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

Progress Report
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I. Introduction and Rationale for Research:

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.

This project is important because we believe that while most golf courses have embraced some, or even all of the general principles of IPM, the development, implementation and optimization of IPM plans can be hampered by several barriers:

- There is a large gap between the general IPM principles found in textbooks and the development of site-specific strategies that address issues of climate and weather, turf varieties, soil and water quality, specific pest complexes, golfer expectations and budgets that vary from course to course.
- The ability to identify, understand the biology and stay abreast of control strategies for golf course pests – including weeds, diseases, insects and other arthropods and nematodes – is essential for development and implementation of IPM plans. Although a great deal of information is available in the scientific literature, trade journals, text books and extension publications, it has not been synthesized in a way that makes it accessible to golf course superintendents, regardless of their location.
- Once IPM plans are developed, they cannot remain static. Shifts in pest populations, changes in golf course expectations and budgets and the introduction of new products, technologies and scientific information require methods of evaluating new advances as well as procedures for periodic updating of IPM plans.
- Monitoring (for pests, weather, equipment operation/calibration and for the quality of water, soil and turf) and record keeping are the backbone of any successful IPM program. Information on monitoring and record keeping tools and procedures needs to be centralized and presented in a form that is easily accessible to golf course superintendents.
- One of the most oft-discussed yet least implemented practices is that of objective evaluation of the success (or failure) of newly introduced practices in meeting turf maintenance goals. Without tools for assessing the effectiveness of new techniques, the superintendent's ability to justify and promote their management decisions can be compromised.
- Superintendents vary widely in their technical backgrounds, computer literacy access to information. And golf courses vary widely in their interest in IPM principles and the budgets available to implement them. Yet the ability to incorporate IPM into turf management programs should be feasible for all interested superintendents and golf courses, despite these differences. Rather than assuming a "one size fits all" approach to IPM, successful plans need to be

flexible enough to take these differences into account and to make it possible for superintendents at levels to participate.

This proposal seeks to remove these barriers by providing a centralized source of easily accessible information, clear procedures for incorporating this information into IPM plans, and tools for documenting, record keeping and planning that will facilitate IPM planning. The project will integrate the experience and knowledge base of turfgrass researchers who span the country by geography (North Carolina, Arizona, California), by discipline (agronomy, weed science, plant pathology and entomology) and by the type of institution they work in (public universities, cooperative extension and private consulting firm).

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 first six months, we have focused on objective # 1. The framework for generating all of the necessary components of the final IPM Template was assembled. This framework includes the following documents, which are attached to this report:

- Materials that will be generated for the IPM Template: a detailed listing of all of the materials (references, forms, planning procedures) that will be generated by the completion of this project (see pages 4-5)
- Examples of reference materials that will be included in the final IPM Template
    - Pest biology and life cycle reference (see pages 6-8)
    - Soil nutritional guidelines reference (see pages 9-10)
    - Water quality guidelines reference (see page11)
- Examples of forms that will be included in the final IPM Template
    - Pest Worksheet Form (see page 12)
    - IPM Planner Form (see page 13)
- A project timetable: all tasks slated for completion by November, 2006, have been completed (see page 14)

- A template review workflow diagram: identifies the process by which materials will be generated, reviewed (by P.I.s, superintendent cooperators and others), revised and finalized.(see page 15)
- A glossary of terms used in constructing the IPM template (see page 16)

In addition, we designed “The IPM Principal Investigators Forum” to act as a chronological repository for discussion and documents associated with the GCSAA IPM Template project. The Forum resides on the website of the PACE Turfgrass Research Institute (http://www.paceturf.org/forum/) and is at this point restricted (by password) to principal investigators in the project. Passwords will be provided to additional reviewers once documents reach the review stage in 2007.

IV. Research to be implemented November 2006 – May, 2007

During the coming year, we will be generating the content for all of the components outlined in the attached documents (objectives 1 and 2). The principal investigators will hold a coordinating meeting in February, 2007 at the GIS in Anaheim. A panel of superintendents who are interested in providing ongoing input will be identified in February, 2007 (objective 3). A draft version of the template will be completed and available for testing by a panel of superintendents by November, 2007 (objective 3).

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…

  - Turf growth potentials
- 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


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): larvae (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

- 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

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.

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.

