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IPM Template References

Soil Calcium (Ca^{++})

Calcium is the dominant cation in normal soils. As soils become acid, calcium is replaced by hydrogen and aluminum. When soils become alkaline, calcium is replaced by sodium. When sodium increases in the soil, clay particles disperse and hydraulic conductivity becomes restricted. Calcium is a critical plant structural component in cell walls and calcium also acts in signal conduction between the environmental factors and the plant's response.

The role of calcium in IPM

As long as calcium exceeds Minimum Levels for Sustainable Nutrition (MLSN) guidelines, sufficient calcium will be available for healthy and robust

Guideline: Mehlich 3 extractable Ca exceeding 331 ppm

Management

Products that are commonly used to help manage sodium or to supply calcium to deficient soils:

15-0-0 Calcium nitrate

$CaCO_3$ lime

$CaSO_4$*2H2O Magnesium sulfate (Epsom Salt)

$CaCl_2$ Calcium chloride

Soil Magnesium (Mg^{++})

Magnesium is an essential element for plant growth and plays a key role in photosynthesis and other critical pathways in the plant. In recent years, high soil magnesium (>20% of the exchangeable cations) has been found to disperse clay particles in a fashion that is similar to the way high sodium can damage soil structure.

The role of magnesium in IPM

Sufficient and balanced magnesium in the soil are needed to provide the optimum turfgrass performance and weed suppression.

Guidelines: Mehlich 3 extractable Mg exceeding 47 ppm

Management

Products that are commonly used to increase soil magnesium levels are listed below.

10-0-0 Magnesium nitrate

$CaCO_3$ *$MgCO_3$ dolomitic lime

$MgSO_4$*7H2O Magnesium sulfate (Epsom Salt)

0-0-22 $MgSO_4$*K_2SO_4 magnesium sulfate potassium sulfate (K-mag)

Magnesium sucrate Granusol magnesium

Reducing magnesium can be accomplished by increasing calcium applications followed by leaching rainfall or irrigation. In cases where magnesium is very high, for example serpentine soils, magnesium can not be reduced due to the very high levels of magnesium in this type of clay soil. In this situation, sand topdressing may be the only solution to improve drainage and aeration of the soil.

Soil Manganese (Mn^{++})

Manganese is an essential element for plant growth and plays a key role in photosynthesis and other critical pathways in the plant. Manganese can substitute for magnesium in some reactions in the plant.

The role of manganese in IPM

Manganese has been found to suppress take-all patch caused by *Gaeumannomyces graminis* on bentgrass. Target levels of manganese are dependent upon soil pH and can be calculated using a manganese availability index value of 110 in the equation below: (use Mehlich III extracted manganese values)

Manganese Availability Index (MnAI) = 101.7 - 15.2 (pH) + 3.75 Mn mg/kg

For optimum turfgrass performance, manganese and iron levels should be balanced at a ratio of 3:1 iron:manganese reported as Mehlich III extracted mg/kg. Although there has been no observed toxicity for manganese levels above the 30 – 45 ppm range reported in the guidelines below, excessive manganese application is not encouraged.

Guidelines: Mehlich 3 extractable Mn exceeding 30 ppm and MnAI exceeding 110

Management

Manganese products that can be used to adjust soil manganese levels are listed below.

$MnSO_4$*H2O Manganese sulfate

Manganese sucrate Granusol manganese

Soil Nitrogen (N)

Nitrogen is the major growth regulating nutrient used in turfgrass management. Optimum levels are difficult to determine and vary by turfgrass type and turfgrass use. Higher nitrogen rates are applied in high traffic areas and lower nitrogen levels are used for low maintenance sites. Excessive levels can result in environmental contamination.

The role of nitrogen in IPM

The role of nitrogen in IPM varies depending upon the disease that is targeted. Higher levels of nitrogen can aid in suppression of anthracnose caused by *Colletotrichum cereale* on *Poa annua* and dollar spot caused by *Sclerotinia homeocarpa* on bentgrass. Alternatively, high nitrogen levels results in increased susceptibility of ryegrass to brown patch caused by *Rhizoctonia solani*. The guidelines below provide a starting point to begin fine tuning management to suppress the diseases that cause the greatest impact at the site.

Guidelines:

Total plant available nitrogen is the sum of nitrate (NO_3) and ammonium (NH_4) forms of nitrogen.

	Low	Normal	Excessive
Nitrate (NO_3) KCl extracted	< 3 mg/kg	3 -15 mg/kg	> 15 mg/kg
Ammonium (NH_4) KCl extracted	Unknown	0 – 7 mg/kg	> 10 mg/kg
Total (NO_3 + NH_4)	< 3mg/kg	3 – 15 mg/l	> 15 mg/kg

Management

There are a multitude of nitrogen products available for use in managing soil nitrogen levels. Here are a few quick and slow release options:

<u>Quick release</u>

- 15-0-0 Calcium nitrate
- 13-0-44 Potassium nitrate
- 46-0-0 Urea
- 21-0-0 Ammonium sulfate

<u>Slow release</u>

IBDU Isobutylenediurea
Ureaformaldehyde
Sulfur coated urea
Polymer coated urea

Soil Phosphorus (P)

Phosphorus requirements may vary greatly depending upon soil conditions and turf management goals. Excess phosphorus can result in contamination of surface and ground water. To prevent over-application and leaching of phosphorus, a phosphorus saturation index (PSI) is calculated (see below) to determine if maximum levels of soil phosphorus have been reached or exceeded. Phosphorus applications should be avoided when the PSI reaches 0.23.

Phosphorus Saturation Index (PSI) $= \dfrac{\dfrac{\text{P mg/kg}}{31}}{\left(\dfrac{\text{Fe mg/kg}}{56} + \dfrac{\text{Al mg/kg}}{27}\right)}$

(NOTE: Phosphorus and aluminum are Mehlich III extracted)

The minimum desired soil phosphorus level will depend upon turf performance and desire to suppress Poa annua.

The role of phosphorus in IPM

The role of phosphorous in control of insects and diseases is not well defined. However, there are some reports that low phosphorus can favor bentgrass in a poa-bentgrass golf course green. The levels below have been targeted toward healthy bentgrass and poa..

Guidelines: Mehlich 3 extractable P exceeding 21 ppm and PSI exceeding 0.10

Management

If the phosphorus saturation index (PSI) exceeds 0.23, avoid further application of phosphorus and increase soil iron levels.

Phosphorus products that are used to address deficiencies include:

- 11-52-0 Monoammoniumphosphate
- 18-56-0 Diamonnium phosphate
- 0-52-34 Monopotassium phosphate
- 0-45-0 Triple super phosphate

Soil Potassium (K^+)

Potassium is an essential element for plant growth and development. It plays a major role in regulation of plant water relations and it is transported freely throughout the plant.

The role of potassium in IPM

The role of potassium in IPM is controversial. Research indicates that increased potassium can suppress rapid blight caused by *Labyrinthula terrestris* and anthracnose caused by *Colletotrichum cereal* while other studies suggest that the snow molds might be increased in high potassium environments.

Guidelines: Mehlich 3 extractable K exceeding 37 ppm unless rapid blight is a problem then increase soil K to 110 ppm if possible.

Management

Soil potassium levels can be increased by use of one of the products listed below. Use caution because each product carries a potentially detrimental companion anion (negatively charged molecue such as nitrate sulfate, phosphate, chloride). Leaching irrigation or rainfall will easily remove excessive potassium.

13-0-44 Potassium nitrate

0-0-50 K_2SO_4 Potassium sulfate

0-0-60 KCl Potassium chloride

0-0-22 $MgSO_4$*K_2SO_4 magnesium sulfate - potassium sulfate (K-mag)

0-52-34 KH2PO5 mono potassium phosphate

Soil Sodium (Na^+)

Sodium is present in the earth's crust at about the same concentration as potassium but most turfgrass plants have developed high selectivity for uptake of potassium. Sodium has been found to be an essential nutrient for a few plant species but in practical terms, sodium plays a detrimental role in turfgrass and soil management. For that reason, the target levels of sodium are low and management of sodium focuses primarily on supplying calcium to displace sodium.

The role of sodium in IPM

Sodium plays a direct role in turfgrass susceptibility to rapid blight caused by *Labyrinthula terrestris*. Increased sodium results in increased susceptibility to rapid blight. In addition, high salinity and sodium stress have been implicated in increasing susceptibility to senectotrophic pathogens that include anthracnose (*Colletotrichum cerealis*) and the leaf spots and melting out caused by *Bipolaris* spp. and *Curvularia* spp. In addition, low sodium soils benefit general plant health and aid in preventing weed invasion and recovery from damage caused by insects.

Guidelines: Mehlich 3 extractable Na of less than 110 ppm if rapid blight is a problem. Higher levels of Na are tolerable for bentgrass and warm season grasses.

Management

Application of the calcium products will help to manage and reduce soil sodium levels.

15-0-0 Calcium nitrate

$CaCO_3$ lime

$CaSO_4$*2H2O Magnesium sulfate (Epsom Salt)

$CaCl_2$ Calcium chloride

SOIL REFERENCE

Monitoring soil salinity

Field Scout EC probe and meter

Protocol for in-office EC measurements (most accurate method):

1) Obtain a representative soil sample, about 50cc (about 2 oz) in a small cup.
2) Add your irrigation water while stirring until the soil surface glistens. Don't add too much water. If the water can be poured off, you've added too much and you will need to start over or add dry soil.
3) Stick the probe into the soil so the electrodes are completely immersed in the soil.
4) Read the meter and convert the meter reading using Table 1 below. Record the converted value for future reference.

Protocol for in-field EC measurements:

1) Saturate the area of the green to be evaluated with irrigation water. The soil must be saturated to obtain an accurate reading.
2) Stick the probe into the soil so the electrodes are completely immersed in the soil.
3) Read the meter and convert the meter reading using Table 1 below. Record the converted value for future reference.

Measurements taken directly from soils in the field are more variable because they are dependent upon soil moisture conditions. However, the direct field readings will provide a quick and easy estimate of soil solution EC which will allow you to determine when salts are building up and leaching is needed. For example, when the meter reading exceeds 0.7 mS/cm (dS/m) for soil under annual bluegrass turf, the extract EC is approaching 3.0 dS/m, the upper limit for healthy poa growth and development (Table 2). In this example, leaching will be needed to prevent further increase in EC and resultant plant stress.

Calibration: The meter should be calibrated once per week or before use if the meter has stored for more than a week. To calibrate, pour a small volume of the calibration solution listed below into a small container. Submerge the meter electrodes completely into the calibration solution. Adjust the meter reading according to manufacturer's instructions, until the meter reads 2.76 mS/cm.

Supplies:

- Field Scout soil EC probe and meter (catalogue # 2265FS) from Spectrum Technologies, 800-248-8873 or www.specmeters.com. About $350.
- Calibration solution 2.76 mS/cm (catalogue # 2254 from Spectrum Technologies, , 800-248-8873 or www.specmeters.com). About $13.00

Table 1. Conversion table for determining the saturated soil extract EC (Extract EC) from the direct soil reading with your salinity meter (Meter). All values are in mS/cm =dS/m= mmhos/cm. To convert your meter reading to the correct EC reading, use the following equation:

EC (mS/cm) = (meter reading X 2.7) + 0.8

Meter	Extract EC	Meter	Extract EC	Meter	Extract EC
0.1	1.1	1.1	3.8	2.1	6.5
0.2	1.3	1.2	4.0	2.2	6.7
0.3	1.6	1.3	4.3	2.3	7.0
0.4	1.9	1.4	4.6	2.4	7.3
0.5	2.2	1.5	4.9	2.5	7.6
0.6	2.4	1.6	5.1	2.6	7.8
0.7	2.7	1.7	5.4	2.7	8.1
0.8	3.0	1.8	5.7	2.8	8.4
0.9	3.2	1.9	5.9	2.9	8.6
1.0	3.5	2.0	6.2	3.0	8.9

Table 2. Relative tolerance of turfgrasses to soil salinity (Harivandi et. al. 1992).

Sensitive < 3 mS/cm	Moderately Sensitive 3-6 mS/cm	Moderately Tolerant 6-10 mS/cm	Tolerant > 10 mS/cm
Annual bluegrass	Annual ryegrass	Bent. cv. Seaside	Alkaligrass
Colonial bentgrass	Chewings fescue	Perennial ryegrass	Bermudagrass
Kentucky bluegrass	Creeping bentgrass	Tall fescue	Seashore paspalum
Rough bluegrass	Hard fescue	Buffalograss	St. Augustinegrass
Centipedegrass	Bahiagrass	Zoysiagrass	

Reference:

Harivandi, M.A., Butler, J.D. and Wu, L. 1992. Salinity and turfgrass culture. Pages 207-229 in Turfgrass (Waddington, D.V., Carrow, R.N. and Shearman, R.C. eds) Series No. 32. American Society of Agronomy, Madison, WI.

SOIL REFERENCE

Weekly Electrical Conductivity Weekly Record Sheet

Year: _____ Meter used: _____

	Location (e.g., G18, F1, R3)													
	Meter	ECe	Meter	ECe	Meter	ECe	Meter	ECe	Meter	ECe	Meter	ECe	Meter	ECe
Jan 1														
2														
3														
4														
Feb 1														
2														
3														
4														
Mar 1														
2														
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Apr 1														
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Nov 1														
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Dec 1														
2														
3														
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To convert meter readings to ECe values in dS/m, see reverse side of sheet

Pesticide Resistance Management

The first signs of pesticide resistance begin with the observation that pests are surviving pesticide applications, and that increased rates or frequencies of application are necessary to provide acceptable control. As more applications are made, pesticide rates must be steadily increased to maintain control of pests. And finally, after many pesticide applications, the pesticide is rendered totally ineffective, regardless of the rate used. Since the introduction, in the 1930s, of pesticides based on synthetic chemistry, the number of pests that have become resistant to pesticides has increased to an alarmingly high number (Table 1). Without good resistance management strategies in place, this number can only continue to grow. In this issue of PACE Insights, we want to explore how pesticide resistance comes about, how it affects pest management practices on golf courses, and what we can do to avoid it. We will tell you up-front, however, that there is no universal solution to the problem of pesticide resistance, partly because so little is actually understood about the complex interactions involved. But by applying the research information and practical experience that we do have, we should be able to at least slow down, if not avoid resistance development.

Table 1. Number of resistant pest species, as of 1986 (from Green et. al., 1990)

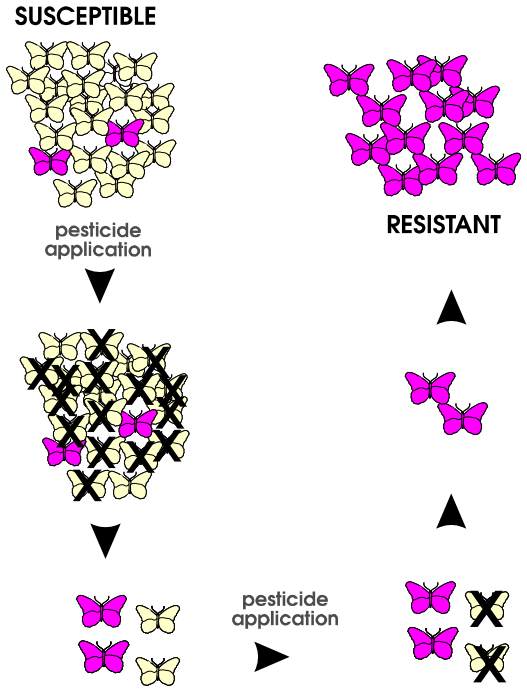
insects and mites	504
plant pathogens	100
weeds	48

Resistance -- a working definition: There are as many definitions of resistance as there are pesticide products, but a good working definition that we will use here is: "Resistance occurs when pests survive doses of the pesticide which would normally be lethal. This is due to a genetic change in the pest population that is caused by exposure to pesticides."

When a new pesticide is commercialized, the hope is that it will kill 100% of the pests that it is targeted against. However, this rarely occurs, partly because each individual in a pest species responds differently to the pesticide. In fact, there is a lot of variation within populations of all living organisms, whether they are human beings (note our different survival rates, different appearances, different abilities to win at "Jeopardy!") or pests. For example, within one pest species, such as the sod webworm, we see moths of different sizes, different colors, and different reproductive abilities. All of this variability is due to small differences in the DNA, or genetic material of each individual pest. With regards to pesticide sensitivity, there is great variability within each pest species as well. Keeping with the example of the sod webworm, imagine a time before the introduction of insecticides such as aldrin, when the majority of webworms were easily killed by this pesticide. However, there were a few moths that had the genetic ability to survive exposure to aldrin -- perhaps because they had enzymes that could break down and detoxify the aldrin. As a result, the aldrin -resistant individuals became more numerous after each aldrin application, while the susceptible individuals began to gradually disappear. This is the stage at which we would begin to notice that the pesticide applications were not working as well as they did originally. Eventually, all of the webworms would be resistant to aldrin, and we would have complete product failure (Figure 1).

Figure 1. Pest population changes that result in development of resistance to pesticides. Susceptible insects (light colored moths) are in the majority before pesticide applications begin, and resistant insects (dark colored moths) are in the minority. As pesticide applications continue, susceptible insects are killed (insects with "X"s) and resistant insects come to dominate the population.

PESTICIDE RESISTANCE MANAGEMENT



Exposure, exposure, exposure: With the information above in hand, it stands to reason that the way to avoid resistance is to avoid constant use of the same pesticide. This is because by reducing the exposure of the insects to the pesticide, you reduce the likelihood that susceptible (easily killed by the pesticide) pests will die and that resistant pests will survive. Reduction of exposure to pesticides is the bedrock upon which most resistance management strategies are based, and it also answers questions such as:

Why are there so many insects that are resistant to pesticides? In Table 1 above, the largest number of resistant pests are found among insects (with 504 resistant species!), with plant pathogens running a weak second place (only 100 species) and weeds even further behind. The reason? Synthetic insecticides were first introduced in the 1930s, with the development of DDT. However, it wasn't until the 1960s that the first highly effective selective fungicides (such as benomyl) were introduced, and it was even later when selective herbicides were introduced. In other words, insects have been exposed to pesticides for many years longer than pathogens or weeds have been exposed to pesticides. In addition, the early insecticides, such as DDT, had exceptionally high residual activities, with some products remaining active for years in the soil. Thus, insects were exposed to the same products on a continuous basis for long periods of time, allowing highly resistant populations to develop.

The recent introduction of highly effective, long residual products such as Heritage (azoxystrobin), Banner (propiconazole) and Merit (imidacloprid) seems to have rekindled concerns about resistance. Why is this? The fact that these products have increased residual activity (vs. other currently available fungicides and insecticides) means that pest exposure has been increased, as it was with DDT in the example above. Therefore, the risk of resistance is higher, unless strategies to decrease risk are implemented.

Why are there fewer cases of pesticide resistance on golf courses in the Western U.S.? As Table 2 illustrates below, there are relatively few cases of resistance for turfgrass pests.

Table 2. Some examples of resistant turf pests.

Pest name	Type	Pesticide
white grubs	insect	chlordane, dieldrin
chinch bugs	insect	diazinon, chlorpyrifos
black turfgrass ataenius	insect	aldrin, chlordane, dieldrin, heptachlor
sod webworms	insect	aldrin, dieldrin
dollar spot	disease	Rubigan, Bayleton, Banner, Chipco 26019, Vorlan, Benlate
Pythium	disease	Subdue
pink snow mold	disease	benomyl and dicarboximides
large crabgrass	weed	triazines
goosegrass	weed	Treflan
ann. bluegrass	weed	Diquat, Princep, Prograss

The documented cases are for the most part related to the use of chlorinated hydrocarbon insecticides (such as DDT, chlordane, dieldrin, aldrin, heptachlor) with their extremely high

residual activities and high exposure levels. The remaining cases are related to diseases or weeds that are persistent pests in the Eastern U.S. and are treated for, wall-to-wall, on a frequent basis. In contrast, on Western golf courses, where pest pressures are lower, exposure to many insecticides and fungicides is limited to golf course greens only. This means that susceptible pests from acres of fairways and roughs will be unaffected by pesticide applications, and will still far outnumber any resistant populations that develop on a few acres of greens.

