

Producing an IPM Template to Assist Golf Course Superintendents in Developing Written IPM Plans for Golf Courses

Progress Report
May 1, 2007

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I. Background:

The two-year project, "Producing an IPM Template to Assist Golf Course Superintendents in Developing Written IPM Plans for Golf Courses", was designed to produce a set of science-based templates that can be used by golf course superintendents in developing, implementing, updating and assessing the effectiveness of IPM programs.

II. Experimental Objectives:

1. Produce a set of templates (written procedures, pest identification guides, agronomic guidelines and other reference materials, spreadsheets, record keeping forms and planning calendars) that will guide golf course superintendents towards development and implementation of IPM plans that meet environmental, agronomic and budgetary goals.
2. Ensure that templates are flexible enough to accommodate site-specific conditions, as well as varying levels of superintendent technical expertise and golf course budget constraints.
3. Evaluate the feasibility of these templates through periodic review and testing by superintendents, and make necessary changes based on their input.
4. Recommend methods for dispersing the templates to the superintendent community.

III. Progress on Objectives:

During the project's second six month period, we have focused on objectives # 1 - 3.

- Objective 1:
 - o Following the framework established previously (see Appendix I, pages 4—5), we have begun producing the reference materials on insects, diseases, weeds, soil quality, water quality and weather that will form the bulk of the final template (see Appendix II, pages 7 - 77). These will be added to the references, forms and procedures already provided in the November, 2006 report. We will continue to complete the documents outlined in Appendix 1 over the next 6 months.
 - o A standardized format for reference materials was established.
 - o The key insect, disease and weed pests that the references will focus on were been identified (see Appendix III, page 78).
- Objective 2: The first step in testing the template for its clarity, robustness and comprehensiveness will take place June 13-14, 2007 when the cooperators will meet in San Diego, CA, to finalize all of the components of the draft template (written procedures, pest identification guides, agronomic guidelines and other reference materials, spreadsheets, record keeping forms and planning calendars).

This will be accomplished through a site visit to Fairbanks Ranch Country Club in San Diego (Brian Darrock, superintendent), where the group will attempt to complete an IPM Plan using the first version of the template. The one day site

visit will be followed up by meetings among cooperators to identify areas of the template requiring modifications, additions and improvements. A timetable for completing a draft template for review by the Superintendent Review Panel (see above) will be established.

- Objective 3: A superintendent review panel, whose function is to provide guidance to our group as we develop the templates, has been identified and the individuals below have confirmed their interest in participating. Templates will be available for review by this panel by November, 2007

Superintendent Review Panel

Mike Claffey	Cape Fear CC, Wilmington, NC
Shawn Emerson	Desert Mountain, Scottsdale, AZ
Larry Gilhuly	USGA Green Section, Northwest Region
Kevin Hutchins	Mission Viejo CC, Mission Viejo, CA
Jon Jennings, CGCS	Chicago Golf Club, Wheaton, IL
Clark Throssel	GCSAA

IV. Research to be implemented May 1, 2007 – November 1, 2007.

We will continue to generate the content for all of the components outlined in the attached documents (objectives 1 and 2). The principal investigators will meet in June, 2007, for the first dry run of the template. At that time, necessary additions, changes and improvements will be identified. Responsibility for addressing each of these will be assigned and a draft template based on this information will be available for review by the superintendent review panel in November, 2007 (objective 3).

Appendix I. Materials that will be generated for the IPM Template

I. Introduction to IPM Planning

II. Planning Procedures

- Setting your goals
- Golf course characteristics
- Naming sites
- Course layout
- Geology and soils
- Erosion
- Water resources
 - Water quality
 - Wetlands
 - Stormwater flow
 - Groundwater protection
- Biological resources
 - Trees
 - Native plant communities
 - Special status plants
 - Wildlife resources
 - Wildlife habitat values
- Weather
 - Your site-specific Climate Appraisal
- Pest management
- Pest biology and life cycle
- Monitoring
- Management strategies
- Management Zones
- Greens Management Zone
 - Soils
 - Irrigation Management
 - Pests
 - Cultural Practices
 - Cultivars
 - Mowing practices
 - Aerification
 - Topdressing
 - Buffer zones and proximity to sensitive areas
- Tees Management Zone
 - Soils
 - Irrigation Management
 - Pests

Tees Management Zone, cont...