Table ___. Black cutworm management strategies

TYPE	THRESHOLD	PRACTICE		COMMENTS
Cultural	N/A	• Utilize tolerant/resistant turf types including Kentucky bluegrass • Remove clippings		
Biological	Apply when 1st small larvae are detected with soap flush	Beneficial nematode products based on *Steinernema carpocapsae* (Millenium). For other suppliers, see http://www.oardc.ohio-state.edu/nematodes/nematode_suppliers.htm		Moderate efficacy
Chemical*	Apply curatively when damage threshold is reached	**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
		• **Spinosad (Conserve)** • Halofenozide (Mach 2) • Bifenthrin (Talstar) • Cyfluthrin (Tempo) • Lambda cyhalothrin (Scimitar) • Chlorpyrifos (Dursban) • Deltamethrin (Deltagard)	**None required** Caution Caution Caution Caution Danger Caution	

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

Soil nutritional guidelines

The "desired" guideline values were derived based on three different sources of information: sufficiency (SLAN) guidelines, balance (BSCR) guidelines and PACE data collected from good performing golf course greens, tees and fairways. Soil analysis using Melich III extraction by Brookside Laboratories, New Knoxville, OH. Unless otherwise indicated, values are in parts per million (ppm).

	Greens		Tees		Fairways	
Nutrient concentration (ppm)	Average	Desired	Average	Desired	Average	Desired
Nitrate:Ammonium	**2.7 to 1**	**3 to 1**	**4.1 to 1**	**3 to 1**	**5.5 to 1**	**3 to 1**
Nitrate (NO_3)	**6.7**	**3-20**	**17.1**	**3-20**	**24.2**	**3-20**
Ammonium (NH_4)	**2.5**	**<7**	**4.2**	**<7**	**4.4**	**<7**
NO_3 + NH_4	**9.4**	**<20**	**21.3**	**<20**	**28.6**	**<20**
Phosphorous (P)	**99**	**51**	**92**	**40**	**101**	**44**
Potassium (K)	**156**	**144**	**135**	**174**	**235**	**229**
Calcium (Ca)	**1346**	**1327**	**1857**	**1916**	**2640**	**3043**
Magnesium (Mg)	**174**	**140**	**332**	**203**	**611**	**322**
Sodium (Na)	**174**	**<67**	**260**	**<67**	**584**	**<67**
Sulfur (S)	**139**	**<130**	**135**	**<460**	**490**	**<460**
Chloride (Cl)	**53**	**<90**	**122**	**<400**	**427**	**<400**
Sulfur + Chloride	**140**	**<200**	**223**	**<800**	**1015**	**<800**
Boron (B)	**1.0**	**0.4 - 1.5**	**1.2**	**0.4 - 1.5**	**1.7**	**0.4 - 1.5**
Copper (Cu)	**4.7**	**0.6 - 2.0**	**3.1**	**0.6 - 2.0**	**2.4**	**0.6 - 2.0**
Iron (Fe)	**185**	**See below**	**175**	**See below**	**157**	**See below**
Manganese (Mn)	**30**	**See below**	**30**	**See below**	**43**	**See below**
Zinc (Zn)	**18.9**	**1.3 - 3.5**	**13.9**	**1.3 - 3.5**	**8.4**	**1.3 - 3.5**

	Greens		Tees		Fairways	
Other measurements	Average	Desired	Average	Desired	Average	Desired
pH	**7.1**	**6.5 - 7.5**	**7.4**	**6.5 - 7.5**	**7.2**	**6.5 - 7.5**
EC (dS/m)	**3.2**	**<3.0**	**3.0**	**<3.0**	**6.4**	**<3.0**
TEC (meq/100 g)	**9.9**	**NA**	**14.5**	**NA**	**24**	**NA**
OM%	**2.0**	**<2.0**	**3.0**	**<6.0**	**4.4**	**<0.6**
% Ca	**69**	**68**	**66**	**68**	**59**	**68**
% Mg	**15**	**12-20**	**20**	**12-20**	**23**	**12-20**
% K	**4**	**4**	**3**	**4**	**3**	**4**
%Na	**8**	**<3**	**8**	**<3**	**11**	**<3**
% H	**0**	**10 - 15**	**0**	**10 - 15**	**0**	**10 - 15**

Guidelines for iron and manganese, for soils at a range of different pHs. Note that the desired levels of micronutrients increases as soil pH increases. Maintaining higher levels of manganese and iron helps to overcome their tendency to become bound, and therefore unavailable, to the plant in more basic soils. We have paid special attention to these two micronutrients because plants are more likely to be deficient in iron than any other micronutrient. And higher levels of manganese appear to play a role in suppressing turf diseases caused by *Gaeumannomyces* such as bermudagrass decline, kikuyugrass decline, and take-all patch.