Cross resistance: the "fly" in the ointment: If high levels of exposure to pesticides are the root cause of pest resistance, then it stands to reason that by reducing exposure, we avoid resistance. If this sounds too good to be true, it is. One of the first strategies developed for resistance management called for the rotation of different pesticides with one another, as a means of reducing exposure to a single pesticide. On paper, this sounds great. If we treat with pesticide A two or three times, and then switch to pesticide B for another three applications, we've reduced the exposure to pesticide A by 50% -- right? The answer is -- well, it depends. This is because cross-resistance frequently occurs -- that is, when a pest becomes resistant to a pesticide that it was never treated with. Cross resistance usually comes about when pests are treated with two or more products in the same chemical class. Products in the same chemical class are closely related to one another chemically, and for that reason also kill the pest using the same mode of action. Therefore, a pest that develops resistance to a pesticide in a given class will probably be cross-resistant to the other products in that same chemical class. **Therefore, to decrease the risk of resistance, rotation of products should occur between different classes of pesticides.** For example, for control of summer patch, Heritage, a methoxyacrylate, could be rotated with Banner, a sterol inhibitor. To avoid a situation where cross-resistance might occur, do not rotate products in the same chemical class. For example, Banner and Bayleton, both sterol inhibitors, should not be rotated with one another. To aid you in your decision-making, classes of different pesticides and some of the turf products in each of these classes are listed in Table 3 below.

Resistance management is a preventive strategy: Resistance management strategies are based on the belief that once resistance occurs, it is too late to do anything about it. Therefore, resistance must be avoided through a variety of preventive strategies which are listed below. In our attempts to develop these strategies, it seems as though the odds are stacked against us. Almost all of the critical factors in development of resistance -- pest genetics, pest behavior and pest physiology -- are beyond our control. There are however, a few factors within our control, including 1) the type of pesticide we select, 2) the size and location of the area we spray, and 3) the timing of the pesticide application. It is upon these factors, in combination with the goal of reducing pest exposure to pesticides, that the strategies below are based.

Rely on cultural and other management practices to reduce the number of pesticide applications. There are, of course, a wide variety of reasons -- from environmental concerns to regulatory issues -- why this strategy is already being implemented at most golf courses. From the standpoint of resistance management, this strategy reduces exposure of pests to pesticides simply by decreasing the number of applications made per year. It's simple, but it makes sense.

Table 3. Chemical classes of insecticides, fungicides and herbicides.

Insecticide Class	Examples
carbamates	Sevin
chlorinated hydrocarbons	aldrin, chlordane, dieldrin, DDT, heptachlor
chloronicotinyls	Merit
diacylhydrazine	Mach 2*
organophosphates	Dylox, Dursban
pyrethroids	Tempo
spinosyns	Conserve*
Herbicide Class	**Examples**
amides	Kerb
benzoics	Banvel
dinitroanilines (DNAs)	Balan, Barricade, Pendulum, Surflan, Team, Treflan
oxadiazoles	Ronstar
phenoxys	2,4D, MCP, MCPA, MCPP, Trimec
sulfonylureas	Manage
triazines	Aatrex, Atrazine, Princep, Sencor, Simazine
unclassified	Basamid, Betasan, Prograss, Round-Up
Fungicide Class	**Examples**
methoxyacrylates	Heritage
benzimidazoles	Cleary's 3336, Fungo
carboximides	Prostar
phenylamides	Subdue, Apron
sterol inhibitors	Banner, Bayleton, Eagle, Rubigan
dicarboximides	Chipco 26019, Curalan, Vorlan
ethylenebisdithio-carbamates	Fore, Dithane
nitriles	Daconil
phosphonates	Aliette

*have received Federal registration, but not California registration

Rotation among different pesticide classes. This strategy, already partially discussed above, has its plusses and minuses. Although rotation is the strategy most commonly recommended in university publications, on product labels and in scientific literature, there is very little real evidence that it is successful at avoiding resistance. This is probably because "rotation" is such a broad term. For example, should products be rotated every other treatment? Every other year? There is little information available to help answer this question. Rotations have also sometimes been unsuccessful in avoiding resistance, even when the products were carefully selected from different pesticide classes. This is because pests are occasionally cross-resistant to pesticides even when they are in different pesticide classes. If we could predict when this would happen, we could avoid it, but unfortunately our knowledge about cross-resistance is too sketchy right now.

Refugia: A refuge, or a non-treated area, provides a breeding ground for pests, the majority of which will be susceptible to pesticides (because they have never been exposed to pesticides). If pests from the refuge are mobile (i.e., flying insects, wind-dispersed weeds, pathogens transported by mowers and foot traffic), then pests from the refuge can breed with and numerically overwhelm any resistant pests that develop on treated areas of the golf course. As mentioned above, golf courses in the Western U.S. have already been utilizing this strategy. In other words, by restricting pesticide treatments almost exclusively to greens, the tees, fairways and roughs have become huge refugia, harboring susceptible pests that it is not necessary to treat for, because they cause little or no damage. Looking at an even bigger picture, the parks and home lawns and gardens near golf courses are also excellent refuges for development of susceptible pests. The only down-side to this concept is that not all pests are mobile, and there is so little known about turfgrass pest behavior, that we just don't how mobile many of our pests are. For example, we know that the black turfgrass ataenius adult beetle can fly fairly long distances, and we therefore assume that this pest is mobile. However, we have observed that ataenius grub infestations develop in the same spot year after year, possibly because the populations become localized. In other words, even though they can fly, they choose to stay in one area to feed and reproduce and therefore become effectively non-mobile. At this point, we don't have enough information to know whether ataenius are mobile or not. Without this type of knowledge, we can only guess at how effective refuges will be for resistance avoidance on golf courses. More

basic research on pest behavior is the only way we can get these answers.

Mixtures of pesticides: In theory, this strategy makes the most sense, but in practice, it is the most difficult to implement. The theory is that by mixing pesticides of two different classes, you are almost guaranteed to kill all targeted pests --whether resistant or not. This is because even if a pest is resistant to one pesticide, it will still be killed by exposure to the second pesticide in the mixture. The pests that are resistant to both pesticides in the mixture will be extremely rare, and should be outnumbered by susceptible pests from refugia (see above). However, there are many requirements that must be fulfilled for this strategy to work. First, as for rotations, pests cannot be cross-resistant to the two pesticides in the mixture. Second, the two pesticides must be equally toxic, and have equal residual activity against the target pest. If this requirement is not fulfilled, then the more toxic or higher residual product will kill all of the pests, making the presence of the second pesticide redundant. Finally, immigration of pests from the untreated refuge must occur. Unfortunately, in most cases, we do not have enough information to know whether we are meeting these requirements or not. For this reason, mixtures, although frequently used for other reasons (i.e., to target two or more different pests with the same application) are infrequently used as a resistance management strategy.

Practical recommendations: As many of you have commented, explorations into technical areas sometimes result in more questions than answers, and resistance management may be such a case. However, we can derive, from the scientific literature, from our own experiences and also from good common sense, a list of practical recommendations:

- To reduce pest exposure to pesticides, continue efforts to avoid unnecessary pesticide applications and use cultural control methods whenever possible
- View your untreated fairways and roughs as a resource, full of susceptible pests which can breed with and overwhelm any resistant pests that develop on greens; wherever possible, avoid treating fairways and roughs with pesticides
- When pesticide applications are necessary, use Table 3 above and rotate among chemical classes, to avoid development of resistance, and also to: 1) avoid deleterious effects of repeated applications with the same product, such as phytotoxicity; 2) comply with newer product labels which now contain restrictions on the number of times a product can be applied sequentially
- If pesticide mixtures are used as a resistance strategy, make sure that there is scientific data available demonstrating that the mixture will be effective, and that the requirements listed above for successful mixtures are fulfilled.

References

Denholm, I. and M.W. Rowland. 1992. Tactics for managing pesticide resistance in arthropods: Theory and practice. Annu. Rev. Entomol. 37:91-112.

Green, M.B., LeBaron, H.M. and W.K. Moberg. 1990. Managing resistance to agrochemicals: From fundamental research to practical strategies. American Chemical Society Symposium Series number 421. American Chemical Society, Washington, D.C. 496 pp.

Vargas, J.M. 1994. Management of Turfgrass Diseases. Lewis Publishers, Boca Raton, FL. 294 pp.

DISESASE REFERENCE

Anthracnose, *Colletotrichum cereale*

DAMAGE CAUSED

Symptoms of damage:

Foliage: older leaves attacked first. Leaves may appear water-soaked and/or display small, reddish-tan leaf spots or elongate yellow leaf spots. As the disease advances, foliage will turn brown and black, hair-like fungal structures known as acervuli (photo to right) may develop.

Crown or basal rot: lower leaf sheaths and crowns become dark-colored, leaves turn yellow-orange, and acervuli (photo to right) are common.

Overall appearance: small, irregular patches of yellowing, thinning or brown turf eventually grow larger if the infestation is not controlled.

Plants attacked:

Poa annua is the most common target.

Other hosts include (in order of frequency observed) bentgrass, Kentucky bluegrass, bermudagrass.

Pests/conditions that cause similar damage

rapid blight

black turfgrass ataenius

high soil salts (salinity)

heat or drought stress

Predictive models

Spring and summertime, once average air temperatures reach 65F (18C).

Conducive environmental conditions:

Average air temperatures greater than 65 F(18C)

Anything that stresses turf, such as:

High soil salts (salinity)

Low fertility

Compaction

Traffic

Heat or drought

Excessive shade

Poor drainage

Low mowing heights

Geographic distribution:

Worldwide

MONITORING TECHNIQUES:

Monitor air temperatures. When average air temperatures reach 65F (18C), begin scouting turf for early symptoms.

Focus scouting efforts on weak or stressed areas, or areas where the disease has occurred in the past. This is where symptoms are likely to occur earliest.

THRESHOLDS:

For golf courses where anthracnose has been a problem in the past, preventive control is warranted (see Management Strategies below).

For situations where a curative approach is used, control should be implemented as soon as symptoms are seen.

DISESASE REFERENCE

MANAGEMENT STRATEGIES:

Strains of anthracnose resistant to QoI (strobilurin) and benzimidazole fungicides have been documented in several locations. These products are noted with a red asterisk (*).Follow resistance management guidelines by rotating products as outlined in IPM Template Reference "Fungicide Resistance Management Groups." Always consult the most recent version of all product labels before use.

TYPE	TIMING	PRACTICE	
Cultural	N/A	• Adequate nitrogen (0.1 – 0.2 lb nitrogen/wk during season), but do not exceed 20 ppm total nitrogen in soil • Maintain soil salinity below 3.0 dS/m for cool season turf • Apply Primo Maxx at 1/8 oz/1000 sq ft every 14 days during anthracnose threat period. • Schedule a monthly "venting" using small diameter (1/4") hollow cores or solid tines. • Raise mowing heights as much as possible.	
Biological	Preventive: apply when average air temperatures reach 65F (18C)	Polyoxin-D (Endorse)[1]	
Chemical	Preventive: apply when average air temperatures reach 65F (18C)	**Active Ingredient (Product)**	**Label signal word**
		Azoxystrobin (Heritage)**	Caution
		Chlorothalonil (Daconil Weatherstik) + fludioxinil (Medallion)*	Caution/Caution
		Chlorothalonil (Daconil Weatherstik) + fosetyl-Al (Chipco Signature)	Caution/Caution
		Chlorothalonil (Daconil Weatherstik) + polyoxin D (Endorse)[1]	Caution/Caution
		Fosetyl-Al (Chipco Signature) + iprodione (Chipco 26GT)	Caution/Caution
		Myclobutanil (Eagle)	Caution
		Propiconazole (Banner)	Warning
		Pyraclostrobin (Insignia)*	Caution
		Thiophanate-methyl (Cleary's 3336)*	Caution
		Trifloxystrobin (Compass)**	Caution
	Curative : less desirable strategy, with less than optimal results in most cases	Chlorothalonil (Daconil Weatherstik) + fludioxinil (Medallion)*	Caution/Caution
		Chlorothalonil (Daconil Weatherstik) + fosetyl-Al (Chipco Signature)	Caution/Caution
		Chlorothalonil (Daconil Weatherstik) + polyoxin D (Endorse)[1]	Caution/Caution
		Chlorothalonil (Daconil Weatherstik) + propiconazole (Banner Maxx)	Caution/Warning

* considered reduced risk by the U.S. Environmental Protection Agency.
* has been ineffective in some locations due to development of resistance.
[1] Designated as a biopesticide by the U.S. Environmental Protection Agency

DISESASE REFERENCE

Fairy ring

Lycoperdon spp., *Marasmius oreades*, *Bovista plumbea*, *Agrocybe pediades* and many other fungi in the family Basidiomycetes

DAMAGE CAUSED

Symptoms of damage:

Type 1: rings of dead grass with outer zone of dark green stimulated turf; basidiocarps (mushrooms or puffballs) may be produced

Type 2: ring of dark green stimulated turf; basidiocarps may be produced

Type 3: rings of basidiocarps with no apparent effect on turf growth

Plants attacked:

All turf types and cultural conditions.

Pests/conditions that cause similar damage

Brown patch

Brown ring patch

PREDICTING DISEASE

Threat temperature:

When average air temperature for five consecutive days exceeds 60 F (16C)

Conducive environmental conditions:

Drought

MONITORING TECHNIQUES:

In spring, once threat temperatures (>60F or 16C) are reached, monitor for dark green rings, localized dry spot in a ring pattern or mushrooms/puffballs in a ring pattern.

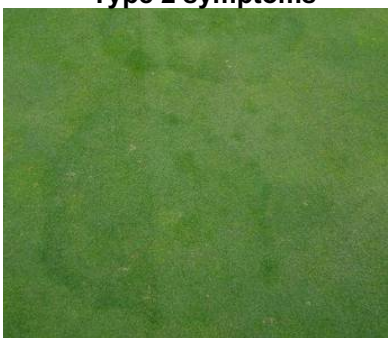
THRESHOLDS:

Curative: Monitor for first signs of rings; make curative applications once rings are detected

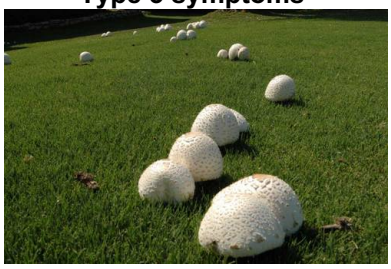
Preventive: If there is a history of fairy ring, make preventive applications of fungicides and wettings agents in spring, once threat temperature is reached.

Type 1 symptoms

Type 2 symptoms



Type 3 symptoms



Thatch degraded by fairy ring fungi

Clamp connection on fairy ring mycelium

MANAGEMENT STRATEGIES:

The products below have demonstrated good activity in research field trials on fairy ring. Follow resistance management guidelines by rotating products as outlined in IPM Template Reference "Fungicide Resistance Management Groups." Always consult the most recent version of all product labels before use.

TYPE OF CONTROL	PRACTICE	
Cultural	• Adequate nitrogen (0.1 – 0.2 lb nitrogen / 1000 ft^2 / wk [0.5 – 1.0 g nitrogen/ m^2 / wk] during season), but do not exceed 20 ppm total nitrogen in soil • Utilize wetting agents to prevent dry spots from developing	
Biological	polyoxin D zinc (Endorse)[1]	
Chemical Curative: Apply as soon as rings or dry patches begin to appear. Treat all areas with a history of disease. **Chemical Preventive**: If a history of fairy ring is present, preventive application may be needed when average air temperature for 5 consecutive days exceed 60 F (16 C)	**Active Ingredient (Product)**	**Signal word**
	azoxystrobin (Heritage)[2]	Caution
	Triadiamefon (Bayleton 50 WP)	Caution
	polyoxin D zinc (Endorse)[1]	Caution
	flutolanil (Prostar 70WP)	Caution
	pyraclostrobin (Insignia)	Caution

[1] Designated as a biopesticide by the U.S. Environmental Protection Agency

[2] Designated "reduced risk" by the U.S. Environmental Protection Agency

DISESASE REFERENCE

Gray leaf spot, Pyricularia grisea

DAMAGE CAUSED

Symptoms of damage:

Foliar disease

Early symptoms include water-soaked lesions on foliage that eventually enlarge, turning grey or brown. A yellow "halo" may form around the lesions

The tips of infected leaves eventually darken, wither and twist before dying.

Production of fungal condia on foliage produces a gray, velvety or felt-like appearance

Dying plants form large (6 – 12 inches or 15 – 30 cm in diameter), irregular shaped patches of discolored turf that eventually coalesce into larger patches

Plants attacked:

Ryegrass

Fescue

St. Augustinegrass

Kikuyugrass

Pests/conditions that cause similar damage

Pythium blight

Predictive models

Optimum conditions when Maximum daily temperature + minimum daily relative humidity $\geq$ 140.

Conducive environmental conditions:

Average air temperatures >68 F

Presence of free water on leaf surface

High relative humidities

Geographic distribution:

All U.S. states with the exception of the upper mid-West and Pacific Northwest

MONITORING TECHNIQUES:

Begin scouting once average air temperatures reach 68 F (20 C). Target the most susceptible areas of the course (high mown perennial ryegrass, areas that are shady or have low air movement).

DISESASE REFERENCE

If there is a history of the disease, preventive fungicide applications once the temperature (F) /humidity index of 140 is reached (maximum temperature, F plus minimum relative humidity)

MANAGEMENT STRATEGIES:

Strains of gray leaf spot resistant to QoI (strobilurin) fungicides have been documented in several locations. These products are noted with a red asterisk (*) Follow resistance management guidelines by rotating products as outlined in IPM Template Reference "Fungicide Resistance Management Groups." Always consult the most recent version of all product labels before use.

TYPE	TIMING/ THRESHOLD	PRACTICE	
Cultural	N/A	• Use tolerant varieties of ryegrass or resistant turf varieties (bermuda, bluegrass, bentgrass) • Be moderate with nitrogen fertility (less than 20 ppm soil nitrogen) • Avoid sand topdressing and aerification during GLS threat period • Improve drainage and irrigation to avoid wet areas • Avoid springtime applications of ethofumesate	
Biological			
Chemical	Preventive: apply when maximum temperature (F) plus minimum relative humidity = 140 OR Early curative	**Active ingredient**	**Label signal word**
		Azoxystrobin (Heritage)* *	Caution
		Propiconazole (Banner) plus chlorothalonil (Daconil Weatherstik)	Warning/Caution
		Pyraclostrobin (Insignia) *	Caution
		Thiophanate-methyl (Cleary's 3336)	Caution
		Triadimefon (Bayleton) plus chlorothalonil (Daconil Weatherstik)	Caution/Caution
		Trifloxystrobin (Compass) * *	Caution

* considered reduced risk by the U.S. Environmental Protection Agency.
* has been ineffective in some locations due to development of resistance.