- Cultural Practices
 - Cultivars
 - Mowing practices
 - Aerification
 - Topdressing
- Buffer zones and proximity to sensitive areas

Fairways Management Zone

- Soils
- Irrigation Management
- Pests
- Cultural Practices
 - Cultivars
 - Mowing practices
 - Aerification
 - Topdressing
- Buffer zones and proximity to sensitive areas

Roughs Management Zone

- Soils
- Irrigation Management
- Pests
- Cultural Practices
 - Cultivars
 - Mowing practices
 - Aerification
 - Topdressing
- Buffer zones and proximity to sensitive areas

Landscaped Areas Management Zone

Water Features Management Zone

III. Forms and Spreadsheets

- Setting Your Goals
- Golf Course Characteristics
- Developing your site-specific Climate Appraisal
- Management Zones
- Pest Worksheet
- Pest monitoring schedule
- Pest monitoring logs

Forms and Spreadsheets, cont...

- Pest management history
- Water and soil monitoring schedule
- Water and soil monitoring logs
- IPM Planner
- Annual review: goals vs. results

IV. References

- Soils
- Soil nutritional guidelines
- Monitoring nutritional status
- Monitoring physical characteristics
- Important calculations
- Water
- Water quality guidelines
- Irrigation management
- Weather

References, cont...

- Pests
- Pest monitoring techniques
- Pest identification, biology and management
- Biological control strategies
- Cultural control strategies
- Chemical control strategies
- Pesticide resistance management guidelines
- Chemical pesticide selection guidelines
- Websites for product labels
- Equipment and sources
- Doing your own research
- Further reading
- Glossary

DISEASE REFERENCE

Appendix II. Reference documents completed to date (5/1/07).

Anthraxnose, <i>Colletotrichum cereale</i>	7
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DISEASE 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

DISEASE REFERENCE

- Low mowing heights

Geographic distribution:

- Worldwide

Links to photographs

- <http://www.paceturf.org/photo/showphoto.php/photo/816>
- <http://www.paceturf.org/photo/showphoto.php?photo=199>
- <http://www.paceturf.org/photo/showphoto.php?photo=815>
- <http://www.paceturf.org/photo/showphoto.php?photo=163>

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.

DISEASE REFERENCE

MANAGEMENT STRATEGIES:

Strains of anthracnose resistant to Qol (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 Reference _____. 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)	
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)	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)	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.

DISEASE 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 conidia 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 ≥ 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

Links to photographs

- Ryegrass: <http://www.paceturf.org/photo/showphoto.php?photo=726>
- Ryegrass: <http://www.paceturf.org/photo/showphoto.php?photo=188>
- Kikuyugrass: <http://www.paceturf.org/photo/showphoto.php?photo=170>
- Kikuyugrass: <http://www.paceturf.org/photo/showphoto.php?photo=640>

DISEASE REFERENCE

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).
- 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 Reference _____. 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	Active ingredient	Label signal word
		Azoxystrobin (Heritage)* *	Caution
		Propiconazole (Banner) plus chlorothalonil (Daconil Weatherstik)	Warning/Caution
	OR	Pyraclostrobin (Insignia) *	Caution
		Thiophanate-methyl (Cleary's 3336)	Caution
	Early curative	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.

DISEASE REFERENCE

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:

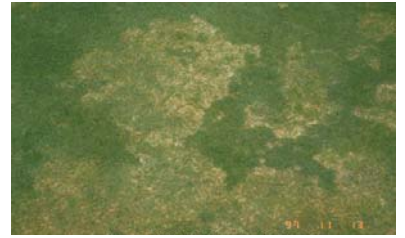
- Soil sodium > 110 ppm (Mehlich III extraction)
- > 2dS/m soil salinity
- Average air temperatures > 55 F (13 C)
- Use of high salinity irrigation water

Geographic distribution:

- Southern U.S., United Kingdom

Links to photographs

- On *Poa annua*: <http://www.paceturf.org/photo/showphoto.php?photo=202>
- On bentgrass: <http://www.paceturf.org/photo/showphoto.php?photo=566>



DISEASE REFERENCE

- On Poa trivialis: <http://www.paceturf.org/photo/showphoto.php?photo=151>

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 Reference _____. 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 salinity levels < 2dS/m. Monitor for soil salinity. 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.

