3		
Fung	Pseudomonas auriofaciens Tx-1	NA <sup>1</sup>	NC <sup>1</sup>		
Fung	Pyraclostrobin	27.01	11		
Fung	Quintozene	27.37	14		
Fung	Tebuconazole	40.30	3		
Fung	Thiophanate-methyl	23.82	1		
Fung	Thiram	29.28	M3		
Fung	Triadimefon	26.96	3		
Fung	Trifloxystrobin	29.78	11		
Fung	Triticonazole	11.73	3		
Fung	Vinclozolin	17.39	2		
Herb	2,4-D	15.30			4
Herb	Acetic Acid	12.23			4
Herb	Benefin, benefluralin	17.00			3
Herb	Bensulide	26.00			8
Herb	Bentazon	18.67			6
Herb	Bispyribac sodium	11.50			2
Herb	Bromoxynil	17.00			6
Herb	Carfentrazone	20.18			14

Herb	Chlorsulfuron	26.67			2
Herb	Clopyralid	18.12			4
Herb	Dicamba	25.33			4
Herb	Dithiopyr	15.73			3
Herb	Ethofumesate	25.82			8
Herb	Fenoxaprop	43.67			1
Herb	Fluroxpyr	36.67			4
Herb	Glyphosate	15.33			9
Herb	Halosulfuron	20.20			2
Herb	MCPA	22.70			4
Herb	MCPP, Mecoprop	15.33			4
Herb	MSMA	18.00			17
Herb	Mesotrione	18.70			28
Herb	Oxadiazon	44.67			14
Herb	Pendimethalin	30.17			3
Herb	Prodiamine	11.73			3
Herb	Quiclorac	NA			26 & 4
Herb	Siduron	11.73			7
Herb	Sulfosulfuron	28.00			2
Herb	Triclopyr	11.00			4
Herb	Trifluralin	18.83			3
Ins	Abamectin	34.68		6	
Ins	Acephate	24.88		1B	
Ins	Azadirachtin	12.10		NC <sup>1</sup>	
Ins	Bacillus thuringiensis	13.33		11	
Ins	Bifenthrin	44.35		3A	
Ins	Carbaryl	22.73		1A	
Ins	Chlorantraniliprole	18.34		28	
Ins	Chlorpyrifos	26.85		1B	
Ins	Cyfluthrin	39.57		3A	
Ins	Deltamethrin	28.38		3A	
Ins	Esfenvalerate	39.57		3A	
Ins	Halofenozide	20.29		18	
Ins	Hydramethylnon	21.39		20A	
Ins	Imidacloprid	36.71		4A	
Ins	Indoxacarb	31.19		22A	
Ins	Lambda-cyhalothrin	44.17		3A	
Ins	Methomyl	22.00		1A	
Ins	Permethrin	29.33		3A	
Ins	Spinosad	14.38		5	
Ins	Trichlorfon	20.17		1B	
PGR	Ethephon	24.80	NA	NA	NA
PGR	Mefluidide	8.00	NA	NA	NA
PGR	Paclobutrazol	26.43	NA	NA	NA
PGR	Trinexapac	19.03	NA	NA	NA
NC <sup>1</sup> : Biological or organic agent - EIQ TBD					
NA: not applicable or not available					

**Audubon Cooperative Sanctuary Program for Golf Courses**

46 Rarick Rd.  
Selkirk, NY. 12158  
Phone: 518-767-9051  
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**New York State Office of Integrated Pest Management**

The Program is located at the New York State Agricultural Experiment Station in Geneva, NY. The address is:

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**New York State Pesticide Management and Education Program (PMEP)**

For more information relative to pesticides and their use in New York State, please contact the PMEP staff at:

5123 Comstock Hall  
Cornell University  
Ithaca, NY 14853-0901  
(607) 255-1866  
URL: <http://pmep.cce.cornell.edu/>



**Pesticide Management  
Education Program**

For chemical labels and information:  
The NYS Pesticide Product, Ingredient, and Manufacturer System (PIMS)  
URL: <http://magritte.psur.cornell.edu/pims/>

For toxicology reports:  
E X T O X N E T - Extension Toxicology Network  
<http://pmep.cce.cornell.edu/profiles/extoxnet/index.html>

**Weather Information and Pest Forecasts:**

Northeast Regional Climate Center  
1123 Bradfield Hall  
Cornell University  
Ithaca, NY 14853 Phone: 607-255-1751  
E-mail: [nrcc@cornell.edu](mailto:nrcc@cornell.edu)  
<http://www.nrcc.cornell.edu/grass/>



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URL: <http://www.nysta.org/>



## **Natural Resource Conservation Service**

The web soil survey allows the identification of the native soil series descriptions and capabilities for turf.



URL: <http://websoilsurvey.nrcs.usda.gov/app/>

## **National Turfgrass Evaluation Program**

10300 Baltimore Ave. Bldg. 003, Rm. 218  
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Beltsville, Maryland 20705

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Fax: (301) 504-5167.  
URL: <http://www.ntep.org/>



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