Rapid blight, *Labyrinthula terrestris*

DAMAGE CAUSED

Symptoms of damage:

Small, irregular shaped patches of diseased turf that develop rapidly

Foliage turns yellow to brown with a water-soaked appearance

No mycelium is formed

Plants attacked:

Poa annua

Poa trivialis

Ryegrass

Bentgrass (to a lesser extent)

Pests/conditions that cause similar damage

Anthracnose

Drought stress

Dollar spot

Necrotic ring spot

Snow mold

Summer patch

Predictive models

Occurs as long as weather is conducive for turf growth (average air temperatures >55F or 13 C)

Conducive environmental conditions:

Soil sodium > 110 ppm (Mehlich III extraction)

> 2dS/m soil salinity

Average air temperatures > 55 F (13 C)

Use of high salinity irrigation water

Geographic distribution:

Southern U.S., United Kingdom

MONITORING TECHNIQUES:

Begin monitoring for early symptoms when average air temperatures reach 55 F (13 C)

MANAGEMENT STRATEGIES:

Follow resistance management guidelines by rotating products as outlined in IPM Template Reference “Fungicide Resistance Management Groups.” Always consult the most recent version of all product labels before use.

TYPE	TIMING/ THRESHOLD	PRACTICE	
Cultural	N/A	Keep soil sodium levels < 110 ppm (Mehlich III) and soil salnity levels < 2dS/m. Monitor for soil salnity. If disease is active, avoid cultural practices that physically injure turf such as aerification, sand topdressing or renovation.	
Biological			
Chemical	Preventive or early curative	**Active ingredient**	**Label signal word**
		mancozeb (Fore)	Caution
		pyraclostrobin (Insignia)	Caution
		trifloxystrobin (Compass) *	Caution

* considered reduced risk by the U.S. Environmental Protection Agency.

Rhizoctonia complex: brown patch, yellow patch, sheath spot and brown ring patch

Rhizoctonia solani (brown patch), *R. cerealis* (yellow patch), *R. zeae* and *R. oryzae* (sheath spot) or *Waitea circinata* var. *circinata* (brown ring patch).

DAMAGE CAUSED

Symptoms of damage:

Chlorotic (yellow) or necrotic (dying) rings or solid patches of various sizes.

Sometimes green rings form after fungicide application

Plants attacked:

All turf types and cultural conditions.

Pests/conditions that cause similar damage

Fairy ring

Pythium blight

Geographic distribution:

Worldwide

PREDICTING DISEASE

Threat temperatures:

Dependent upon species:

Brown patch (*Rhizoctonia solani*) average air temperature 70 – 90 F (21 – 32 C)

Yellow patch (*Rhizoctonia cerealis*) average air temperature 50 – 65 F (10 – 18 C)

Sheath spot (*Rhizoctonia oryzae* and *R. zeae*) average air temperature 80 – 97 F (27 – 36 C) insensitive to thiophanate methyl

Brown ring patch (*Waitea circinata* var *circinata*) average air temperature 77 – 86 F (25 – 30 C) insensitive to thiophanate methyl

Conducive environmental conditions:

High relative humidity or leaf wetness

Low light levels

High soil nitrogen levels

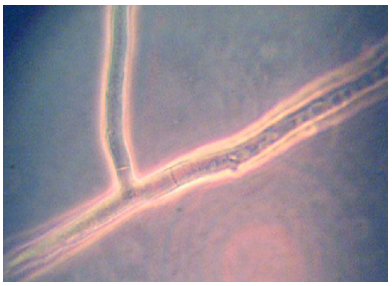
Brown patch on bermuda

Brown patch on kikuyugrass

Waitea on Poa annua

Waitea mycelium on rye overseeded bermudagrass

Micrograph of Rhizoctonia hypha



DISESASE REFERENCE

MONITORING TECHNIQUES:

Monitor air temperatures and begin scouting for early signs of damage when threat temperatures (see above) are reached

Focus scouting efforts on areas with a known history of disease.

THRESHOLDS:

In most cases, curative application of effective fungicides at the first signs of disease will provide good control.

If there is a history of Rhizoctonia disease, preventive application of fungicides may be needed to prevent serious damage and to reduce fungicide inputs. If the disease becomes established, multiple fungicide applications will be needed.

MANAGEMENT STRATEGIES:

The products below have demonstrated good activity in research field trials on Rhizoctonia diseases. Follow resistance management guidelines by rotating products as outlined in IPM Template Reference "Fungicide Resistance Management Groups." Always consult the most recent version of all product labels before use.

TYPE OF CONTROL	PRACTICE	
Cultural	• Adequate nitrogen (0.1 – 0.2 lb nitrogen / 1000 ft^2 / wk [0.5 – 1.0 g nitrogen/ m^2 / wk] during season), but do not exceed 20 ppm total nitrogen in soil • Maintain soil salinity below 3.0 dS/m for cool season turf • Avoid excessive irrigation and leaf wetness during warm conditions.	
Biological	polyoxin D zinc (Endorse)[1]	
Chemical Curative: Apply as soon as any chlorotic rings appear. Treat all areas with a history of disease. **Chemical Preventive**: If there is a history of Rhizoctonia disease, preventive application may be needed when threat temperatures are reached	**Active Ingredient (Product)**	**Signal word**
	azoxystrobin (Heritage)[2]	Caution
	chlorothalonil (Daconil Weatherstik)	Caution
	flutolanil (Prostar 70WP)	Caution
	fludioxonil (Medallion)[2]	Caution
	iprodione (Chipco 26019)	Caution
	polyoxin D zinc (Endorse)[1]	Caution
	propiconazole (Banner Maxx)	Warning
	pyraclostrobin (Insignia)	Caution
	trifloxystrobin (Compass)[2]	Caution

[1] Designated as a biopesticide by the U.S. Environmental Protection Agency

[2] Designated "reduced risk" by the U.S. Environmental Protection Agency

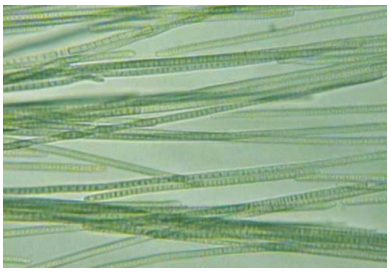
Yellow spot (algae, cyanobacteria)

Oscillatoria spp, Phormidium spp.

Symptoms on A4 bentgrass

Algae on leaf tips after 48 hr incubation in dark

Oscillatoria trichomes under microscope



DAMAGE CAUSED

Symptoms of damage:

Initial symptoms are yellow spots that can expand to encompass large areas.

Severe symptoms can result in large declining areas with algal scum at the surface of the thatch

Plants attacked:

Low mown turfgrasses including poa, bentgrass and bermudagrass.

Pests/conditions that cause similar damage

High soil salts (salinity)

Traffic damage

Heat or drought stress

Localized black layer

Geographic distribution:

Worldwide

PREDICTING DISEASE

Threat temperature

Spring and summertime, once average air temperatures exceed 60F (16C) for 5 consecutive days

Conducive environmental conditions:

Shade

Average air temperatures greater than 60 F(16C)

Low mowing height

Use of organic fertilizers

Compaction

Traffic

Poor drainage

MONITORING TECHNIQUES:

Monitor air temperatures. When average air temperatures exceed 60F (16C), begin scouting turf for early symptoms.

Focus scouting efforts on shady areas with a history of algae. This is where symptoms are likely to occur earliest.

Collect a cup cutter sample and incubate in a plastic bag (closed) in the dark for 48 hours. Opening the bag will release a musty odor and the leaf tips will be colonized by a dark slimy film of cyanobacteria.

THRESHOLDS:

Curative: Monitor for characteristic small, yellow spots; apply fungicides curatively once spots appear

Preventive: In shady areas with a history of algae, periodic preventive applications of fungicides, made during the spring and summer, may be needed to prevent decline

MANAGEMENT STRATEGIES:

The products below have demonstrated good activity in research field trials on cyanobacteria. Always consult the most recent version of all product labels before use.

TYPE	TIMING	PRACTICE	
Cultural	N/A	• Adequate nitrogen (0.1 – 0.2 lb nitrogen / 1000 ft^2 / wk [0.5 – 1.0 g nitrogen/ m^2 / wk] during season), but do not exceed 20 ppm total nitrogen in soil • Maintain soil salinity below 3.0 dS/m for cool season turf • Raise mowing heights as much as possible. • Avoid use of organic fertilizers • Regularly topdress greens with sand	
Biological	None known		
Chemical	Curative: Apply after a few spots appear on a green. Only treat affected greens. Preventive: Apply once average air temperatures exceed 60F (16C) in areas with history of infestation	**Active Ingredient (Product)**	**Label signal word**
		Chlorothalonil (Daconil Weatherstik)	Caution
		Mancozeb (Fore 80WP)	Caution

Fungicide Resistance Management Groups

Fungicides are organized into Fungicide Resistance Groups based on mode of action and chemical structure. In general, a pest that develops resistance to one fungicide within a group will probably be cross-resistant to other members of the group. Therefore, current resistance management strategies rely on rotation among different fungicide resistance groups. Source: Fungicide Resistance Action Committee (www.frac.info)

Active Ingredient	Trade Names	Fungicide Resistance Group Name	Group #	Comments
thiophanate-methyl	Cavalier, Cleary's 3336, Fungo, Systemic Fungicide	MBC methyl benzimidazole carbamates	1	High Risk: Resistance common for many diseases including dollar spot and anthracnose
iprodione	Chipco 26019, Chipco 26GT, Fungicide X	dicarboximides	2	Medium Risk: Resistance known in some fungal species, including dollar spot
vinclozolin	Curalan, Touche, Vorlan	dicarboximides	2	
fenarimol	Patchwork, Rubigan	DMI demethylation inhibitor	3	Medium Risk: Resistance known in some fungal species, including dollar spot
myclobutanil	Eagle, Golden Eagle	DMI	3	
propiconazole	Banner Maxx	DMI	3	
triadimefon	Accost, Bayleton, Fungicide VII, Granular Turf Fungicide	DMI	3	
mefonoxam	Subdue Maxx, Quell	Phenylamides	4	High Risk: Resistance known in Pythium
metalaxyl	Pythium Control, Subdue	Phenylamides	4	
boscalid	Emerald	Carboxamides	7	Medium Risk: No known resistance in turf diseases
flutolanil	Prostar	Carboxamides	7	
azoxystrobin	Heritage	QoI: includes strobilurins	11	High Risk. Resistance known in gray leaf spot and anthracnose
pyraclostrobin	Insignia	QoI	11	
trifloxystrobin	Compass	QoI	11	
fludioxonil	Medallion	Phenylpyrrole	12	Medium Risk
etridiazole	Koban, Terrazole	Aromatic hydrocarbons	14	Medium Risk: Resistance known, but none on turf diseases
PCNB (quintozene)	Defend, Engage, Penstar, Revere, Terraclor, Turfcide	Aromatic hydrocarbons	14	
polyoxin D zinc	Endorse	Polyoxins	19	Medium Risk: No problems known on turf
propamocarb	Banol	Carbamate fungicides	28	Medium Risk: No resistance on turf diseases
fosetyl-Al	Aliette	Phosphonates	33	Low Risk: Resistance known, but none on turf diseases
phosphonates	Prodigy, Alude, Magellan, ReSyst	Phosphonates	33	
mancozeb	Dithane, Fore, Mancozeb, Protect, Pentathlon	Multi-site activity	M	Low Risk: no signs of resistance developing
thiram	Thiram, Spotrete	Multi-site activity	M	
chlorothalonil	Concorde, Daconil, Echo, Manicure, Thalonil	Multi-site activity	M	

Selected Fungicide Active Ingredients and the Diseases that They Control

Based upon observations and research from around the United States

		azoxystrobin	boscalid	captan	chlorothalonil	etridiazole	fenarimol	fludioxonil	flutolanil	fosetyl-Al	iprodione	mancozeb	mefenoxam	metalaxyl	myclobutanil	PCNB	phosphonates	polyoxin D zinc	propamocarb	propiconazole	pyraclostrobin	thiophanate-methyl	thiram	triadimefon	trifloxystrobin	vinclozolin
Target Roots 2+gal/1000 sq ft or light syringe	Fairy ring, other basidiomycetes *Agrocybe, Bovista*																									
	Necrotic ring spot *Ophiosphaerella*																									
	Root rot *Pythium*																									
	Spring dead spot *Ophiosphaerella*																									
	Summer patch *Magnaporthe*																									
	Take-all patch and decline *Gaeumannomyces*																									
Target Foliage for best results apply in 1-2 gal/1000 sq ft	Algae *Oscillatoria,* cyanobacteria																									
	Anthracnose *Colletotrichum*	R																			R	R			R	
	Bentgrass dead spot *Ophiosphaerella*																									
	Blight and leaf spot *Curvularia, Bipolaris*																									
	Brown/yellow patch *Rhizoctonia*																									
	Dollar spot *Sclerotinia*																									
	Pink snow mold/fusarium patch *Microdochium*																									
	Gray leaf spot *Pyricularia*	R																			R				R	
	Gray snow mold *Typhula*																									
	Blight *Pythium*																									
	Rapid blight *Labyrinthula*																									
	Red thread Laetisaria																									
	Southern blight *Sclerotium*																									

Always refer to the product label to confirm all use, handling, and application details.

some systemicity: xylem, phloem or localized

Contact

R Resistance management is critical - use with caution

INSECT REFERENCE

Annual white grubs

DESCRIPTION OF INSECT

- Asiatic garden beetle, *Maladera castenea*
- European chafer *Rhizotrogus majalis*
- Japanese beetle, *Popillia Japonica*
- Masked chafers, *Cyclocephala spp*.
- Oriental beetle, *Exomala orientalis*

Immature stage:

C-shaped, thick bodied, creamy white with yellow to brown head capsule

Chewing mouthparts, 3 pairs of short yellow legs

Size ranges from 3/8 in black turfgrass ataenius (BTA) to 2 in green June beetle (GJB)

Mature stage:

Beetles

Colors range from green to shades of tan, brown, or black

Stout and oval, size ranges from 3/16 in (BTA) to 1 in (GJB)

Forewings hardened, forming a shell like cover over membranous hindwings

Forelegs with teeth like projections used for burrowing

Damaging stage(s):

larvae (grubs) only; adult beetles can be problematic on surrounding ornamentals

Predictive models (degree day, plant phenology, threat temperatures, other)

Degree Days for first adult flights range from 900-1200

Damage appears in late summer and early falls as grass is heading into dormancy or experiencing drought stress

Life cycle:

1 year from egg to egg

Adults mate and lay eggs in mid-summer (June through August)

Eggs hatch in 2-3 weeks

Grubs (larval stage) molt twice becoming full grown by fall

Grubs move down into soil profile due to decreasing soil temperatures in late fall

Feeding resumes at the root zone as temperatures warm in the spring

Larvae move down in the soil to pupate, a few weeks later adults emerge

Conducive environmental conditions:

Well irrigated, or areas with high soil moisture are conducive for survival of eggs and larvae

Damage occurs late summer to early fall

Damage occurs more rapidly when turf is subjected to other stresses (i.e. drought conditions)

Geographic distribution:

worldwide

DAMAGE CAUSED:

Plants attacked:

Roots of all turfgrass species are susceptible

Symptoms of damage:

Yellowing and thinning of grass similar to drought stress

Irregular dead patches of turf that continue to increase in size

Turf is easily pulled back due to loss of root zone

Predators (geese, skunks, armadillos, javelinas) rip up turf when foraging for grubs in high density areas

Larvae of GJB push up mounds of soil while feeding in the organic layer

Timing of damage:

Damage occurs late summer to early fall

Damage occurs more rapidly when turf is subjected to other stresses (i.e. drought conditions)

Insects that look similar; Pests that cause similar damage:

billbugs

MONITORING TECHNIQUES:

Monitor adult flight using pheromone traps for day active beetles (i.e. Japanese beetle, Oriental beetle) or black light trap for those active at night (i.e. masked chafers.)

For grubs, use a standard golf course cup cutter or flat spade to sample the upper 3-4” of soil under the turf. The majority of grubs can be found within the 2” of soil just below the thatch.

THRESHOLDS:

Thresholds will vary depending on the species of grub, turf species, management regime, and environmental conditions.

The majority of species will incite damage at 6-10 grubs per square foot.

MANAGEMENT STRATEGIES:

Follow resistance management guidelines by rotating products as outlined in IPM Template Reference “Insecticide Resistance Management Groups.” Always consult the most recent version of all product labels before use.

White grub management strategies				
TYPE	TIMING/ THRESHOLD	PRACTICE		COMMENTS
Chemical	Preventive treatment: target small grubs in the late spring	**Active Ingredient (Product)**	**Label signal word**	Products should be watered in
		Clothianidin (Arena)	Caution	
		Halofenozide (Mach 2)	Caution	
		Imidacloprid (Merit)	Caution	
		Imidacloprid + bifenthrin (Allectus)	Caution	
		Thiamethoxam (Meridian)	Caution	
	Curative control: target grubs as needed. Only moderate control will be achieved if grubs are mature	Acephate (Orthene)	Caution	Products should be watered in
		Carbaryl (Sevin)	Warning	
		Trichlorfon (Dylox)	Caution (granular) ; Warning (liquid)	

Fire ants, *Solenopsis invicta*

DESCRIPTION OF INSECT

All stages live in underground colony, only adult workers are seen on the surface.

Immature stage:

Egg, larval and pupal stages are white and only occur in underground nest.

Mature stage:

Adult workers are typical ants with a reddish brown color and a darker abdomen (third and last segment of body). Worker size varies considerably and not a good character for identification.

Male and female reproductives are winged, but fly at night, and are not generally seen. Mating flights can occur at almost any time, but most often in spring or fall. Winged adults may be attracted to lights during mating flights.

Workers most frequently seen feeding on insects, sweet or oily substances

Damaging stage(s):

Mound building can be considered as damage in some situations. The main concern is the toxic sting delivered by adult workers.

Predictive models (degree day, plant phenology, threat temperatures, other)

Fire ants can be active year round where climate is warm or moderate. Cooler temperatures in northern part of range limit activity in winter. Mounds are generally present throughout the year.

Surface activity occurs when soil surface temperatures are between 65 and 950F. Activity is greatest May-September. Activity can occur both day and night, but is generally observed from dusk through the early morning hours during the hottest portion of the summer.

Bait treatments must be applied when workers are actively foraging. Prebaiting is the best method to determine when the ants are foraging.

Life cycle:

Mated queen continuously lays eggs. Queens can live up to 5 years.

Larval and pupal stages are cared for by sterile female worker ants.

Egg stage to adult worker takes approximately one month.

Fire ants only live in colonies, not as single ants.

Conducive environmental conditions:

warm rainy periods precede spring and fall mating flights and colony establishment

Geographic distribution:

native to limited portions of South America, invasive across the southern US

DAMAGE CAUSED:

Mound building can be considered as damage in some situations, especially where appearance or playing surface is of critical importance. The main concern is the sting delivered by adult workers.

Symptoms of damage:

Mounds are generally the only indicator of infestation.

Timing of damage:

Mounds are present year round when not disturbed. The main period of mound building occurs during moist warm weather in early summer and again in fall. Mound building in summer is often hindered by dry weather; however, the underground portion of the colony remains viable.

Insects that look similar; Pests that cause similar damage:

Many species of ants look similar to the naked eye. Worker size can vary tremendously and is not a good diagnostic character. However, fire ants are one of the few ants that build soil mounds without ant apparent entry holes. The mounds are the best way to determine if fire ants are present.

MONITORING TECHNIQUES:

No specialized monitoring techniques are necessary. Mapping of the infestation based on the presence of mounds may be appropriate to determine where treatments are required at larger sites. Surface activity can be determined by prebaiting with greasy foods such as French fries or pieces of hot dog prior to the application of insecticidal baits for control.

THRESHOLDS:

There are no hard and fast thresholds for this pest. Fire ants should be controlled in areas where there is a high probability of contact with humans, or in areas where mounds are aesthetically unacceptable.

MANAGEMENT STRATEGIES:

Mapping of mounds is highly recommended to facilitate scouting and determine where insecticide treatments are required. Always consult the most recent version of all product labels before use. Follow resistance management guidelines by rotating products as outlined in IPM Template Reference "Insecticide Resistance Management Groups."