Key Fungicide Active Ingredients, Trade Names and Fungicide Resistance 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	

INSECT REFERENCE

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

Links to photographs, illustrations of insects

- Ants: <http://cedarcreek.umn.edu/insects/album/025058067ap.html>

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)

INSECT REFERENCE

MANAGEMENT STRATEGIES:

Follow resistance management guidelines by rotating products as outlined in Reference . 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 1 st 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 1 st 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

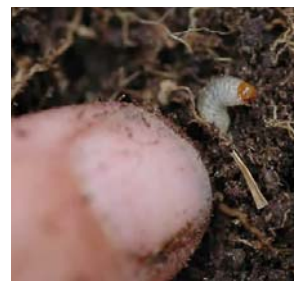
INSECT REFERENCE

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)

Links to photographs, illustrations of insects

- LARVA: <http://www.paceturf.org/photo/showphoto.php?photo=220>
- LARVA: <http://entomology.unl.edu/turfent/pestkey/billgrub.jpg>
- •ADULT & LARVA: <http://edis.ifas.ufl.edu/images/486597945>
- ADULT: <http://www.paceturf.org/photo/showphoto.php?photo=499>
- ADULT: <http://entweb.clemson.edu/cuentres/cesheets/corn/ce45.jpg>

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)

INSECT REFERENCE

Geographic distribution:

- North America

DAMAGE CAUSED:

Plants attacked:

Common name	Host plants
Bluegrass billbug <i>Sphenophorus parvulus</i>	Bluegrass, rye, fescue, bentgrass (occasionally) zoysia
Hunting billbug <i>S.venatus vestitus</i>	Zoysia & hybrid Bermuda. Occasionally on bahia, centipede & St. Augustinegrass
Phoenician billbug <i>S.phoeniciensis</i>	Bermuda, zoysia and kikuyugrass
Denver billbug <i>S. cicatristriatus</i>	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.

Links to photographs, illustrations of damage

- <http://www.paceturf.org/photo/showphoto.php?photo=506>
- <http://www.paceturf.org/photo/showphoto.php?photo=229>
- <http://www.ipm.ucdavis.edu/TOOLS/TURF/IMAGES/PESTMANIM/inbilldam.jpg>
- <http://www.urbanext.uiuc.edu/lawnchallenge/images/photo7-3.jpg>

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.

INSECT REFERENCE

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 Reference . 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 1 st 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	

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

INSECT REFERENCE

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

Links to photographs, illustrations of insects

- LARVA: <http://bugs.ufl.edu/glinda/blackcutwormlarvae.jpg>
- LARVA: <http://entomology.unl.edu/charts/bcwchart.jpg>
- ADULT: <http://cropandsoil.oregonstate.edu/smartkey/images/insects/fullsize/Agip03.JPG>
- ADULT: <http://www.ento.csiro.au/aicn/images/cain1920.jpg>

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

INSECT REFERENCE

- 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)

Links to photographs, illustrations of damage

- <http://bugs.osu.edu/~bugdoc/Shetlar/462/462TurfSurfacePests/TurfFoliageImages/turfsurfacepestsWMF05.JPG>
- <http://bugs.osu.edu/~bugdoc/Shetlar/462/462TurfSurfacePests/TurfFoliageImages/turfsurfacepestsWMF12.JPG>

INSECT REFERENCE

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: see Reference ____ for details. This is the most useful of the monitoring techniques for cutworms. Begin weekly soap flushes in the springtime, once average air temperatures exceed 55F (13C). Continue monitoring as long as temperatures exceed 55F. Use in indicator areas where cutworms are typically a problem. Use this technique to confirm the presence of cutworms. Treat only if damage from insects or birds is not tolerable.

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.

INSECT REFERENCE

MANAGEMENT STRATEGIES:

Follow resistance management guidelines by rotating products as outlined in Reference _____. 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 1 st small larvae are detected with soap flush	Beneficial nematode products based on <i>Steinernema carpocapsae</i> (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	

INSECT REFERENCE

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

Links to photographs, illustrations of insects

- <http://www.paceturf.org/photo/showphoto.php?photo=438>
- <http://www.paceturf.org/photo/showphoto.php?photo=471>
- <http://www.paceturf.org/photo/showphoto.php?photo=438>
- <http://www.paceturf.org/photo/showphoto.php?photo=989>

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.

INSECT REFERENCE

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:
 - o Ground beetles: ground beetles differ in their size (usually larger), their long, thin antennae and their rapid running movements
 - o 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:

INSECT REFERENCE

- o Newly hatched larvae of other white grub species including Japanese 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 ____) 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 Reference . 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)

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

INSECT REFERENCE

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

Links to photographs, illustrations

- <http://hcs.osu.edu/images/cd0005/cd0005-277.jpg>

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



INSECT REFERENCE

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.

Links to photographs, illustrations of damage

- <http://hcs.osu.edu/images/cd0005/cd0005-278.jpg>
- <http://www.paceturf.org/photo/showphoto.php?photo=947>

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.

INSECT REFERENCE

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	

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

INSECT REFERENCE

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 from 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.

Links to photographs, illustrations of insects

- http://ento.psu.edu/extension/factsheets/fall_armyworm.htm
- <http://vegipm.tamu.edu/chewing2/falarmyworm.html>
- http://creatures.ifas.ufl.edu/field/fall_armyworm.htm

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.

INSECT REFERENCE

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 avoid predation by birds. After 3-4 weeks the caterpillars burrow into the soil to pupate.
- Moth 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, fall 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.

INSECT REFERENCE

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. A 1-2% soapy water solution (liquid dishwashing detergent) in a gallon of water poured slowly over a 3 ft X 3 ft area works well to move armyworms up out of soil, thatch, and the base of the plants to a position up high on the plant where they can easily be seen. 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 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 damaged. Established bermuda usually recovers, but may take several weeks for regrowth to occur. Newly-sodded, seeded or sprigged areas are prime areas for damage.

INSECT REFERENCE

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 Reference . Always consult the most recent version of all product labels before use.

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 <i>Steinernema scapterisci</i> . 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 cyhalothrin (Scimitar)	Caution	

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

INSECT REFERENCE

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.

Links to photographs, illustrations of insects

- <http://vinsonlab.tamu.edu/ants.htm>

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 95°F. 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

INSECT REFERENCE

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.

Links to photographs, illustrations of damage

- <http://aggie-horticulture.tamu.edu/galveston/images/GCMG-1686%20Fire%20ant%20mound%20in%20lawn.GIF>

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.

INSECT REFERENCE

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 Reference . Always consult the most recent version of all product labels before use.

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	
		Priproxiifen (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

INSECT REFERENCE

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.

Links to photographs, illustrations of insects

- <http://www.paceturf.org/photo/showphoto.php?photo=451>
- <http://www.paceturf.org/photo/showphoto.php?photo=456>
- http://iaa.umd.edu/umturf/Insects/Green_June_Beetle.html
- <http://ento.vt.edu/Fruitfiles/gjb.html>
- <http://www.ces.ncsu.edu/depts/ent/notes/forage/gjbnote02/note02.htm>

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.

INSECT REFERENCE

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.
-

Links to photographs, illustrations of damage

- http://iaa.umd.edu/umturf/Insects/Green_June_Beetle.html

INSECT REFERENCE

- <http://ento.vt.edu/Fruitfiles/gjb.html>
- <http://www.ivyhall.district96.k12.il.us/4th/kkp/1insects/junebeetle.html>

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.

INSECT REFERENCE

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 Reference . Always consult the most recent version of all product labels before use.

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	

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

INSECT REFERENCE

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.
- Their 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.