Red Imported Fire Ant management strategies				
TYPE	TIMING/ THRESHOLD	PRACTICE		COMMENTS
Cultural	N/A	Check deliveries of soil, sod and nursery plants to avoid new ant introductions at the site		
Biological	N/A	Currently, applications of biological agents are limited to state and federal agencies.		
Chemical*	Baits are the safest and most cost effective form of control. Apply baits when workers are actively foraging for food.	**Active Ingredient (Product)**	**Label signal word**	• Apply baits to dry soil and avoid rainfall and irrigation for 24-48 hours after application • Some baits take several weeks to reach maximum effectiveness. See label for specific time required.
		Abamectin (Affirm)	Caution	
		Hydramethylnon (Amdro)	Caution	
		Indoxacarb (Advion)	Caution	
		Methoprene (Extinguish)	Caution	
		Methoprene+ Hydramethylnon (ExtinguishPlus)	Caution	
		Priproproxifen (Distance)	Caution	
		Spinosad (Payback)	Caution	
	Mound drench is the fastest method to control colonies where immediate action must be taken.	Bifenthrin (Talstar)	Caution	• Apply adequate volume of liquid formulations as drench, or apply granules over mound and water in with a sufficient amount of water to ensure deep penetration
		Chlorpyrifos (Dursban)	Danger (WP), Caution (Liquid)	
		Cyfluthrin (Tempo)	Caution	
		Deltamethrin (Deltagard)	Caution	
	Contact insecticides can be broadcast as sprays or granules	Acephate (Orthene)	Caution	• Conserve native ants by avoiding wide area broadcast applications • Can be used as a surface dust treatment over top of mound where allowed by label
		Bifenthrin (Talstar)	Caution	
		Deltamethrin (Deltagard)	Caution	
		Fipronil (TopChoice)	**Caution**	

*chemical products shown in green type are considered reduced risk by the U.S. Environmental Protection Agency

Nuisance ants, Lasius neoniger

DESCRIPTION OF INSECT

Small (1/10 inch long), brown ants that create troublesome mounds on greens and tees.

Usually a beneficial insect that eats the eggs of white grubs and caterpillars

Predictive models (degree day, plant phenology, threat temperatures, other)

Become active once average air temperatures reach 55F (13C)

Conducive environmental conditions:

Average air temperatures > 55F (13 C)

Presence of root aphids in soil

Geographic distribution:

worldwide

DAMAGE CAUSED:

Plants attacked:

Greens and tees: all turf varieties. Areas with sandy rootzone mixtures and located in sunny areas are most likely to suffer damage.

Symptoms of damage:

Small mounds, most abundant at the edges of greens and tees

Mounds are unsightly, dull mower blades, create a bumpy playing surface and can smother the turf underneath.

Timing of damage:

Springtime, through early summer. Mound building starts to decline in late summer.

MONITORING TECHNIQUES:

Scout for mounds weekly, beginning in spring when average air temperatures exceed 55F (13C)

THRESHOLDS:

None established.

MANAGEMENT STRATEGIES:

Follow resistance management guidelines by rotating products as outlined in IPM Template Reference "Insecticide Resistance Management Groups." Always consult the most recent version of all product labels before use.

Nuisance ant management strategies				
TYPE	TIMING/ THRESHOLD	PRACTICE		COMMENTS
Cultural	N/A	If ants are not causing significant damage with their mounds, try to avoid treating with insecticides! As mentioned above, they play an important role in natural control of even more serious pests such as grubs and caterpillars.		
Biological		No effective strategies known		
Chemical*	Curative: treat when mounds 1st detected	Active Ingredient (Product)	Label signal word	Focus treatments on greens perimeter and collars. Control lasts 4-6 wks.
		Bifenthrin (Talstar)	Caution	
		Cyfluthrin (Tempo)	Caution	
		Chlorpyrifos (Dursban)	Danger	
		Deltamethrin (Deltagard)	Caution	
	Curative: treat when mounds 1st detected.	**fipronil (Chipco Choice, Top Choice)***	Caution	Control lasts 3 months. Must be applied by a PCO
	Curative: spot treat mounds	hydramethylnon (MaxForce)	Caution	Season-long control. The most effective treatment.
		abamectin (Advance Granular Carpenter Ant Bait)	Caution	

*chemical products shown in green type are considered reduced risk by the U.S. Environmental Protection Agency

INSECT REFERENCE

Billbugs, *Sphenophorus* spp.

DESCRIPTION OF INSECT

Immature stage:

Soft-bodied, small white grubs

Slightly tapered abdomen with a brown head capsule.

Larvae have no legs, unlike true white grubs.

Range in size from 1.3mm – 10mm (0.05 - 0.4 inches)

Pupae are cream color at first and turn reddish brown before adult emergence.

Mature stage:

Typical weevil form with snout (i.e. bill), elbowed antennae, and elytra (hard wing covers).

10-15mm in length. Body is longer than it is wide.

Damaging stage(s):

larvae (grubs)

Predictive models (degree day, plant phenology, threat temperatures, other)

To date there is not a degree day model developed for billbugs. Depending upon species the adults become active in April and early May, mate and lay eggs. In the southern states hunting billbug adults have been observed year round.

Life cycle:

30 - 60 days from egg to adult (dependant on species and location)

Females lay eggs into holes in the stems of grass where they had been feeding.

Eggs hatch in 6 -10 days

Larvae live for 30 – 50 days

Young larvae feed up and down the stem of the grass.

Older larvae can tunnel into the crown of the plant to feed and kill it.

Larvae pupate in the soil near the surface and emerge in 8-10 days.

Conducive environmental conditions:

temperatures above 65F (18C)

Geographic distribution:

North America

INSECT REFERENCE

DAMAGE CAUSED:

Plants attacked:

Common name	Host plants
Bluegrass billbug *Sphenophorus parvulus*	Bluegrass, rye, fescue, bentgrass (occasionally) zoysia
Hunting billbug *S.venatus vestitus*	Zoysia & hybrid Bermuda. Occasionally on bahia, centipede & St. Augustinegrass
Phoenician billbug *S.phoeniciensis*	Bermuda, zoysia and kikuyugrass
Denver billbug *S. cicatristriatus*	Cool-season turf, esp. bluegrass and ryegrass

Symptoms of damage:

Stems turn straw color as they die.

Small patches of dead grass that resemble dollar spot.

Larger patches of dead grass that can be mis-diagnosed as white grub damage, late green up, drought damage.

Tufts of grass will easily lift from the rest of the sod mat.

Timing of damage:

Most symptoms of damage appear in late June and July or when the grass begins stress from the summer heat.

Insects that look similar; Pests that cause similar damage:

White grub larvae maybe mistaken for billbugs. The key difference is the presence of legs on white grubs while they are absent from billbug larvae.

Billbug damage can be mistaken for white grub damage and/or dollar spot damage.

Slow green up or winter kill in warm season grass also looks similar to billbug damage.

MONITORING TECHNIQUES:

Soapy water flush for adults. Begin weekly soap flushes in the springtime, once average air temperatures exceed 65F (18C).

Adults are very active and can be seen walking across side walks and cart paths in the spring once temperatures warm up.

THRESHOLDS:

There are no thresholds for this pest.

Turf can tolerate very high numbers with out any obvious signs of damage, so it is usually best to wait until early signs of damage are observed.

If damage is noted adult billbugs may not be present.

Investigation of the stem and crown of the grass will then be needed to detect the larvae.

MANAGEMENT STRATEGIES:

Follow resistance management guidelines by rotating products as outlined in IPM Template Reference "Insecticide Resistance Management Groups." Always consult the most recent version of all product labels before use.

Billbug management strategies				
TYPE	TIMING/ THRESHOLD	PRACTICE		COMMENTS
Cultural	N/A	If infestations are light, and/or if damage is minimal, turf can sometimes "grow out" of the damage, especially if the turf is babied with more frequent irrigation and light fertilizer applications		
Biological	N/A	Use endophyte enhanced seed, if available		
Chemical*	Preventive control: target grubs in springtime, about 4 wks after adults 1st seen	**Active Ingredient (Product)**	**Label signal word**	
		Imidacloprid (Merit)	Caution	
		Halofenozide (Mach 2)	Caution	
		Clothianidin (Arena)	Caution	
		Thiamethoxam (Meridian)	Caution	
	Curative: target adults in springtime before they lay eggs	Bifenthrin (Talstar)	Caution	
		Chlorpyrifos (Dursban)	Danger	
		Cyfluthrin (Tempo)	Caution	
		Deltamethrin (Deltagard)	Caution	
		Lambda cyhalothrin (Scimitar)	Caution	
	Curative and preventive: treat in spring, soon after adults first appear	Imidacloprid + bifenthrin (Allectus)	Caution	

Black cutworm, *Agrotis ipsilon*

DESCRIPTION OF INSECT

Immature stage:

Caterpillars are relatively thick bodied, and reach 1.75 inches in length and 1/4 inch in width when mature.

Color varies from dark gray to black in upper half of body, without distinctive markings other than a pale stripe down the middle of the back and a few randomly scattered bristles. The caterpillar is otherwise hairless. The underside of the caterpillar is light gray. Under a hand lens, the skin appears bumpy and greasy.

Spiracles (small breathing holes on the thorax and abdomen) are black.

Three pairs of true legs on thorax (behind head); five pairs of prolegs towards the rear of the insect, on the abdomen.

Mature stage:

Adults are thick bodied, dark colored moths that fly at night. Their wingspan ranges from 1 – 1.75 inches.

The forewings are dark gray, brown or black and have a distinctive, dark colored marking in the shape of a dagger in the center of each forewing.

Hindwings are off-white or dirty white.

Damaging stage(s):

(caterpillars) only; adult moths do not feed

Predictive models (degree day, plant phenology, threat temperatures, other)

Caterpillars hatch once average air temperatures reach 55F (13C), and multiple overlapping generations can occur as long as temperatures are above this threshold.

Damage frequently appears following aeration, though caterpillars are typically present, without causing damage, before aeration

Life cycle:

40 – 60 days from egg to egg

Females lay eggs during the nighttime, usually on the tips of grass blades or on weeds such as curled dock or yellow rocket mustard.

Eggs hatch in 3-6 days

Larvae live for 20 – 40 days

Young larvae feed directly on leaf blades, causing little to no obvious damage

Older larvae are voracious feeders, eating up to a handful of foliage per night. These larvae reside during the day in the thatch and upper soil profile, where they construct silk-lined burrows. These are frequently found in aeration holes.

Larvae pupate in the larval burrow and the adult moth emerges roughly 2 weeks later.

Conducive environmental conditions:

temperatures above 55F (13C)

Geographic distribution:

worldwide

DAMAGE CAUSED:

Plants attacked:

Foliage of cool-season turf on greens, tees and sometimes fairways. Bentgrass, Poa annua, tall fescue and ryegrass are preferred. Cutworms do not survive well on Kentucky bluegrass.

Symptoms of damage:

small dead patches of turf that can resemble dollar spot

sunken areas or pockmarks that resemble ball marks.

Pecking by birds

Damage frequently occurs around aeration holes or spike mark holes, where cutworms burrow during the day.

Timing of damage:

Damage is frequently most obvious following aeration

Damage occurs when average air temperatures are above 55F (13C)

Insects that look similar; Pests that cause similar damage:

Sod webworms are thinner bodied, and have prominent spots throughout the body.

Fall armyworm has obvious striping patterns and pale colored spiracles surrounded by a whitish ring.

Dollar spot causes similar damage, but produces mycelium when turf is incubated overnight.

MONITORING TECHNIQUES:

Soap flush for larvae: This is the most useful of the monitoring techniques for cutworms. See IPM Template reference on “Monitoring for insects with soap flushes”.

Pheromone traps with female sex attractant. Monitoring for larvae should begin two weeks after the first peak of males is trapped.

THRESHOLDS:

There are no hard and fast thresholds for this pest. Turf, even on greens, can tolerate very high numbers without any obvious signs of damage, so it is usually best to wait until early signs of damage are observed. Following use of a soap flush to confirm the presence of cutworms, treatments can be triggered.

MANAGEMENT STRATEGIES:

Follow resistance management guidelines by rotating products as outlined in IPM Template Reference "Insecticide Resistance Management Groups." Always consult the most recent version of all product labels before use.

Black cutworm management strategies				
TYPE	TIMING/ THRESHOLD	PRACTICE		COMMENTS
Cultural	N/A	Utilize tolerant/resistant turf types including Kentucky bluegrass Remove clippings		
Biological	Apply when 1st small larvae are detected with soap flush	Beneficial nematode products based on *Steinernema carpocapsae* (Millenium). For other suppliers, see http://www.oardc.ohio-state.edu/nematodes/nematode_suppliers.htm		Moderate efficacy
Chemical	Apply curatively when damage threshold is reached	Active Ingredient (Product)	Label signal word	Include treatment of a 20 – 30 foot buffer zone around greens and tees to avoid re-infestation Apply in 1 – 2 ga/1000 sq ft. Do not water in
		Bifenthrin (Talstar)	Caution	
		Cyfluthrin (Tempo)	Caution	
		Chlorpyrifos (Dursban)	Danger	
		Deltamethrin (Deltagard)	Caution	
		Halofenozide (Mach 2)	Caution	
		Lambda cyhalothrin (Scimitar)	Caution	
		Spinosad (Conserve)	None required	

Black turfgrass ataenius, *Ataenius spretulus*

DESCRIPTION OF INSECT

Immature stage:

Small (less than 1/4 inch maximum length) white to transparent grub with 6 legs, light brown head.

Frequently lies in “C” shaped position

Lives in soil; feeds on roots

Mature stage:

Small (1/4 inch long), hard-bodied black beetle with short antennae and striations on wings

Frequently found walking on surface of greens, especially on warm and sunny days

3 pair of legs

The color of ataenius beetles may be reddish brown for the first day or two after they emerge from their pupae in the soil. After this, they remain black for the duration of their lives.

Damaging stage(s):

Grubs only

Predictive models

Monitor average air temperatures in the springtime. When there are 3 or more consecutive days of 65F, be prepared for grubs to appear within the next 2 -4 weeks.

Life cycle:

Eggs are laid in the soil by adult beetles.

Grubs hatch from the eggs and spend their entire lives in the soil. They live 4 – 8 weeks, depending on soil temperatures.

Once grubs reach their maximum size, they form pupae in the soil. Soon afterwards, adult beetles emerge and crawl to the surface of the turf, where they begin to look for mates.

In warmer climates, there can be 2 or more generations of ataenius per year. In cooler climates, there is only one generation per year.

Conducive environmental conditions:

Average air temperatures >65F (18C)

High organic matter in soil (>2% on greens; >6% on other turf)

Location near livestock operation (horses, chickens, cows, etc). Ataenius are dung beetles and are drawn to the odor of manure and to high organic matter environments

Use of organic fertilizers

Damage will develop more rapidly when turf is stressed due to:

High soil salts (salinity)

Compaction or traffic

Heat or drought

Geographic distribution:

Most of North America. Related insects cause problems on golf course turf in other regions of the world.

DAMAGE CAUSED:

Plants attacked:

All varieties of turf are attacked, but damage develops only on cool season turf. This is due to the relatively shallow root system of cool-season turf, which cannot withstand sustained feeding by ataenius grubs.

Animals damage due to birds, reptiles or mammals searching for grubs and adults of the ataenius can occur on any turf type.

Symptoms of damage:

Initial symptoms are small areas of thin, yellowing or wilting turf. As grub feeding continues, affected patches grow in size and turf eventually dies. Turf can be easily picked up by hand, due to destruction of the root system.

Timing of damage:

Late spring, summer and early fall, as long as average air temperatures are greater than 65F (18C)

Insects that look similar; Pests that cause similar damage:

Adult black turfgrass ataenius can be confused with:

- Ground beetles: ground beetles differ in their size (usually larger), their long, thin antennae and their rapid running movements
- Aphodius beetles: these closely related beetles have a similar size and shape, but are lighter colored — usually light to dark brown.

Larval (grub) black turfgrass ataenius can be confused with:

- Newly hatched larvae of other white grub species including Japanes beetle, chafers, Oriental beetle, Asiatic beetle or May/June beetles). Although these grubs will eventually become much larger than ataenius grubs, when they are first hatched, they are difficult to distinguish from ataenius.

MONITORING TECHNIQUES:

Adults: Adult beetles can be detected by examine the surface of greens, in clippings in mower baskets, or by applying a 1% soap solution (see Reference “Monitoring for insects with soap flushes”) to the turf surface.

Larvae (grubs): The only way to locate grubs is to cut or peel away the turf surface. Grubs usually reside near the thatch/soil interface. Grubs are typically found in areas showing signs of damage and/or areas that were infested in previous years. Other areas to start looking include locations where animals have been digging for insects, wet and poorly draining areas, areas where turf is stressed for other reasons.

THRESHOLDS:

There are no generally accepted threshold levels. On greens, a few ataenius grubs per square foot can cause damage on cool-season turf. On higher mown turf, higher densities can be tolerated.

INSECT REFERENCE

MANAGEMENT STRATEGIES:

Follow resistance management guidelines by rotating products as outlined in IPM Template Reference “Insecticide Resistance Management Groups.” Always consult the most recent version of all product labels before use.

TYPE	TIMING/ THRESHOLD	PRACTICE	
Cultural	N/A	Avoid stressed turf through management of irrigation, traffic, black layer, drainage salinity Avoid organic fertilizers To stop animals from digging for grubs, apply Milorganite to turf at labeled rates.	
Biological			
Chemical	Preventive: target grubs w/ applications made late spring/early summer after average air temperatures >65F (18C)	Active Ingredient (Product)	Label signal word
		clothianidin (Arena)*	Caution
		halofenozide (Mach 2)	Caution
		imidacloprid (Merit)	Caution
		imidacloprid + bifenthrin (Allectus)	Caution
		thiamethoxam (Meridian)	Caution
	Curative: target adults once they are detected	Bifenthrin (Talstar)	Caution
		Cyfluthrin (Tempo)	Caution
		Chlorpyrifos (Dursban)	Danger (WP); Caution (liquid)
		Deltamethrin (Deltagard)	Caution
		Lambda cyhalothrin (Scimitar)	Caution
	Curative: target grubs once they are detected	Acephate (Orthene)	Caution
		Clothianidin (Arena)*	Caution
		Imidacloprid (Merit)	Caution
		Thiamethoxam (Meridian)	Caution
		Trichlorfon (Dylox)	Caution (granule); Warning (powder)

Earthworms

DESCRIPTION OF INSECT

All stages live in the soil and are only seen on the surface after rain or irrigation, or rarely at night.

Immature stage:

Eggs are laid underground in cocoons

• All stages appear similar and vary only in size

Mature stage:

Adults are elongated cylindrically shaped Annelids, generally with a pinkish color.

Damaging stage(s):

Juveniles and adults can produce castings at the soil surface

Predictive models (degree day, plant phenology, threat temperatures, other)

Earthworms are active at the surface when the soil is moist and soil temperatures are moderate. Generally most activity is seen in spring and fall with less activity during the hot dry summer months.

• Castings produced at the surface are the best indicator of earthworm activity. However, feeding activity by birds, moles and other worm-eating mammals is also an indicator.

Life cycle:

Many earthworms are long-lived with a multi-year life cycle.

• Eggs are generally laid in spring and are contained in a cocoon produced by the female.

Occurrence and surface activity are primarily influenced by soil moisture and temperature

Conducive environmental conditions:

moist soil conditions, high levels of soil organic matter.