Links to photographs, illustrations of insects

- LARVA: <http://www.uky.edu/Ag/PAT/cat3/3fig49.gif>
- LARVA: <http://www.ent.iastate.edu/images/coleoptera/scarabaeidae/phyllophaga3936-61.jpg>
- LIFE CYCLE: <http://entomology.unl.edu/turfent/turfchts/threeyr.jpg>
- ADULT: http://creatures.ifas.ufl.edu/field/white_grub3.jpg

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).

INSECT REFERENCE

- 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>

INSECT REFERENCE

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.

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 m² (1 ft²) for direct damage from the larvae.
- In the case of mammal damage the threshold is 0.

INSECT REFERENCE

MANAGEMENT STRATEGIES:

Follow resistance management guidelines by rotating products as outlined in Reference . 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	

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

INSECT REFERENCE

Southern mole cricket, *Scapteriscus borellii*

Tawny mole cricket, *Scapteriscus vicinus*

DESCRIPTION OF INSECT

All stages live in the soil and are rarely seen 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

INSECT REFERENCE

- 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.

Links to photographs, illustrations of damage

- <http://www.turffiles.ncsu.edu/DesktopDefault.aspx?tabindex=7&tabid=3&Content=467&ExtID=HTM>

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.

INSECT REFERENCE

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 Reference _____. Always consult the most recent version of all product labels before use.

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 <i>Steinernema scapterisci</i> . 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 1 st 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	

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

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

Links to photographs, illustrations of insects

- LARVA: <http://www.uky.edu/Ag/Entomology/entfacts/images/whgrub.jpg>
- LARVA (masked chafer)
<http://www.paceturf.org/photo/showphoto.php?photo=440>
- LARVA: <http://aesop.rutgers.edu/~hamilton/wgrub.jpg>
- ADULT: http://creatures.ifas.ufl.edu/field/white_grub2.jpg
- ADULT: <http://entomology.unl.edu/images/seedpest/mchafer.jpg>
- ADULT (masked chafer):
<http://www.paceturf.org/photo/showphoto.php?photo=219>

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

INSECT REFERENCE

- 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)

Links to photographs, illustrations of damage

- <http://www.paceturf.org/photo/showphoto.php?photo=441>
- <http://www.paceturf.org/photo/showphoto.php?photo=721>
- http://bexartx.tamu.edu/HomeHort/F1Column/2004Articles/Graphics%20Ento/whtgrubwormdam_ageksueduento.jpg
- <http://www.agry.purdue.edu/turf/agry210/insects/images/ataenius41.jpg>

INSECT REFERENCE

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 Reference . 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)	

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

INSECT REFERENCE

Insecticide resistance management groups.

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

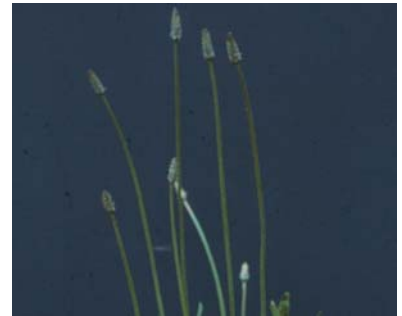
ACTIVE INGREDIENT	TRADE NAME	INSECTICIDE GROUP NAME	GROUP #
acephate	Orthene	acetyl choline esterase inhibitors	1
carbaryl	Sevin	acetyl choline esterase inhibitors	1
chlorpyrifos	Dursban, Pageant	acetyl choline esterase inhibitors	1
trichlorfon	Dylox, Proxol	acetyl choline esterase inhibitors	1
fipronil	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

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

WEED REFERENCE

MANAGEMENT STRATEGIES:

Always check labels to determine turfgrass sensitivity to herbicides.

Follow resistance management guidelines by rotating products as outlined in Reference [_____](#). 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 Reference . 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 (MCP)	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.

WEED REFERENCE

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 Reference _____. 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

WEED REFERENCE

MANAGEMENT STRATEGIES:

Always check labels to determine turfgrass sensitivity to herbicides.

Follow resistance management guidelines by rotating products as outlined in Reference [_____](#). 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 enhanced 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).

WEED REFERENCE

MANAGEMENT STRATEGIES:

Always check labels to determine turfgrass sensitivity to herbicides.

Follow resistance management guidelines by rotating products as outlined in Reference [_____](#). 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
		oryzalin (Surflan)	Caution
		oxadiazon (Ronstar)	Warning
		pendimethalin, trifluralin + benefin (Team pro)	Warning
		proflam (Barricade)	Caution
	Post-emerge: apply when weeds are small	fenoxaprop (Acclaim Extra)	Caution
		fluazifop (Fusilade)	Caution
		quinclorac (Drive)	Caution

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.

WEED REFERENCE

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 Reference _____. 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)

WEED REFERENCE

MANAGEMENT STRATEGIES:

Always check labels to determine turfgrass sensitivity to herbicides. Follow resistance management guidelines by rotating products as outlined in Reference _____. 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.

WEED REFERENCE

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 Reference _____. 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
		sulfentrazone (Dismiss)	Caution
		sulfosulfuron (Certainty)	Caution
		trifloxysulfuron (Monument)	Caution

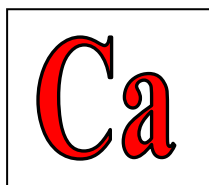
WEED REFERENCE

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, avoiding resistance relies 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	MCP	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

SOIL REFERENCE



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

Calcium plays a critical role in management of rapid blight caused by *Labyrinthula terrestris*. Calcium does not directly suppress the disease, but increased calcium levels ensure that sodium does not accumulate to levels above 110 ppm by Mehlich III extraction. Adequate calcium is also known to result in healthy soil and turf conditions that results in suppression of various weed species.

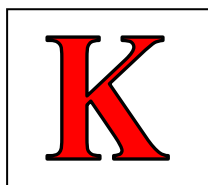
Guidelines

	Low	Normal	Excessive
Mehlich III SLAN	< 750 mg/kg	>750 mg/kg	unknown
Mehlich III BSCR	<60%	60 - 85 %	unknown
Saturated Paste	< 60 mg/l	60 - 200 mg/l	unknown
Saturated Paste %	<20	>20%	unknown

Management

- Products that are commonly used to help manage sodium or to supply calcium to deficient soils:
- 15-0-0 Calcium nitrate
- CaCO₃ lime
- CaSO₄*2H₂O Magnesium sulfate (Epsom Salt)
- CaCl₂ Calcium chloride

SOIL REFERENCE



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* while other studies suggest that the snow molds might be increased in high potassium environments. Moderation seems to be the key in this situation and a target of about 110 mg/kg is a good starting place.

Guidelines

	Low	Normal	Excessive
Mehlich III SLAN	< 110 mg/kg	>110 mg/kg	>300 mg/kg
Mehlich III BSCR	< 2 %	2 - 7%	unknown
Saturated Paste	< 40 mg/l	40 - 100mg/l	unknown

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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 molecule such as nitrate sulfate, phosphate, chloride). Leaching irrigation or rainfall will easily remove excessive potassium.
- 13-0-44 Potassium nitrate
- 0-0-50 K₂SO₄ Potassium sulfate
- 0-0-60 KCl Potassium chloride
- 0-0-22 MgSO₄*K₂SO₄ magnesium sulfate - potassium sulfate (K-mag)
- 0-52-34 KH₂PO₅ mono potassium phosphate



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

	Low	Normal	Excessive
Mehlich III SLAN	< 140 mg/kg	>140 mg/kg	unknown
Mehlich III BSCR	<12%	12 - 20 %	>20 %
Saturated Paste	< 20 mg/l	20 - 70 mg/l	unknown

•

Management

- Products that are commonly used to increase soil magnesium levels are listed below.
- 10-0-0 Magnesium nitrate
- $CaCO_3 \cdot MgCO_3$ dolomitic lime
- $MgSO_4 \cdot 7H_2O$ Magnesium sulfate (Epsom Salt)
- 0-0-22 $MgSO_4 \cdot K_2SO_4$ 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 REFERENCE



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)

$$\text{Manganese Availability Index (MnAI)} = 101.7 - 15.2 (\text{pH}) + 3.75 \text{ Mn mg/kg}$$