Geographic distribution:

worldwide

DAMAGE CAUSED:

Plants attacked:

The primary concern are the castings (mounds of extruded waste soil) deposited on the surface in short mowed, high maintenance turfgrass areas (such as greens and tees) where appearance or playing surface is of critical importance. Mowing during moist soil conditions can smear soil over growing grass and affect growth and appearance.

Earthworms exiting the soil and moving to adjacent impervious surfaces (sidewalks) during rainfall and irrigation can also be considered as a problem in some areas.

Symptoms of damage:

Castings produced at the soil surface.

• Earthworms on sidewalks

Timing of damage:

Castings can be produced at any time of year, but most often occur in spring and fall.

• Earthworm may exit the soil in response to high soil moisture caused by rainfall and irrigation.

Pests that look similar; Pests that cause similar damage:

Some beetles produce small mounds of soil, but these mounds do not have an 'extruded' appearance.

MONITORING TECHNIQUES:

Soap flush, mustard solution flush or heavy application of irrigation can cause earthworms to surface.

Casting counts can be used as an index of abundance

THRESHOLDS:

There are no thresholds for earthworms. Earthworms are generally considered as beneficial organisms and are not a problem in most turfgrass situations. The primary concern are the castings (waste soil mounding) deposited on the surface in short mowed, high maintenance turfgrass areas such as greens and tees where appearance or playing surface is of critical importance. Low to moderate populations can be considered undesirable in these situations, especially on greens where ball roll can be affected.

MANAGEMENT STRATEGIES:

Earthworms are most often a problem where moist soil conditions occur. Improving drainage reduces soil moisture and earthworm activity. Where drainage is not a viable solution, flooding can cause earthworms to come to the surface where they can be preyed upon by birds. No pesticides are labeled for earthworm control.

Earthworm management strategies				
TYPE	TIMING/ THRESHOLD	PRACTICE		COMMENTS
Cultural	N/A	Reduce soil moisture by managing irrigation or improving drainage Sand topdressing Avoid organic fertilizers, manage organic matter		
Biological	N/A	——-		
Chemical	There are no pesticides registered for control of earthworms. However, those listed to the right are registered for use on golf course turf and have been shown to be effective against earthworms	Active Ingredient (Product)	Label signal word	
		Carbaryl (Sevin)	Warning	
		Thiophanate-methyl (Cleary's 3336)	Caution	

Fall armyworm, *Spodoptera frugiperda* (J.E. Smith)

DESCRIPTION OF INSECT

All stages except the pupae are above ground.

Eggs:

Eggs are small and circular (0.2 in) and laid in clusters of about 50-250. The eggs are initially greenish-white when first laid, but turn almost black just prior to hatching. The egg masses appear fuzzy due to scales form the female's body.

Immature stage:

Caterpillars: Larvae are green to brown to almost black. The head is dark and marked by a conspicuous yellow or white inverted "Y" on the front of the head. Unlike the black cutworm, fall armyworms have a black stripe on each side that runs the length of the body and a less prominent faint stripe that runs the length of the body down the middle of the "back". Each abdominal segment has four small, but distinct dots. When fully grown, the caterpillars range in size from just over 1 ¼ inches up to almost 2 inches long.

Pupae are about ½ inch long and reddish brown to near black. The pupae are always found in the soil.

Mature stage:

Adults are moths with a wingspan of 1 ½ inches. Front wings are mottled dark gray with light and dark markings. There is a distinct white blotch near the tip of each front wing. Markings on the male are more pronounced than the female with males having a more gray color and a light diagonal marking on the forewing, the female is more brownish. The back wings are white.

Damaging stage(s):

The caterpillars are the damaging stage and typically cause the most severe damage during the last 3-5 days prior to pupation.

Predictive models (degree day, plant phenology, threat temperatures, other)

Moths arrive from spring through mid summer depending upon location. Since this insect does not overwinter in most areas of the U.S. it is difficult to forecast its occurrence. Timing of outbreaks are influenced by migratory patterns of moths each spring.

Weekly soap flush sampling starting in late spring in the southern U.S. and mid summer in the northern U.S. is the best method to determine if fall armyworm eggs have hatched in your area.

Life cycle:

The fall armyworm has multiple generations per year depending upon the location. This insect overwinters in south Florida and along the extreme southern Gulf Coast. Each spring moths migrate north and the timing and extent of these migrations is dependent upon spring weather patterns. In the Southeast, damage may occur in May and three

or more generations may occur. Whereas in areas further north in the U.S. may not see damaging populations until August and only one generation occurs.

Females lay eggs on light-colored objects including materials, foliage of plants, flags on golf greens, fences and buildings, metal gutters, and other objects. The moths are attracted to lights and egg laying is often more common in those areas.

Eggs hatch in 2-10 days and most eggs in a mass hatch about the same time.

The small caterpillars spin down to the turf on threads and feed in the morning and early afternoon.

As the caterpillars become larger after 2-3 weeks they may feed more at night to avid predation by birds. After 3-4 weeks the caterpillars burrow into the soil to pupate.

Moths emerge from the pupae in 10-14 days.

Conducive environmental conditions:

warm, wet springs with weather fronts moving up from the South may lead to earlier outbreaks. Wet spring also appear to be detrimental to natural enemies of the fall armyworms.

Geographic distribution:

South, Central and North America

DAMAGE CAUSED:

Plants attacked:

Although bermudagrass is most commonly damaged, falll armyworms feed on most grasses. Infestations are most commonly associated with lush, green, dense grass.

Symptoms of damage:

Young larvae skeletonize the tenderest leaf tissue.

Older larvae consume most of the leaf tissue

Warm season turfgrass may take on the appearance of frost or freeze damage.

Presence of or pecking in turf by birds.

Larvae move in groups and often is definite line of damage starting at edge of turf

Damage often associated with lights.

Growing tips of cool season turf is often affected and serious damage results.

Timing of damage:

Visible damage typically begins in mid summer through fall.

Since this pest must migrate back into areas each spring there is usually no relationship between infestation from one year to the next..

Links to photographs, illustrations of damage

http://www.turffiles.ncsu.edu/news/insects/FallArmyWorm.htm

Insects that look similar; Pests that cause similar damage:

Areas with a serious fall armyworm infestations may have a similar appearance to drought stress or in the case of warm season turf, may resemble frost damage. However, grub infestations are much more common in cool-season grass and much less common in warm season turf. Mole cricket damage mainly limited to sandy soils and warm season turfgrass.

Some surface-dwelling crickets look similar, but are much darker in coloration and do not have large front feet modified for digging.

MONITORING TECHNIQUES:

Fall armyworms may feed actively during the day when small, but have a tendency to be more reclusive and to avoid feeding during the day when they become larger (and more damaging). The presence of birds in a turf area may be an indicator of fall armyworm presence. Weekly soap flush sampling (see IPM Template Reference “Monitoring for insects with soap flushes”) starting in late spring in the southern U.S. and mid summer in the northern U.S. is the best method to determine if fall armyworm are present in turfgrass.

THRESHOLDS:

There are no hard and fast thresholds for this pest. Some fairways can tolerate moderate infestations, but infestations usually move in from the rough and numbers as high as 100 per square yard can occur. Cool season turf is likely to be more seriously damage. Established bermuda usually recovers, but may take several weeks for regrowth to cccur. Newly-sodded, seeded or sprigged areas are prime areas for damage.

MANAGEMENT STRATEGIES:

Watching for birds on turf, observing large numbers of moths flying around lights, and green fecal pellets in the turf can be indicators of a fall armyworm infestation. Use of soapy water flushes to confirm presence is critical. Mowing will mechanically kill some larvae. Mowing also reduces depth and thickness of turf and allows for better coverage with spray applications. Irrigation prior to treatment may stimulate caterpillars to be more active during application. Always consult the most recent version of all product labels before use.

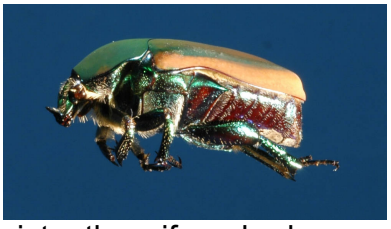
Follow resistance management guidelines by rotating products as outlined in IPM Template Reference "Insecticide Resistance Management Groups."

Fall armyworm management strategies				
TYPE	TIMING/ THRESHOLD	PRACTICE		COMMENTS
Cultural	N/A	Mowing		
Biological	Apply when adult stage is detected, or by damage, or with soap flush	Beneficial nematode products based on *Steinernema scapterisci*. For current suppliers, see http://www.oardc.ohiostate.edu/nematodes/nematode_suppliers.htm		• Pre and post application irrigation critical • Not recommended for heavy infestations
Chemical	Apply when small larvae are first detected with soap flush for best results	**Active Ingredient (Product)**	**Label signal word**	Sprayable formulations typically outperform granular formulations Sprayable formulations typically outperform granular formulations Apply while armyworms are less than 1 inch long for best control.
		Acephate (Orthene)	Caution	
		Bifenthrin (Talstar)	Caution	
		Carbaryl (Sevin)	Warning	
		Cyfluthrin (Tempo)	Caution	
		Deltamethrin (Deltagard)	Caution	
		Indoxacarb (Provaunt)	Caution	
		Lambda cyahalothrin (Scimitar)	Caution	

Green June beetle, Cotinus nitida (L.)

DESCRIPTION OF INSECT

Eggs, larvae, and pupae are found in the soil, but adults are present above ground. Green June beetles have a one year life cycle.



Eggs:

Eggs are dull white when laid and about 1/16 inch in diameter. They absorb moisture from the soil and increase in size to about 1/8 inch. Eggs are laid in a cluster of 10-30 eggs and a female may lay from 60-75 eggs. Eggs hatch in about two weeks.

Immature stage:

White grubs: Larvae are unique in that they have stiff abdominal bristles on the grubs back, short legs, a rather consistently uniform body shape with parallel sides. The grubs have three instars and the approximate sizes are: 1st instar – ¼ in., 2nd instar – ¾ in., and 3rd instar – 2 in. These grubs have the unique habit of emerging from the soil and crawling on their backs. They construct vertical tunnels in the soil.

Pupae are about 1 inch long and whitish at first, but darkening through time. The pupal cell resembles a bird's egg and is covered with soil particles held together by a sticky secretion.

Mature stage:

The adult beetles are quite large (¾ to 1 inch long) and vary in color of the wings from dull brown to velvety forest green. The outer margins of the wings have a thin band around them that varies from tan to orange-yellow. The adults prefer to feed on overripe fruits such as peaches, tree sap, and other sugary foods.

Damaging stage(s):

The larvae or grubs are the damaging stage and almost exclusively, the third instar is the damaging stage in late summer through fall and again in the spring.

Predictive models (degree day, plant phenology, threat temperatures, other)

There are no predictive models for green June beetle grubs. The timing of beetle flights and grub appearance is consistent from year to year. Populations often cycle through high to low levels every 5 or 6 years.

Life cycle:

Beetles emerge in the summer from pupal cells. The adults fly over open grassy areas and often fly early in the morning and rest on vegetation or under thatch at night. Eggs are laid in mid summer and hatch in two weeks, Grubs grow to the 3rd instar by late summer, early fall and overwinter in that stage. The grubs feed briefly in the spring before pupating.

Conducive environmental conditions:

Too much thatch, composted yard waste, and the use of manure-based fertilizers in the spring and summer can create a more attractive and more favorable site for green June beetle grub infestations. Prefers light-textured soils and requires at least 20 in. of rain or irrigation per year.

Geographic distribution:

Eastern United States into Texas and small area in southern California. Through the transport of plant materials and soil, this pest has the potential to spread to additional areas.

DAMAGE CAUSED:

Plants attacked:

Green June beetle grubs attack all turf types and particularly prefer moist, light-textured soils with higher organic matter. Little feeding on the roots actually occurs.

Symptoms of damage:

Vertical tunnels cause mounds of soil to be produced. Tunnels may extend 18 inches deep.

Thinning of turf, weed encroachment, drying out of soil

Tunneling near the soil surface, loosening of soil

Presence of or damage from moles, raccoons, skunks, birds.

Grubs found on sidewalks, garages, etc in the morning

Timing of damage:

Visible damage typically begins in late summer through fall.

Damage will continue in fall until soil becomes too cool for activity

Damage will appear again in spring as soil warms until grubs pupate in late spring.

Preferred sites often suffer from infestations year after year, but often cycle through low and high years of damage every 3-5 years.

Insects that look similar; Pests that cause similar damage:

Areas with a serious green June beetle infestation may have a similar appearance to mole cricket or earthworm infestations. Drought stress may also resemble the affect of grub tunneling.

MONITORING TECHNIQUES:

Soap flush will NOT bring white grubs to the surface. Beetles are often noticed flying or “dive-bombing” turf areas in the morning. The first signs of small mounds of soil pushed up should be investigated. Watch for signs of a large, dark blue wasp flying in a figure 8 pattern about one foot above the turf. This is a parasitic scoliid wasp that is present when green June beetle grub populations infest an area.

THRESHOLDS:

There are no hard and fast thresholds for this pest. Some turfgrass may be able to tolerate 6 to 7 grubs per square foot and turf with thicker blades and higher cut tend to hide the damage better. Most turfgrass will recover given proper soil moisture.

MANAGEMENT STRATEGIES:

Management of thatch and organic matter can help reduce the attractiveness of an area to this pest. Composted yard waste or manure based fertilizers applied in the spring or early summer will increase the likelihood of an infestation. Treating an infestation in late summer/early fall once the grubs are large with a surface insecticide such as carbaryl (Sevin) will provide good control, but the grubs die on the surface within 12 hours. The next few days will consist of thousands of dead unsightly and smelly grubs lying on the surface.

Follow resistance management guidelines by rotating products as outlined in IPM Template Reference "Insecticide Resistance Management Groups."

Green June beetle management strategies				
TYPE	TIMING/ THRESHOLD	PRACTICE		COMMENTS
Cultural	N/A	Avoid excessive thatch and the presence of organic matter, particularly in summer when adults are flying		
Biological	Apply when grubs are small (late summer)	Entomopathogenic nematodes. For current suppliers, see http://www.oardc.ohiostate.edu/nematodes/ nematode_suppliers.htm		Pre and post application irrigation critical Not recommended for heavy infestations
Chemical	Apply during egg laying, egg hatch or when grubs are small	Active Ingredient (Product)	Label signal word	Sprayable and granular formulations typically perform the same Irrigation post-treatment is recommended for all products except carbaryl
		Carbaryl (Sevin)	Warning	
		Clothianidin (Arena)	Caution	
		Halofenozide (Mach 2)	Caution	
		Imidacloprid (Merit)	Caution	
		Imidacloprid + bifenthrin (Allectus)	Caution	
		Thiamethoxam (Meridian)	Caution	

May and June beetles (2 and 3 year grubs), Phyllophaga spp.

DESCRIPTION OF INSECT

Immature stage:

Difficult to identify to species.

C – shaped larvae with 3 pairs of well developed legs

Large brown head capsule with well developed mandibles.

Distinguished from other white grubs by the broad Y-shaped anal slit and two rows of parallel bristles that point toward each other on the raster (bottom side of rear end near anus).

Range from 6.3 mm – 38 mm (3/16 – 1 ¼ inches) fully grown.

Mature stage:

Adults vary in color from light brown to almost black depending upon species.

There bodies support different amounts of hair from none at all to dense stands.

Size varies from 10.5 mm – 30 mm (3/8 – 1 1/8 inches).

Damaging stage(s):

mainly larvae damage turf but adults maybe found feeding on foliage of certain grasses, trees, and shrubs.

Predictive models (degree day, plant phenology, threat temperatures, other)

No degree day model exists for predicting flights of May/June beetles. The adults are dependant upon soil moisture along with warmer temperatures and large flights of beetles may be noted with in days of a large rain.

A black light trap may be used to help monitor for adult flights to help determine when egg lay will occur.

Life cycle:

1 – 3 years from egg to adult.

Females lay eggs individually in earthen cells usually during the nighttime, although there are a few daytime active species.

Eggs are small white ovals that become more round with age. 2 mm in size (5/64 inch).

Larvae develop through three instars in the ground and feed on organic matter and available roots.

They proceed through the first two instars and pupal stage rather quickly, spending most of their lives as 3rd instars

Larvae will migrate deeper into the soil profile to over winter and migrate back up to the surface in the spring.

Depending upon the species and the year of development the larvae will over winter as 2nd or 3rd instars, in some cases as pupae or adults.

Adults typically emerge from April-June to mate, although in the southern regions some species can be found flying into the fall.

Conducive environmental conditions:

Adult mating flights are dependant upon warming temperatures and adequate soil moisture.

Geographic distribution:

North and South America

DAMAGE CAUSED:

Plants attacked:

Root systems of cool-season and warm-season grasses on greens, tees and fairways.

Symptoms of damage:

Damaged turf wilts under drought stress and eventually dies in uneven patches.

In cases of a high density grub population the sod maybe lifted free from the root system.

Mammals also cause severe damage when searching for white grubs. They root up and dig unsightly holes in turfgrass.

Timing of damage:

Damage is most obvious during the hottest days of the summer when the lack well developed root system stresses the grass.

Damage due to mammals usually noted in last half of summer or in fall when larvae are larger.

Links to photographs, illustrations of damage

http://www.oznet.ksu.edu/dp_hfrr/TURF/insects%20grub%20damage%20on%20soccer%20field%202.jpg

• http://hcs.osu.edu/images/cd0005/cd0005-06.jpg

Insects that look similar; Pests that cause similar damage:

All white grubs look similar in appearance this includes; Japanese beetle, masked chafers, green june beetle, oriental beetle, black turfgrass ataenius.

Some of these maybe ruled out according to geographic location.

Adult beetles of each of these larvae can be more easily identified from each other.

MONITORING TECHNIQUES:

Black light trapping of adults can give an indication of oviposition.

Pheromones are not currently available but may be available in the near future.

INSECT REFERENCE

THRESHOLDS:

There are no thresholds supported by experimentation. Depending upon the turf type, region, and moisture availability thresholds can range from 4-12 per 0.1 m^2 (1 ft^2) for direct damage from the larvae.

In the case of mammal damage the threshold is 0.

MANAGEMENT STRATEGIES:

Follow resistance management guidelines by rotating products as outlined in IPM Template Reference "Insecticide Resistance Management Groups." Always consult the most recent version of all product labels before use.

May and June beetle management strategies				
TYPE	TIMING/ THRESHOLD	PRACTICE		COMMENTS
Chemical	Target young larvae (grubs) in late spring	**Active Ingredient (Product)**	**Label signal word**	
		Clothianidin (Arena)	Caution	
		Halofenozide (Mach 2)	Caution	
		Imidacloprid (Merit)	Caution	
		Thiamethoxam (Meridian)	Caution	

INSECT REFERENCE

Southern mole cricket, *Scapteriscus borellii*

Tawny mole cricket, *Scapteriscus vicinus*

DESCRIPTION OF INSECT

All stages live in the soil and are rarely see on the surface.

Immature stage

Nymphs of both species are similar in appearance to adults, but lack wings. Nymphs proceed through 8-10 instars ranging in size from 0.2 to 1.25 inches in length. Each instar is progressively larger with wing buds apparent on later instars.

Color varies from gray to brown. Pronotum (large shield behind head) with distinctive mottling or spots, depending on species and location.

Mature stage

Adults are somewhat cylindrically shaped, light colored crickets 1.26 to 1.38 inches in length.

Adults have two pairs of wings, but only fly at night during two brief flight periods in fall and early spring. Spring flights are generally more extensive than fall flights.

Damaging stage(s)

Both nymphs and adults cause damage

Links to photographs, illustrations of insects

ADULT Tawny Mole Cricket: http://molecrickets.ifas.ufl.edu/mcri0039.htm

ADULT Southern Mole Cricket: http://molecrickets.ifas.ufl.edu/mcri003e.htm

Predictive models (degree day, plant phenology, threat temperatures, other)

Both species hatch in spring/early summer. TMC hatches slightly earlier (June), SMC hatches slightly later (July) and has a protracted hatch. Egg-laying and hatch timing are affected by soil moisture.

Preventative treatments should be timed to slightly precede or coincide with peak hatch.

Weekly soap flush sampling in June and early July is the best method to determine when hatch is occurring, and the best time to treat.

Life cycle:

Both species have a one-year life cycle throughout most of range. SMC may have more than one generation in southern Florida.

Females lay eggs in underground chambers in spring.

Eggs hatch in approximately 20 days, depending on soil temperature and moisture.

Nymphs are present from June hatching until winter or spring

Nymphs of TMC become adults in late fall, nymphs of SMC become adults in early spring

Nymphs generally cause no visible damage until mid to late July

Conducive environmental conditions:

warm, wet springs may lead to earlier hatch date

Geographic distribution:

worldwide

DAMAGE CAUSED

Plants attacked:

Roots and stems of warm-season turf on fairways, greens and tees.

Although bermudagrass is most commonly damaged by feeding, mechanical damage from tunneling can occur in any managed turf where appearance or playing surface is of critical importance.

Symptoms of damage:

Small and large tunnels produced by nymphs and adults

The disappearance of grass and a spongy feel under foot

A tilled appearance where larger nymphs have been actively tunneling

Pecking or digging in turf by birds and mammals

Timing of damage:

Visible damage begins to appear in mid to late July and gets progressively worse until the onset of cold weather

Damage from large nymphs and adults begins in early spring as soil temperatures rise.

Damage in spring is usually less severe than that occurring the proceeding summer and fall.

Insects that look similar; Pests that cause similar damage:

Areas with a serious grub infestation may have a similar appearance and a spongy feeling under foot at about the same time as mole cricket damage appears. However, grub infestations are much more common in cool-season grass and much less common in warm season turf. Mole cricket damage mainly limited to sandy soils and warm season turfgrass.

• Some surface-dwelling crickets look similar, but are much darker in coloration and do not have large front feet modified for digging.

MONITORING TECHNIQUES:

Soap flush for nymphs and adults is the most useful of the monitoring technique for mole crickets. Begin weekly soap flushes in the springtime in mid-June and continue monitoring to confirm the presence, distribution and size of the nymphs, and to

determine the effectiveness of insecticide applications. Mapping of the infestation based on damage noted the previous season is highly recommended to facilitate scouting and determine where treatments are required. Treatments should be applied before new damage occurs. Preventive treatments should be applied prior to egg-hatch (Early June) or at the time of peak hatch (last week of June, first week of July.

THRESHOLDS:

There are no hard and fast thresholds for this pest. Some fairways can tolerate moderate infestations, especially of the SMC. Any damage to greens and tees is more serious, and little damage can be tolerated in these areas.

MANAGEMENT STRATEGIES:

Mapping of previously damaged areas is highly recommended to facilitate scouting and determine where insecticide treatments are required. Always consult the most recent version of all product labels before use.

Follow resistance management guidelines by rotating products as outlined in IPM Template Reference "Insecticide Resistance Management Groups."

Mole cricket management strategies				
TYPE	TIMING/ THRESHOLD	PRACTICE		COMMENTS
Cultural	N/A	• Map infestations when damage is evident in fall and spring • Determine when nymphs are hatching using soapy water flush		
Biological	Apply when adult stage is detected by damage or with soap flush	Beneficial nematode products based on *Steinernema scapterisci*. For current suppliers, see http://www.oardc.ohiostate.edu/nematodes/nematode_suppliers.htm		• Pre and post application irrigation critical • Not recommended for heavy infestations
Chemical	Preventative: apply when 1st small larvae are detected with soap flush	**Active Ingredient (Product)**	**Label signal word**	• Early treatments applied to and around previously damaged areas may be sufficient to control infestation • Apply while nymphs are less than ¼ inch long
		Bifenthrin (Talstar)	Caution	
		Cyfluthrin (Tempo)	Caution	
		Deltamethrin (Deltagard)	Caution	
		Fipronil (TopChoice)	Caution	
		Imidacloprid (Merit)	Caution	
		Lambda cyhalothrin (Scimitar)	Caution	
	Curative: apply when damage first detected	Acephate (Orthene)	Caution	• Water before application. Do not water in • Avoid rain or irrigation for 24 hrs after application
		Mole cricket bait (several active ingredients)	Caution	
			Caution	

IPM Monitoring: Soap flush

Black cutworm larvae emerging from thatch following a soap flush

USES

Detects the following pests:

Black cutworm larvae

Sod webworm larvae

Black turfgrass ataenius adults

Billbug adults

Earthworms

Armyworms

NOTE: This method will NOT detect white grubs (chafers, black turfgrass ataenius, Japanese beetle, etc) and will NOT detect the larvae (grubs) of billbugs

PROCEDURE:

To prepare a soap solution, there are two approaches: for monitoring of small areas, using the watering can solution (#1 below). For monitoring of larger or multiple areas, consider use of the hose-end sprayer method (#2 below).

- Beginning in late Spring, when average air temperatures begin to exceed 55F (13C), keep an eye out for signs of caterpillars: feeding holes (Figure 3), bird activity, or dew trails (by walking over the surface of the turf at night and early morning, cutworms make a visible trail when there is dew). Use signs of early cutworm damage as a trigger date for beginning your caterpillar sampling program. Continue monitoring throughout the spring and summer, until average air temperatures begin to cool off, dropping below 55F (13C).

Purchase liquid dishwashing soap such as Lemon Joy, Ivory Clear or Ultra Dawn. These have been shown to cause the least damage to turf. Avoid Palmolive liquid dishwashing soap, as this sometimes may cause damage to turf.

Prepare a solution according to #1 (watering can method) or #2 (hose-end sprayer method) below.

Apply soap solution (using either a water can, Figure 1, or hose-end sprayer, Figure 2) to an area 1 square yard (91^2 cm). A sampling square with these dimensions can easily be assembled from PVC pipe (see Figure 1).

1) Watering can method: For use when monitoring small areas

- Add 1 oz (two tablespoons) of liquid dishwashing soap to 2 gallons of water (30 ml soap per 7.6 liters of water)
- Apply to a one square yard area, as shown in Figure 1. The turf and thatch should be well drenched with the soap solution until some suds begin to appear.

Cutworm and armyworm larvae and black turfgrass ataenius adults will surface within 10 minutes. Sod webworm larvae may take up to 15 minutes to surface.

2) Hose end sprayer method

- Prepare at least one gallon of a solution that contains two parts water to 1 part dishwashing liquid. If you plan to prepare one gallon of solution, you would need 86 oz (2.6 liters) of water and 42 oz (1.3 liters) of dishwashing liquid. It is necessary to dilute the dishwashing liquid in this way BEFORE adding it to a hose-end sprayer because it is too thick for spraying and mixing in its unaltered state.
- Obtain a hose-end sprayer such as the Gilmour Insecticide and Fertilizer sprayer (Figure 2). When using the 2:1 solution of Lemon Joy described above, set the dial of the Gilmour sprayer to 1 tablespoon.
- Apply to a one square yard area, as shown in Figure 2. The turf and thatch should be well drenched with the soap solution until some suds begin to appear.

Cutworm and armyworm larvae and black turfgrass ataenius adults will surface within 10 minutes. Sod webworm larvae may take up to 15 minutes to surface.

WARNING: Soap solution can damage turf if used at rates higher than specified above

Figure 1. Application of soap solution with a watering can. PVC pipe was used to construct this sampling square.

Figure 2. Application of soap solution with a hose-end sprayer.

Insecticide resistance management groups.

Current resistance management strategies rely on rotation among different pesticide groups. Insecticide RAC (www.plantprotection.org/irac/).

Active Ingredient	Trade Name	Insecticide Group Name	Group #
acephate	Orthene	acetyl choline esterase inhibitors	1
carbaryl	Sevin	acetyl choline esterase inhibitors	1
chlorpyrifos	Dursban, Pageant	acetyl choline esterase inhibitors	1
trichlorfon	Dylox, Proxol	acetyl choline esterase inhibitors	1
fipronil	Chipco Choice	GABA-gated chloride channel antagonists	2
bifenthrin	Talstar	sodium channel modulators	3
cyfluthrin	Tempo	sodium channel modulators	3
deltamethrin	Deltagard	sodium channel modulators	3
λ cyhalothrin	Scimitar	sodium channel modulators	3
clothianidin	Arena	acetyl chlorine receptor antagonists	4
imidacloprid	Merit	acetyl chlorine receptor antagonists	4
thiamethoxam	Meridian	acetyl chlorine receptor antagonists	4
spinosad	Conserve	acetyl chlorine receptor modulators	5
halofenozide	Mach 2	ecdysone agonist/disruptor	18

INSECT REFERENCE

Selected Insecticide Active Ingredients and the Insects they Control. Contact (foliar) products are printed in green; and systemic (soil) insecticides in red. P = preventive control; C = curative control; P/C = both preventive and curative control. Always read the most recent version of product labels to insure compliance with all use instructions.

	STAGE		INSECTICIDE ACTIVE INGREDIENT													
INSECT PEST	Larvae	Adults	Acephate	Abamectin	Bifenthrin	Carbaryl	Cyfluthrin	λ cyhalothrin	Chlorpyrifos	Deltamethrin	Fipronil	Halofenozide	Hydramethylnon	Imidacloprid	Spinosad	Trichlorfon
CONTROL TARGET = ROOTS (SOIL) OR INSIDE PLANT																
Annual bluegrass weevil	X											P		P		
Billbugs	X											P		P		
Mole crickets	X	X	C		C		C	C		C	P/C			P/C		
White grubs, including:	X		P/C			C*						P		P		P/C
• Asiatic garden beetle****	X		P/C			C*						P				P/C
• Black turfgrass ataenius	X		P/C			C*						P/C		P/C		P/C
• European chafer	X		P/C			C*						P**		P**		P/C
• Green June beetle***	X		P/C			C*						P		P		P/C
• Japanese beetle	X		P/C			C*						P		P		P/C
• Masked chafers	X		P/C			C*						P		P		P/C
• May and June beetles	X		P/C			C*						P		P		P/C
• Oriental beetle	X		P/C			C*						P**		P**		P/C
CONTROL TARGET = FOLIAGE or SOIL SURFACE																
Ants (turfgrass, nuisance)		X	C		C	C	C	C	C	C	C					
Annual bluegrass weevil		X			C		C	C	C	C						
Billbugs		X					C	C	C	C						
Chinch bugs	X	X	C		C	C	C	C	C	C						
Crane flies (leatherjackets)	X		C			C			C							
Cutworms and armyworms	X		C		C	C	C	C	C	C		C			C	C
Fire ants		X	C	B	C	C	C	C	C	C	C		B		C	
Mites	X	X			C		C	C	C	C						C
Sod webworms	X		C		C	C	C	C	C	C		C			C	C

***carbaryl curative activity on white grubs is fair to moderate; ** Oriental beetle & European chafer less susceptible to imidacloprid and halofenozide than other white grubs. ***Green June beetle less susceptible to halofenozide than to imidacloprid.**

Contact and systemic insecticides

CONTACT INSECTICIDES

- Best activity on insects that feed on foliage
- Less activity when insects feed on roots, inside plants
- Activity reduced by mowing, water, weather
- Apply in 1-2 ga/1000ft^2 (4 – 8 liters/100 meters^2). Do not water in
- Usually, multiple applications per season are required

ACTIVE INGREDIENT	TRADE NAME
acephate	Orthene
bifenthrin	Talstar
carbaryl	Sevin
cyfluthrin	Tempo
lambda cyhalothrin	Scimitar
chlorpyrifos	Dursban, Pageant
deltamethrin	Deltagard
fipronil**	Chipco Choice, Firestar**
hydramethylnon***	Amdro, Maxforce, Siege
spinosad	Conserve

SYSTEMIC INSECTICIDES

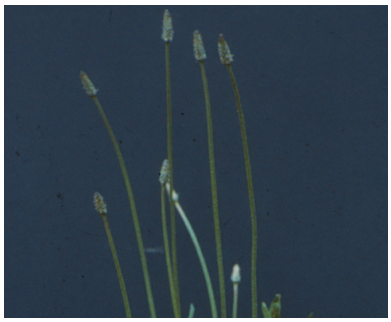
- Effective on insects that feed on foliage or roots
- Absorbed by plant and distributed **inside** the plant via the vascular system
- Less prone to break-down by water, weather, mowing
- Apply in 2-4 ga/1000 ft^2 (8 – 16 liters/100 meters^2) and water in
- Usually only one application per season is required

ACTIVE INGREDIENT	TRADE NAME
abamectin***	Ascend, Avid, Varsity
halofenozide	Mach 2
imidacloprid	Merit
thiamethoxam	Meridian
trichlorfon	Dylox, Proxol

**fipronil works on contact and also when ingested ***available as fire ant bait

WEED REFERENCE

Buckhorn plantain*, Plantago lanceolata*



DESCRIPTION:

Buckhorn plantain is a very common fibrous-rooted perennial weed that is found in low maintenance areas or areas where turf is not competitive. The leaves arise from the base and are long, narrow, and pointed with several prominent parallel veins. Flowers are arranged in a dense terminal spike on a long, hairy, leafless stem. As it blooms, the stamens are exerted from the spike.

Type of plant:	Broadleaf
Life cycle:	Perennial
Growth habit:	Bunch type
Aggressiveness (1-10 scale; 10=most aggressive):	5
Leaf attachment	whorled
Leaf color:	Dark green
Flower description:	Small, white to pink and arranged in a dense terminal spike on a long, hairy, leafless stem
Seed description:	Tan colored, oblong
Reproduces by:	Seed, rootstock
U.S. states found in:	Throughout U.S.
Countries found in:	Canada, Mexico, South and Central America, Europe and Asia
Golf course areas found in:	roughs, low maintenance areas

MONITORING:

Scout once temperatures reach 55 F (13 C). Most common in neutral to high pH soils and in areas where turf is weakened

MANAGEMENT STRATEGIES:

Always check labels to determine turfgrass sensitivity to herbicides.

Follow resistance management guidelines by rotating products as outlined in IPM Template Reference “Herbicide Resistance Management Groups.” Always consult the most recent version of all product labels before use.

TYPE	TIMING/ THRESHOLD	PRACTICE	
Cultural	N/A	Encourage healthy turf	
Biological			
Chemical	Pre-emerge: most effect when post-emergence herbicides are part of the overall program	Active ingredient (example)	Label signal word
		atrazine	Caution (restricted use)
		isoxaben (Gallery)	Caution
		metribuzin (Sencor)	Caution
		Simazine (Simazine)	Caution
	Post-emerge:	2,4-D (Barrage)	Caution
		Triclopyr (Turflon)	Caution

WEED REFERENCE

Dandelion, *Taraxacum officinale*

DESCRIPTION:

Dandelion is a hardy perennial with a thick, fleshy taproot and no stem. Leaves grow in a rosette from the crown. They are long, narrow, irregularly lobed, and lance shaped. The lobed tips are often opposite each other and pointing toward the crown. Leaves are often purple at the base and emit a milky latex when broken. The deep golden yellow flowers are borne in heads on long hollow stalks. Blossoms soon mature into spherical clusters of whitish fruits, like white puffballs, composed of parachute-like seeds. Seeds are carried by wind.

Type of plant:	broadleaf
Life cycle:	Perennial
Growth habit:	Bunch type
Aggressiveness (1-10 scale; 10=most aggressive):	7
Leaf attachment	whorled
Leaf color:	Dark green
Flower description:	Deep yellow, with only one flower per seed stalk
Seed description:	Spherical clusters that appear as white puffballs. The seed resembles a parachute
Reproduces by:	Seed, rootstock
U.S. states found in:	Throughout the U.S.
Countries found in:	Mexico, South and Central America, Africa, Europe, Asia
Golf course areas found in:	Tees, fairways, roughs, low maintenance areas

MONITORING:

Begin scouting when average air temperatures reach 55 F (13 C)

WEED REFERENCE

MANAGEMENT STRATEGIES:

Always check labels to determine turfgrass sensitivity to herbicides.

Follow resistance management guidelines by rotating products as outlined in IPM Template Reference “Herbicide Resistance Management Groups.” Always consult the most recent version of all product labels before use.

TYPE	TIMING/ THRESHOLD	PRACTICE	
Cultural	N/A	Encourage healthy turf, mow regularly	
Biological			
Chemical	Pre-emerge: most effective when post-emerge herbicides are also part of the program	Active ingredient (example)	Label signal word
		Atrazine	Caution (restricted use)
		Isoxaben (Gallery)	Caution
		Metribuzin (Sencor)	Caution
		Simazine (Simazine)	Caution
	Post-emerge:	2,4-D (Barrage)	Caution
		Dicamba (Banvel)	Caution or Warning, depending on formulation
		mecoprop (MCPP)	Caution to Danger, depending on formulation
		Triclopyr plus clopyralid mixture (Confront)	Danger

WEED REFERENCE

Dollarweed (pennywort), *Hydrocotyle* spp.

DESCRIPTION:

Dollarweed has several different species that make up this weed complex. Sometimes, these weeds are referred to as pennywort. Dollarweed is a perennial that has rhizomes and some species produce tubers. The most distinguishing characteristic is the position of the petiole relative to the leaf. In most dollarweed species, the petiole is in the center of the leaf. Several species of dollarweed have very shiny leaves which is a result of a very waxy leaf cuticle.

Type of plant:	Broadleaf
Life cycle:	Perennial
Growth habit:	Spreading
Aggressiveness (1-10 scale; 10=most aggressive):	8
Leaf color:	Dark green
Flower description:	Flowers are white and are elongated spikes at the top of stalks
Seed description:	Small and dark brown in color
Reproduces by:	Seed, rhizomes, tubers
U.S. states found in:	Coastal areas of U.S. From ME south through FL and west to TX, AZ and CA.
Countries found in:	South and Central America, Canada, southern Europe, Africa, Mexico
Golf course areas found in:	Greens, tees, fairways, roughs, low maintenance areas

MONITORING:

Begin scouting when average air temperatures reach 55 F (13 C). Focus scouting areas on wet areas of the golf course, where dollarweed thrives. Do not ignore greens — dollarweed can tolerate very low mowing heights.

MANAGEMENT STRATEGIES:

Many species of dollarweed are difficult to control with postemergence herbicides because of the waxy leaf cuticle.

Follow resistance management guidelines by rotating products as outlined in IPM Template Reference “Herbicide Resistance Management Groups.” Always consult the most recent version of all product labels before use.

TYPE	TIMING/ THRESHOLD	PRACTICE	
Cultural	N/A	Encourage healthy turf	
Biological		——-	
Chemical	Post-emerge:	Active ingredient (example)	Label signal word
		Dicamba (Banvel), 2,4-D, and triclopyr (Turflon) mixture: repeat applications will be necessary	Caution or Warning (depends on formulation)/ Caution/ Caution
		Imazaquin (Image): most effective product available, but labeled only on warm-season turf	Caution

WEED REFERENCE

Kikuyugrass, *Pennisetum clandestinum*

DESCRIPTION:

Kikuyugrass is a very aggressive perennial grass that spreads rapidly via vigorous rhizomes and stolons. Kikuyugrass thrives in mild climates (Mediterranean climates) and often takes over golf course fairways and is sometimes grown as a desirable turfgrass species. Kikuyugrass is a major weed of golf courses in California and is not found on the east coast. Kikuyugrass prefers climates with low humidity. Under humid conditions, kikuyugrass often suffers from various diseases.