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

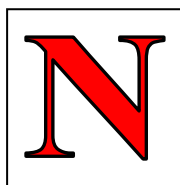
	Low	Normal	Excessive
Mehlich III SLAN	< 30 mg/kg	30 - 45 mg/kg	unknown
MnAI	< 110	> 110	unknown

•

Management

- Manganese products that can be used to adjust soil manganese levels are listed below.
- $MnSO_4 \cdot H_2O$ Manganese sulfate
- Manganese sucrate Granusol manganese

SOIL REFERENCE



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:

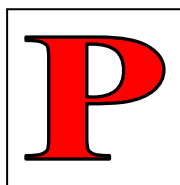
Total plant available nitrogen is the sum of nitrate (NO_3) and ammonium (NH_4) forms of nitrogen.

	Low	Normal	Excessive
Nitrate (NO_3) KCl extracted	< 3 mg/kg	3 - 20 mg/kg	> 20 mg/kg
Ammonium (NH_4) KCl extracted	Unknown	0 – 7 mg/kg	> 10 mg/kg
Total ($\text{NO}_3 + \text{NH}_4$)	< 3mg/kg	3 – 20 mg/l	> 20 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:
- Quick release
 - 15-0-0 Calcium nitrate
 - 13-0-44 Potassium nitrate
 - 46-0-0 Urea
 - 21-0-0 Ammonium sulfate
- Slow release
 - IBDU Isobutylenediurea
 - Ureaformaldehyde
 - Sulfur coated urea
 - Polymer coated urea

SOIL REFERENCE



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 availability 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 1.25.

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

(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 phosphorus 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 growth and are dependent upon soil pH and extraction methods. .

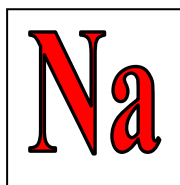
Guidelines

	Low	Normal	Excessive
Bray II P	< 50 mg/kg	>50 mg/kg	Refer to PSI
Mehlich III P	< 50	>50 mg/kg	Refer to PSI
Olsen P (soil pH > 7.5)	< 5 mg/kg	>15 mg/kg	Refer to PSI
PSI	—	<1.25	>1.25

Management

- Phosphorus products that are used to address deficiencies include:
- 11-52-0 Monoammoniumphosphate
- 18-56-0 Diammonium phosphate
- 0-52-34 Monopotassium phosphate
- 0-45-0 Triple super phosphate

SOIL REFERENCE



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

	Low	Normal	Excessive
Mehlich III SLAN	unknown	<110 mg/kg	> 110mg/kg
Mehlich III BSCR	unknown	<3 %	>6 %
Saturated Paste	unknown	0 – 30 mg/l	> 30 mg/l
Saturated Paste %	unknown	0 – 30%	> 35%

Management

- Application of the calcium products will help to manage and reduce soil sodium levels.
- 15-0-0 Calcium nitrate
- CaCO₃ lime
- CaSO₄*2H₂O Magnesium sulfate (Epsom Salt)
- CaCl₂ Calcium chloride

APPENDIX III.

Key insect, weed and disease pests that will be dealt with in IPM template reference publications. References that have been completed as of 5/1/07 are highlighted in green.

Key weeds

Bentgrass	Dollarweed	Poa trivialis
Bermudagrass	Goosegrass	Purple nutsedge
Brass buttons	Kikuyugrass	Quackgrass
Buckhorn plantain	Knotweed	Spurge
Chickweed	Kyllinga	Swinecress
Clover	Moss	Virginia buttonweed
Crabgrass	Oxalis	Yellow nutsedge
Dallisgrass	Perennial ryegrass	
Dandelion	Poa	

Key insects

Billbugs	Fire ants
Black cutworm	Grubs (1 year)
Black turfgrass ataenius	Mole crickets
Cotinus (Green June beetle)	Nuisance ants
Cutworms	Phyllophaga
Earthworms	Sod webworm
Fall armyworms	

Key diseases

Anthracnose	Pythium
Brown patch	Rapid blight
Decline/take all patch	Snow molds
Dollar spot	Spring dead spot
Fairy ring/localized dry spot	Summer patch
Gray leaf spot	Waitea (brown ring patch)
Leaf spot/melting out	