Type of plant:	grass
Life cycle:	perennial
Growth habit:	spreading
Aggressiveness (1-10 scale; 10=most aggressive):	10
Leaf color:	Dark green
Flower description:	Flowers not distinguishable with the naked eye
Seed description:	Small and tan in color
Reproduces by:	Seed, rhizomes, stolons
U.S. states found in:	CA, HI
Countries found in:	Mexico, South and Central America, Zustralia, New Zealand, Africa, Asia, various Pacific Islands
Golf course areas found in:	Greens, tees, fairways, roughs, low maintenance areas

MANAGEMENT STRATEGIES:

Always check labels to determine turfgrass sensitivity to herbicides.

Follow resistance management guidelines by rotating products as outlined in IPM Template Reference “Herbicide Resistance Management Groups.” Always consult the most recent version of all product labels before use.

TYPE	TIMING/ THRESHOLD	PRACTICE	
Cultural	N/A	Encourage healthy turf	
Biological			
Chemical	Post emerge: In tolerant turf species only. Repeat applications are necessary.	Active ingredient (example)	Label signal word
		MSMA (MSMA) plus triclopyr (Turflon)	Caution/Caution
		Quinclorac (Drive)	Caution

WEED REFERENCE

Large Crabgrass, *Digitaria sanguinalis*

DESCRIPTION:

Large crabgrass is a summer annual and is very similar to smooth crabgrass. The distinguishable feature between the two species is large crabgrass has hairy stems whereas smooth crabgrass has smooth stems. Both species germinate when 24 hour mean soil temperatures average about 53 to 55 degrees F near the soils surface for several days. Alternating dry and wet conditions at the soil surface in the spring encourages germination. Crabgrass species germinate and grow best when adequate light and moisture are present. Crabgrass species are some of the most problematic weeds in golf course turf due to their abundance and the fact that they can survive very low mowing heights such as those found on putting greens. Crabgrass competition is enhances by thin, open turfgrass stands.

Type of plant:	grass
Life cycle:	Summer annual
Growth habit:	Slightly spreading
Aggressiveness (1-10 scale; 10=most aggressive):	9
Leaf color:	Medium green
Flower description:	Not distinguishable with naked eye
Seed description:	Small tan, oblong seed that drops in late summer
Reproduces by:	seed
U.S. states found in:	Throughout U.S.
Countries found in:	Central and South America, Europe, Asia
Golf course areas found in:	Greens, tees, fairways, roughs, low maintenance areas

MONITORING:

Begin monitoring when weeds begin to germinate, when soil temperatures reach a 24 hour average of 53 – 55 F (12-13 C).

MANAGEMENT STRATEGIES:

Always check labels to determine turfgrass sensitivity to herbicides.

Follow resistance management guidelines by rotating products as outlined in IPM Template Reference “Herbicide Resistance Management Groups.” Always consult the most recent version of all product labels before use.

TYPE	TIMING/ THRESHOLD	PRACTICE	
Cultural	N/A	Keep turf healthy to avoid weed invasion	
Biological			
Chemical	Pre-emerge: apply late winter/spring before average soil temperatures reach 53 – 55 F (12 – 13 C)	**Active ingredient (example)**	**Label signal word**
		dithiopyr (Dimension)	Caution or Warning, depending on formulation
		oryazalin (Surflan)	Caution
		oxadiazon (Ronstar)	Warning
		pendimethalin, trifluralin + benefin (Team pro)	Warning
		prodiamine (Barricade)	Caution
	Post-emerge: apply when weeds are small	fenoxapropr (Acclaim Extra)	Caution
		fluazifop (Fusilade)	Caution
		quinclorac (Drive)	Caution

Silvery thread moss: *Bryum argenteum*

DAMAGE CAUSED

Symptoms of invasion:

Small dollar-sized velvety green patches that can coalesce if not managed.

Plants attacked:

Low mown bentgrass and poa.

Pests/conditions that cause similar damage

None

Geographic distribution:

Worldwide

PREDICTING INFESTATION

Threat temperature:

50 F (10C)

Conducive environmental conditions:

Wide range of conditions are suitable for invasion

MONITORING TECHNIQUES:

Monitor for very small patches of moss invasion (top photo above)

Start looking on slopes and contours that might be mowed slightly lower than desired.

THRESHOLDS:

Depending upon the desired quality of the green, up to several percent infestation can be tolerable. For high quality greens performance there is no tolerance for moss.

MANAGEMENT STRATEGIES:

The products below have demonstrated good activity in research field trials on moss. Always consult the most recent version of all product labels before use.

TYPE OF CONTROL	PRACTICE	
Cultural	• Increase mowing height • Adequate nitrogen (0.1 – 0.2 lb nitrogen / 1000 ft^2 / wk [0.5 – 1.0 g nitrogen/ m^2 / wk] during season), but do not exceed 20 ppm total nitrogen in soil • Aerify and regularly topdress to encourage robust turfgrass growth • Brush and groom regularly • Physically remove small patches of moss • Avoid wetting agents that hold water near the surface of the thatch • Manage irrigation wet spots – hand water as needed	
Biological	No effective products currently available	
Chemical Curative: Apply when moss infestation reaches the tolerance level for the facility.	**Active Ingredient (Product)**	**Signal word**
	carfentrazone (Quicksilver) *	Caution
	chlorothalonil (Daconil Weather Stik) use when average air temperature > 65	Caution

* Designated “reduced risk” by the U.S. Environmental Protection Agency

WEED REFERENCE

Purple nutsedge, *Cyperus rotundus*

DESCRIPTION:

Purple nutsedge is an aggressive perennial and has one of the most prolific growth rates of any weed in the world. Tubers are dark colored and form in chains along rhizomes.

Tubers are bitter to the taste. Tubers start to form in spring and proceed throughout the summer. Leaf tips are more blunt than yellow nutsedge. Seedhead is purple or dark red in appearance. One of the most difficult turfgrass weeds to control.

Type of plant:	Sedge
Life cycle:	Perennial
Growth habit:	Spreading
Aggressiveness (1-10 scale; 10=most aggressive):	10
Leaf attachment:	3 ranked
Leaf color:	Dark green
Flower description:	Indistinguishable to the naked eye
Seed description:	Seedhead has characteristic purple color
Reproduces by:	Rhizomes, tubers
U.S. states found in:	Warmer climates — north to KY and west to southern CA
Countries found in:	Mexico, Central and South America, Europe, Africa
Golf course areas found in:	Tees, fairways, roughs, low maintenance areas

MONITORING:

Begin scouting when average air temperatures reach 55 F (13 C). Target wet and poorly draining areas.

MANAGEMENT STRATEGIES:

One of the most difficult of all weeds to control, and more difficult to control than yellow nutsedge. As with other sedges and rushes, purple nutsedge tends to thrive in wet areas of the golf course. Therefore, poor drainage and overwatering can enhance purple nutsedge presence. However, once established on the golf course, this weed can thrive in areas that are not wet.

Always check labels to determine turfgrass sensitivity to herbicides. Follow resistance management guidelines by rotating products as outlined in IPM Template Reference "Herbicide Resistance Management Groups." Always consult the most recent version of all product labels before use.

TYPE	TIMING/ THRESHOLD	PRACTICE	
Cultural	N/A	Address wet and poorly drained areas. Lower mowing heights to less than 0.5 inch (1.3 cm). Encourage healthy turf	
Biological			
Chemical	Post emerge: Apply in early summer before additional tubers form. Repeat applications and multi-year programs will be necessary.	Active ingredient (example)	Label signal word
		Halosulfuron (Manage)	Caution
		Sulfosulfuron (Certainty)	Caution
		Trifloxysulfuron (Monument)	Caution

WEED REFERENCE

Virginia buttonweed*, Diodia virginiana*

DESCRIPTION:

Virginia buttonweed is a perennial with prostrate or spreading branches that thrives in wet areas of the golf course. The stems are longitudinally ridged with hairs along the ridges. Leaves are opposite without petioles and rough along the margins. The leaves are slightly thickened, green on the upper surface and light green on the lower surface with both surfaces smooth and slightly folded. The leaves of Virginia buttonweed often take on a mottled-yellow mosaic look. The white flowers sometimes have pink streaks in the center and are borne in the leaf axil. Petals are united into a tube. The fruit, bearing four membranous sepals at the tip, is produced in leaf axils.

Type of plant:	broadleaf
Life cycle:	perennial
Growth habit:	spreading
Aggressiveness (1-10 scale; 10=most aggressive):	9
Leaf attachment:	opposite
Leaf color:	Dark green, variegated
Flower description:	Small white flowers have 4 petals
Seed description:	Dark brown seeds are slightly round to oblong in shape
Reproduces by:	Seed, rootstock, stem fragments
U.S. states found in:	NJ, south to FL and west to MO
Countries found in:	No known occurrence in other countries
Golf course areas found in:	Tees, fairways, roughs, low maintenance areas

MONITORING

Start scouting when average air temperatures reach 55 F (13 C)

MANAGEMENT STRATEGIES:

Always check labels to determine turfgrass sensitivity to herbicides. Follow resistance management guidelines by rotating products as outlined in IPM Template Reference "Herbicide Resistance Management Groups." Always consult the most recent version of all product labels before use.

TYPE	TIMING/ THRESHOLD	PRACTICE	
Cultural	N/A	Manage moisture to avoid overly wet areas. Encourage growth of healthy turf	
Biological			
Chemical	Post-emergence: repeat applications to target re-growth every 4 -5 weeks. A full year of applications may be necessary for full control.	**Active ingredient (example)**	**Label signal word**
		2,4-D (Barrage)	Caution
		Dicamba (Banvel): use in combination with 2,4-D	Caution or Warning, depending on formulation
		Triclopyr (Turflon): use in combination with 2,4-D	Caution

WEED REFERENCE

Yellow nutsedge, *Cyperus esculentus*

DESCRIPTION:

Yellow nutsedge is a perennial that gets its name from the characteristic tubers (ironically – not nuts) that form on the tips of rhizomes. Tubers are chestnut colored and occur below the soil surface. Tubers often break off when plant is pulled up. To find tubers, plant must be carefully dug to prevent tubers from dislocating from rhizomes. Tubers are produced in summer only. Tubers have a sweet taste and have a high nutritional value. Plant is often planted as wildlife food called Chufa.

Type of plant:	sedge
Life cycle:	Perennial
Growth habit:	spreading
Aggressiveness (1-10 scale; 10=most aggressive):	8
Leaf attachment:	3 ranked
Leaf color:	Medium green
Flower description:	Flowers are indistinguishable to the naked eye
Seed description:	Seedhead has characteristic yellow color, the basis of the plant's name
Reproduces by:	Seed, rhizomes, tubers
U.S. states found in:	Throughout North America
Countries found in:	Central and South America, Europe, Africa
Golf course areas found in:	roughs, low maintenance areas

MONITORING:

Begin scouting when average air temperatures reach 55 F (13 C). Target wet areas, poorly draining areas.

MANAGEMENT STRATEGIES:

As with other sedges and rushes, yellow nutsedge tends to thrive in wet areas of the golf course. Therefore, poor drainage and overwatering can enhance yellow nutsedge presence. However, once established on the golf course, this weed can thrive in areas that are not wet.

Always check labels to determine turfgrass sensitivity to herbicides. Follow resistance management guidelines by rotating products as outlined in IPM Template Reference "Herbicide Resistance Management Groups." Always consult the most recent version of all product labels before use.

TYPE	TIMING/ THRESHOLD	PRACTICE	
Cultural	N/A	Address wet areas and poorly draining areas. Decrease mowing heights to 0.5 inch (1.3 cm) or less. Encourage healthy turf	
Biological			
Chemical	Post-emerge: Begin treatment in early summer, before new tubers form. Repeat applications and multi-year programs usually necessary.	Active ingredient (example)	Label signal word
		bentazon (Basagran)	Caution
		DSMA	Caution
		halosulfuron (Manage)	Caution
		imazaquin (Image)	Caution
		MSMA	Caution
		sulfentrazon (Dismiss)	Caution
		sulfosulfuron (Certainty)	Caution
		trifloxysulfuron (Monument)	Caution

WEED REFERENCE

Herbicide resistance management groups. Pesticides are organized into Resistance Management Groups based on mode of action and chemical structure. In general, a pest that develops resistance to one pesticide within a group will probably be cross-resistant to other members of the group. Therefore, current resistance management strategies rely on rotation among different pesticide groups. Source: Herbicide Resistance Action Committee (www.plantprotection.org/HRAC/)

Active ingredient	Trade Name	Herbicide Group	Group #
fenarimol	Rubigan	unclassified	
clethodim	Envoy	cyclohexanediones	A
fenoxaprop	Acclaim	aryloxyphenoxy-propionates	A
fluazifop	Fusilade 2000	aryloxyphenoxy-propionates	A
bispyribac	Velocity	pyrimidinylthiobenzoates	B
chlorsulfuron	Corsair	sulfonylurea	B
foramsulfuron	Revolver	sulfonylurea	B
halosulfuron	Manage	sulfonylurea	B
imazaquin	Image	imidazolinones	B
metsulfuron	Manor, Escort	sulfonylurea	B
rimsulfuron	TranXit	sulfonylurea	B
trifloxysulfuron	Monument	sulfonylurea	B
atrazine	Drexel, Atrazine, AAtrex, Purge.	triazines	C1
metribuzin	Sencor	triazinones	C1
simazine	Princep, Simazine	triazines	C1
siduron	Tupersan	ureas	C2
bentazon	Basagran	benzothiadiazinone	C3
bromoxynil	Buctril	nitriles	C3
oxadiazon	Ronstar	oxadiazoles	E
glyphosate	Roundup	glycines	G
glufosinate	Finale	phosphinic acids	H
asulam	Asulox, Asulam	carbamate	I
benefin	Balan	dinitroanimilines	K1
DCPA	Dacthal W-75	benzoic acids	K1
dithiopyr	Dimension	pyridines	K1
oryzalin	Surflan	dinitroaniline	K1
pendimethalin	Pre-M, Pendulum	dinitroaniline	K1
prodiamine	Barricade	dinitroaniline	K1
pronamide	Kerb	benzamides	K1
trifluralin	Team 2G	dinitroaniline	K1
metolachlor	Pennant	chloroacetamides	K3
napropamide	Devrinol	acetamides	K3
isoxaben	Gallery	benzamides	L
bensulide	Betasan, Bensumec, Presan	phosphorodithioates	N
ethofumesate	Prograss	benzofuranes	N
2,4-d amine	2, 4-D	phenoxy-carboxylic-acids	O
clopyralid	Stinger, Lontrel	pyridine carboxylic acids	O
dicamba	Banvel, Vanquish	benzoic acids	O
mecoprop	MCPP	phenoxy-carboxylic-acids	O
quinclorac	Drive	quinoline carboxylic	O
triclopyr	Turflon	pyridine carboxylic acids	O
dazomet	Basamid	unknown	Z
DSMA	Methar	unknown	Z
MSMA	MSMA, etc.	unknown	Z
pelargonic acid	Scythe	unknown	Z

Sensitivity of turf species to herbicides

Sensitivity of turf species to pre-emergence herbicides. Modified from: UC IPM Pest Mgt Guidelines: ANR Publication 3365T

PREEMERGENCE												
TURF SPECIES	**ATR**	**BEN**	**BES**	**FEN**	**DIT**	**ISO**	**ORY**	**OXA**	**PEN**	**PRD**	**PRO**	**SIM**
bentgrasses	S	S	T		R		S	S	S	S	S	
bermudagrass, common	R	T	T	T	T	T	R	T	T	T	T	D
bermudagrass, hybrid	R	T	T	T	T	T	R	T	T	T	T	D
bluegrass, Kentucky	S	T	T	T	T	T	S	T	R	R	S	
dichondra	S	S	T				T	S	T	R	R	
fescue, fine	S	T	T		R		S	T	T	T	S	
fescue, tall	S	T	T	T	T	T	S	T	T	T	S	
kikuyugrass		T	T					R	R	T		
ryegrasses	S	T	T	T		T	S	R	R	T	S	
St. Augustinegrass	T	T	T			T	T	R			S	T
zoysiagrass	T	T	T			T	S	R	R	T	S	T

RATINGS LEGEND

S = sensitive R = relatively tolerant T = tolerant D = dormant turf only

PRODUCTS

ATR = atrazine (Drexel Atrazine)
BEN = benefin (Balan)
BES = bensulide (Presan)
DIT = dithiopyr (Dimension)
FEN = fenarimol
ISO = isoxaben (Gallery)
ORY = oryzalin (Surflan)
OXA = oxadiazon (Ronstar)
PEN = pendimethalin (PreM, Pendulum)
PRD = prodiamine (Barricade)
PRO = pronamide (Kerb)
SIM simazine

Sensitivity of turf species to post-emergence herbicides. Modified from: UC IPM Pest Mgt Guidelines: ANR Publication 3365T

POSTEMERGENCE																	
TURF SPECIES	ETH	QUI	CLO	DIC	DSM	FLU	GLY	HAL	SIM	MSM	PRO*	TRY	IMA	METR	CHL	METS	RIM
bentgrasses			T	R	R	S	S	T		S	S	S					
bermudagrass, common	D	R	T	T	T	S	S	T	D	T	T	R	R	R	T	T	T
bermudagrass, hybrid	D	R	T	T	T	R	S	T	D	T	T	S	R	R	T	T	T
bluegrass, Kentucky	T	T	T	T	T	S	S	T		R	S	T			T		
dichondra			T	S	R	T	S			S	R	S					
fescue, fine	R	R	T	T	T	T	S	T		T	S	T			R		
fescue, tall	T	T	T	T	T	S	S	T		T	S	T					
kikuyugrass				R	R	S	S			S		S					
ryegrasses	T	T	T	T	T	S	S	T		T	S	T					
St. Augustinegrass				S	S		S	T	R	S	S	S	T		R	R	
zoysiagrass		T	T	R	R	S	S	T	R	T	S	S	T		R	T	

RATINGS LEGEND

S = sensitive R = relatively tolerant T = tolerant D = dormant turf only

PRODUCTS

ATR = atrazine (Drexel Atrazine)
BEN = benefin (Balan)
BES = bensulide (Presan)
CHL = chlorsulfuron
CLO = clopyralid (Stinger, Lontrel)
DIC = dicamba (Banvel 4S)
DIT = dithiopyr (Dimension)
DSM = DSMA (Methar)
ETH = ethofumesate
FLU = fluazifop (Fusilade 2000)
GLY = glyphosate (Roundup)
HAL = halosulfuron (Manage)
IMA = imazaquin
ISO = isoxaben (Gallery)
METR = metribuzin
METS = metsulfuron
MSM = MSMA
NAP = napropamide (Devrinol)
ORY = oryzalin (Surflan)
OXA = oxadiazon (Ronstar)
PEN = pendimethalin (PreM, Pendulum)
PRD = prodiamine (Barricade)
PRO = pronamide (Kerb)
QUI = quinclorac
RIM = rimsulfuron
SIM = simazine
TRY = triclopyr (Turflon)

WEATHER REFERENCE

Using threat temperatures for IPM Planning

Threat temperatures are rough guidelines that we have proposed to try to predict when pests are likely to first begin causing damage on golf course turf. Once a threat temperature is reached, some type of action is usually triggered. In the case of curatively controlled pests, that action is usually monitoring for symptoms (control procedures should take place only after evidence of the pest or its symptoms has been confirmed). In the case of preventively controlled pests, a preventive action such as pesticide application or cultural practice is usually called for. These threat temperatures were developed based on our knowledge of turf pest biology, as well as by mining the scientific literature for temperature data on insect, disease, weed and nematode pests of turf.

Threat temperatures for curative insect control

Insect	Threat * temperature		Monitoring (begin at threat temp. unless otherwise noted)	Control Measure
	F	C		
Annual bluegrass weevil	>55	>13	Monitor for adult weevils, starting at avg air temp >55F (13C). Peak activity @68F	If adult weevils detected, apply contact product against adults, 2 wks after adults 1st appear
Ants (nuisance)	>65	>18	Monitor for foraging ants.	If detected, apply labeled ant product at entrance to mounds
Armyworms	>60	>16	Monitor for caterpillars w/soap drench	Apply contact product when larval numbers are high enough for concern
Bermudagrass scale	>65	>18	Monitor for eggs & crawlers in damaged patches of turf.	If detected scale, fertilize and irrigate to promote recovery. No effective products are labeled
Billbugs (bluegrass)	>60	>16	Monitor for adults on paved areas, starting at avg. air temp>62F (17C)	If adult billbugs detected, apply contact product against adults, 2 wks after adults 1st appear
Cicada killers & tarantula hawk wasps	>65	>18	Monitor for flying wasps	Treat burrows with contact product, but only if completely necessary; these are usually beneficial insects!
Chinch bug, hairy (cool season turf)	>60	>16	Monitor for chinch bugs (all stages)	Apply contact product when numbers are high enough for concern
Chinch bug, southern (warm season turf)	>55	>13	Monitor for chinch bugs (all stages)	Spot treat w/contact product when numbers are high enough for concern
Crane flies	>45	>7	Monitor for larvae w/cup cutter	Apply contact product when larval numbers are high enough for concern
Cutworms	>55	>13	Monitor for caterpillars w/soap drench	Apply contact product when larval numbers are high enough for concern
Fall armyworms	>65	>18	Monitor for caterpillars w/soap drench	Apply contact product when larval numbers are high enough for concern
Fire ants	All year		Monitor for foraging ants, starting when average air temp>65F (18C)	When detected, broadcast a bait formulation Follow several days later with a contact insecticide applied broadcast (in heavily trafficked areas) or to individual mounds (in areas of lower use)
Ground pearls	All year		Monitor roots of damaged turf, starting when avg air temp>75F (24C)	If ground pearls detected, fertilize and irrigate to promote recovery.
Mole crickets	>75	>24	Monitor w/soap flush, starting when avg air temp >75F(24C)	If present, target small nymphs (<1/2" or <1.2 cm) w/contact product; or large nymphs & adults w/ beneficial nematodes
Sod webworms (cool season turf)	>70	>21	Monitor for caterpillars w/soap drench	Apply contact product when larval numbers are high enough for concern
Sod webworms (warm season turf)	>75	>24	Monitor for caterpillars w/soap drench	Apply contact product when larval numbers are high enough for concern

*average daily air temperature unless otherwise noted

NOTE: Most contact (curative) products require 1 or more follow-up applications, within 1-2 weeks of application

WEATHER REFERENCE

Threat temperatures for preventive insect control

Timing of threat periods and management activities for key insect pests of turf. The threat temperature is a rough guideline that indicates when insects are likely to begin laying eggs or causing damage on golf course turf.

Insect	Threat temperature*		Monitoring (begin when threat temp is reached unless otherwise noted)	Control Measure
	F	C		
WHITE GRUBS	65-73	18-23	No monitoring. Control appropriate only if history of infestation.	Apply systemic product within 2-4 wks after reaching threat temperature. If multiple white grubs spp present, use insect w/lowest threat temperature to time application.
• Asiatic garden beetle	>70	>21	"	Apply systemic product 2-4 wks after reaching threat temperature.
• Black turfgrass ataenius	>65	>18	"	Apply systemic product 2-4 wks after reaching threat temperature.
• European chafer	>70	>21	"	Apply systemic product 2-4 wks after reaching threat temperature.
• Green June beetle	>73	>23	"	Apply systemic product 2-4 wks after reaching threat temperature.
• Japanese beetle	>70	>21	"	Apply systemic product 2-4 wks after reaching threat temperature.
• Masked chafers	>71	>22	"	Apply systemic product 2-4 wks after reaching threat temperature.
• May/June beetles	>71	>22	"	Apply systemic product 2-4 wks after reaching threat temperature.
• Oriental beetle	>70	>21	"	Apply systemic product 2-4 wks after reaching threat temperature.
OTHER PREVENTIVELY CONTROLLED INSECTS				
Annual bluegrass weevil	>55	>13	Monitor for adult weevils, starting at avg air temp >55F (13C) **OR**	Apply systemic product against grubs, 4 wks after adults appear
Annual bluegrass weevil	>55	>13	No monitoring. Appropriate only if history of infestation	Apply systemic product against grubs 2 wks after reaching threat temperatures
Billbugs	>60	>16	Monitor for adults on paved areas, starting at avg. air temp>60F (16C) **OR**	Apply systemic product against grubs, 4 wks after adults appear
Billbugs	>60	>16	No monitoring. Appropriate only if history of infestation)	Apply systemic product against grubs within 2 – 4 wks after reaching threat temperature.
Earthworms	>45	>7	Monitor for earthworm casts	Institute sand topdressing program on fairways at least 4X/year during periods of active turf growth only
Mole crickets	>60	>16	No monitoring; use this option only if history of infestation	Target hatching eggs w/imidacloprid or fipronil when avg air temps > 65 F(18C)

*average daily air temperature unless otherwise noted

NOTE: Most systemic products (imidacloprid, halofenozide) applied against soil pests are applied 1X/ season, & have 2-3 months residual activity. Follow-up applications are required only in warm locations with long (>3 months) periods of threat from damage

WEATHER REFERENCE

Timing disease control using threat temperatures

The average air temperatures below are rough guidelines that indicate when diseases are likely to begin causing damage on golf course turf. If you have a history of a preventively controlled disease, preventive control measures should begin when threat temperatures are reached. For curatively controlled diseases, begin monitoring at beginning of threat period; do not treat until symptoms are confirmed

DISEASE	THREAT TEMPERATURE
Anthracnose	**≥ 65**
Bacterial wilt	**≥ 60**
Bipolaris Leaf Spot	**≥ 70**
Brown Patch	**≥ 60**
Curvularia Blight	**≥ 70**
Cyanobacteria	**≥ 55**
Dollar Spot	**≥ 65**
Fairy Ring	**≥ 65**
Gray Leaf Spot	**≥ 68**

DISEASE	THREAT TEMPERATURE
Bermuda/ kikuyu decline	**≥ 75**
Pythium Blight	**≥ 70**
Rapid Blight	**>55**
Red thread	**≥ 65**
Snow Mold	**≤ 62**
Southern Blight	**≥ 70**
Spring Dead Spot	**≥ 65 and < 80**
Summer Patch	**≥ 65**
Take-all Patch	**≥ 65**

Timing herbicide applications and weed threat temperatures

Common Name	Scientific name	Activity	Timing/Threat temperature*
Barnyardgrass	***Echinocloa***	**Pre-emerge herbicides**	**When air temperatures reach >60F (16C) for 3 days in a row**
Crabgrass	***Digitaria***	**Pre-emerge herbicide**	**When air temperatures reach >50F (10C) for 3 days in a row**
Foxtails	***Setaria***	**Pre-emerge herbicide**	**When air temperatures reach >65F (18C) for 3 days in a row**
Goosegrass	***Eleusine***	**Pre-emerge herbicide**	**When air temperatures reach >60F (16C) for 3 days in a row**
Annual bluegrass	***Poa annua***	**Pre-emerge herbicide**	**Fall/winter, when air temperatures drop to <75F (24C) (and >50F/10C) for 3 days in a row**
Weeds controlled post-emergence		**Begin weekly monitoring, mapping, record keeping**	**When air temperatures reach >50F (10C)**

***average daily air temperatures.** NOTE: Most pre-emerge products have 2-3 months of residual activity. Split applications, spaced 2-3 months apart, can be used to extend the period of control.

Growth potentials

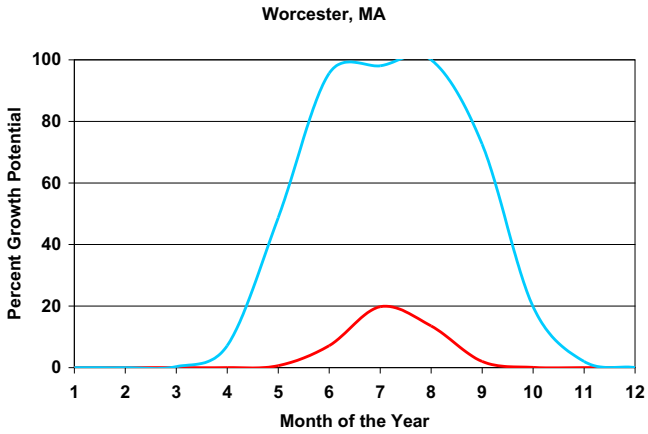
The concept of growth potential was developed to explain the myriad of ways in which weather impacts turf growth. The basic assumptions are that:

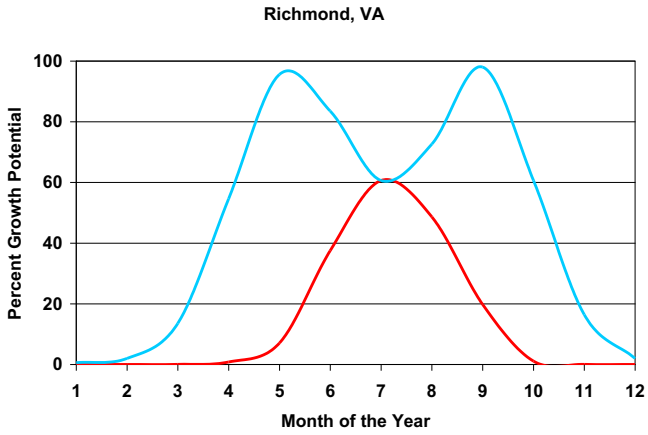
- turf growth is good when the growth potential (GP) is between 50% and 100%
- the best possible growth occurs at a GP of 100%.
- when weather conditions are either too hot or too cold for optimal turf growth, the GP falls below 50%, and turf becomes progressively more stressed. When the GP falls to 10% or lower, growth is extremely limited.
- Based on the scientific literature, cool-season turf grows best between average air temperatures of 60° and 75°F (with optimum growth at about 68F), while warm-season turf grows best at average air temperatures between 80° and 95°F (with optimum growth at about 88F).

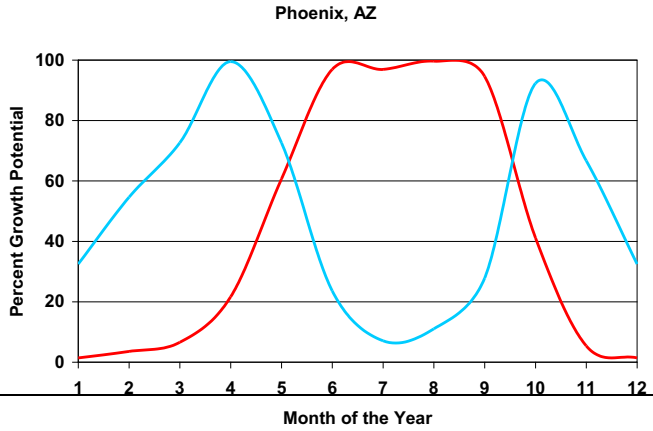
Using the growth potential concept

Growth potential data can be used to educate golfers and managers, to provide a scientific basis for decisions, to predict the performance of different turf types when exposed to different climates, and to forecast the effects of different overseeding and transition practices. Specific examples include:

- Timing application for chemical transition accelerators (Kerb, Revolver, Monument, Manor, Blade, TranXit): Warm-season turf GP should be 50% or higher at the time of application in order to ensure that sufficient warm-season turf cover is present.
- Scheduling aggressive management practices (aerification) or stressful events (tournaments): Turf growth potential should be as high as possible (greater than 50%) and on the rise when stressful events are scheduled. This allows for the greatest recovery potential of the turf.
- Explaining why cool- or warm-season turf is performing poorly (or well): Use growth potential to illustrate how your current weather conditions are affecting turf performance.







WEATHER REFERENCE

Percent growth potential (GP) of cool-season and warm-season turf at different average air temperatures

Air Temp (F)	%Warm GP	%Cool GP
38	0	1
39	0	2
40	0	2
41	0	3
42	0	4
43	0	5
44	0	6
45	0	8
46	0	10
47	0	12
48	0	15
49	1	18
50	1	22
51	1	26
52	1	30
53	2	35
54	2	40
55	3	46
56	3	52
57	4	58
58	5	64
59	6	70

Air Temp (F)	%Warm GP	%Cool GP
60	7	75
61	9	81
62	10	86
63	12	90
64	15	94
65	17	97
66	20	99
67	23	100
68	27	100
69	30	99
70	35	97
71	39	94
72	43	90
73	48	86
74	53	81
75	58	75
76	63	70
77	68	64
78	73	58
79	78	52
80	82	46
81	86	40

Air Temp (F)	%Warm GP	%Cool GP
82	90	35
83	93	30
84	96	26
85	98	22
86	99	18
87	100	15
88	100	12
89	99	10
90	98	8
91	96	6
92	93	5
93	90	4
94	86	3
95	82	2
96	78	2
97	73	1
98	68	1
99	63	1
100	58	1
101	53	0
102	48	0
103	43	0

Air Temp (F)	%Warm GP	%Cool GP
104	39	0
105	35	0
106	30	0
107	27	0
108	23	0
109	20	0
110	17	0
111	15	0
112	12	0
113	10	0
114	9	0
115	7	0
116	6	0
117	5	0
118	4	0
119	3	0
120	3	0
121	2	0
122	2	0
123	1	0

GROWTH POTENTIAL MODEL EQUATION

The growth potential values above were calculated using the equation below:

GP = growth potential

obsT = observed temperature (F)

optT = optimum turf growth temperature (F)

sd = standard deviation of the distribution

(sd warm = 12; sd cool = 10)

e = natural logarithm base **2.718282…**

$$GP := 100 \cdot \left[\frac{1}{e^{\left[\frac{1}{2} \cdot \left[\frac{(obsT - optT)}{sd} \right]^2 \right]}} \right]$$

WEATHER REFERENCE: Using growth potentials

Percent warm season and cool season turfgrass growth potential (GP) in selected U.S. locations. Months with 50% or more warm season turf growth potential are highlighted in red, while months with 50% or more cool season turf growth potential are highlighted in blue. Values are based on 30-year normal average monthly air temperatures from the National Oceanic and Atmospheric Administration.

	PERCENT WARM SEASON TURFGRASS GP												PERCENT COOL SEASON TURFGRASS GP											
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
PHOENIX, AZ	2	5	11	34	77	100	88	95	99	56	10	2	38	62	87	97	53	12	3	6	19	78	85	41
LITTLE ROCK, AR	0	0	2	11	35	75	90	85	54	12	1	0	2	6	35	86	96	55	35	42	80	90	31	5
FRESNO, CA	0	1	3	9	30	66	90	84	56	18	2	0	9	26	46	82	99	66	35	44	78	97	38	9
LOS ANGELES AP, CA	5	7	8	13	19	33	55	59	52	33	12	5	56	61	64	76	89	98	99	96	97	100	84	57
PALM SPRINGS, CA	3	7	13	31	65	97	94	98	97	58	12	3	46	73	91	99	67	24	5	8	23	75	90	50
RIVERSIDE, CA	2	3	4	8	18	39	69	68	53	22	5	2	34	46	56	78	98	94	62	64	81	100	65	36
DENVER, CO	0	0	0	0	4	23	51	41	11	1	0	0	0	0	2	16	59	100	84	93	87	27	2	0
JACKSONVILLE, FL	1	3	9	23	50	78	89	87	74	34	10	3	32	47	81	100	84	51	37	39	57	97	85	46
TAMPA, FL	7	10	22	40	70	88	91	91	86	57	25	11	75	84	100	93	61	39	33	33	41	77	100	87
ATLANTA, GA	0	0	2	10	31	63	77	74	47	11	2	0	3	8	38	84	99	70	53	57	87	87	35	7
MACON, GA	0	1	4	15	43	75	87	84	60	17	3	1	9	17	57	95	91	55	39	44	74	96	52	17
HONOLULU,HI	48	48	55	62	71	80	84	88	86	81	69	54	86	86	79	71	61	49	43	38	40	48	62	80
CHICAGO,IL	0	0	0	1	6	29	49	42	16	2	0	0	0	0	1	17	69	99	85	92	95	34	2	0
INDIANAPOLIS, IN	0	0	0	1	12	43	60	49	22	2	0	0	0	0	3	32	90	91	73	85	100	44	5	0
DES MOINES, IA	0	0	0	1	11	42	66	53	18	2	0	0	0	0	1	25	87	91	66	81	97	38	2	0
WICHITA, KS	0	0	0	3	19	62	88	79	36	6	0	0	0	0	9	54	98	71	38	50	96	67	7	0
SHREVEPORT, LA	0	1	4	19	46	80	92	91	67	22	4	0	8	19	61	98	88	49	31	34	65	100	56	15
BOSTON, MA	0	0	0	0	5	26	51	43	17	2	0	0	0	0	2	15	65	100	84	91	96	45	9	0
DETROIT, MI	0	0	0	0	5	25	45	37	13	1	0	0	0	0	1	13	66	100	89	96	91	26	2	0
MINNEAPOLIS, MN	0	0	0	0	5	27	51	37	8	1	0	0	0	0	0	11	67	100	83	96	78	17	0	0
JACKSON, MS	0	0	4	16	43	77	88	86	63	16	3	0	6	15	56	96	90	53	38	41	70	96	50	14
ST. LOUIS, MO	0	0	0	4	20	60	81	71	35	5	0	0	0	0	8	56	99	73	47	60	96	66	10	0
LAS VEGAS, NV	0	1	3	15	53	98	96	100	84	28	3	0	9	26	53	94	81	22	6	11	43	100	46	9
RENO, NV	0	0	0	1	4	18	42	33	8	1	0	0	0	1	5	17	55	97	92	98	78	25	2	0
NEW YORK (JFK AP), NY	0	0	0	1	7	32	61	57	25	4	0	0	0	0	3	24	75	98	73	77	100	58	13	1
RALEIGH, NC	0	0	1	6	23	55	74	69	39	7	1	0	2	4	23	70	100	79	57	63	94	76	26	5
AKRON, OH	0	0	0	1	6	26	43	36	14	1	0	0	0	0	1	16	70	100	91	96	93	32	4	0
OKLAHOMA CITY, OK	0	0	1	8	28	67	90	87	48	10	1	0	1	3	23	78	100	65	35	40	86	86	20	2
GUAM, PC	70	69	72	78	81	82	80	78	79	78	79	75	62	62	59	52	48	46	49	51	50	51	50	55
PITTSBURGH, PA	0	0	0	1	7	26	44	37	14	1	0	0	0	0	2	20	73	100	90	96	94	32	4	0
CHARLESTON AP,SC	0	1	5	17	47	75	88	85	65	23	5	1	14	24	64	97	87	56	38	42	67	100	66	26
KNOXVILLE, TN	0	0	1	4	18	49	66	63	35	5	1	0	1	2	18	61	98	85	66	70	97	66	17	2
AUSTIN, TX	1	2	10	33	61	88	97	98	83	39	9	1	17	34	84	98	72	39	24	22	45	94	80	28
CORPUS CHRISTI, TX	3	5	19	46	73	90	96	96	86	53	19	5	46	67	98	88	58	35	25	25	40	81	98	65
HOUSTON, TX	1	2	8	28	56	84	92	91	74	33	9	2	23	40	79	100	78	44	32	33	56	98	81	38
SAN ANTONIO, TX	1	2	10	32	61	91	98	98	79	35	8	1	19	38	85	98	73	34	22	22	50	96	78	31
RICHMOND, VA	0	0	0	4	20	53	73	67	35	6	1	0	1	2	15	59	99	81	58	65	97	67	20	2