	Desired soil ppm for pH 6 - 8.5 soils						Avg. for greens, tees & fairways (across all pHs)
	6	6.5	7	7.5	8	8.5	
Iron (Fe)	80	86	92	98	104	110	157-185
Manganese (Mn)	27	29	31	33	35	37	30-43

Saturated paste extraction values. Saturated paste extracts (SPE) are sometimes used to determine the nutritional content of soils that are calcareous or that cannot be effectively analyzed using Melich III extraction methods. However, the accuracy of using SPE for this purpose has not been thoroughly established. For this reason, the guidelines provided below are very rough, and should not be relied upon as the sole source of information in making fertility decisions. There is unfortunately no conversion factor that allows one to compare results of saturated paste extracts with results from standard extraction methods — they are two different systems entirely. The soil guidelines in References 6 and 7 are based on standard extraction methods such as the Mehlich III test

	Desired Value
pH	6.2 – 6.9
Salt (ppm)	< 1280
Chloride (ppm)	<1,000
Nitrate (ppm)	5 - 20
Ammonium	<7
Bicarbonate HCO3 (ppm)	<60
Phosphorous (ppm)	2 – 10
Calcium	30 - 100 ppm or >20%
Magnesium	15 - 50 ppm
Potassium	20 - 40 ppm
Sodium	0 – 30 ppm or <35%
ESP	<5.0%
SAR	< 4.0

Irrigation water guidelines

Water that meets the “no restriction” guidelines can be used almost anywhere with good results.

Parameter	No restriction	Domestic	Rain	Recycled	Poor Well	Good Well	Urban Runoff
EC (dS/m)	<0.8	0.7	0.1	1.1	4.02	0.6	16.1
TDS (ppm)	<525	499	46	723	2573	378	10323
pH	6.5-7.8	7.8	6.3	7.2	7.5	8.1	7.7
SAR	<3.0	2.7	0.5	4.0	5.2	0.9	11.7
HCO_3 (ppm)	<50	134	26	201	364	266	847
Na (ppm)	<100	85	5.6	147	407	30.5	1820
RSC (meq/l)	<1.0	0.04	0	0.12	0	0	0
B (ppm)	<0.5	0.22	0.03	0.42	0.41	0.06	2.05
Cl (ppm)	<90	74	0.7	149	1004	45	3886
NO_3 (ppm)	<8.0	3.2	—	7.3	—	3.6	0.4

Using water analysis data to calculate nutrients delivered in irrigation water.

In addition to keeping turf alive during dry periods, irrigation water is also the (frequently unknown) source of hundreds of pounds of nutrients to your turf. Depending on the water, different nutrients -- from calcium to sodium to boron to nitrogen -- are prevalent.

To keep track of both the beneficial and injurious nutrients that are delivered through your irrigation water, it should be tested at least annually by an analytical laboratory. You can then compare it against PACE’s water quality guidelines so that you can identify any potential problems.

Using the data from your report, it is also relatively easy to calculate how many pounds of each nutrient are being delivered each year to your golf course. The procedure is the same for any nutrient, but we will use total dissolved salts (TDS) below as an example.

1. On your water report, locate the total dissolved salts analysis. It will probably be reported either in ppm (parts per million) or milligrams per liter (mg/liter). These two measurements are equivalent.
2. Multiply the ppm or mg/l value by 2.72. The value you obtain is the pounds of total dissolved salts per acre foot of water. A value of 500 ppm TDS on a water report (this is a fairly low number that results in very few problems with soil salinity) will therefore translate into 1,360 pounds (2.72 X 500) total dissolved salts per acre foot of water.
3. To determine how many pounds of total dissolved salts are delivered per year to the golf course, multiply the 1,360 pounds value by the number of acre feet of water that you use on the golf course per year per acre. In this example, suppose that the course used 3 acre feet of water per acre last year. This would translate into 4,080 lbs of salts (3 X 1,360) per acre delivered to the golf course per year. This is equivalent to 94 lbs/1000 sq ft of salts. Obviously, as the volume of water used for irrigation increases, the pounds of salts dumped onto the golf course will also escalate.

Pest Worksheet			JAN				FEB				MAR				APR				MAY				JUN				JUL				AUG				SEP				OCT				NOV				DEC			
			1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
I1																																																	
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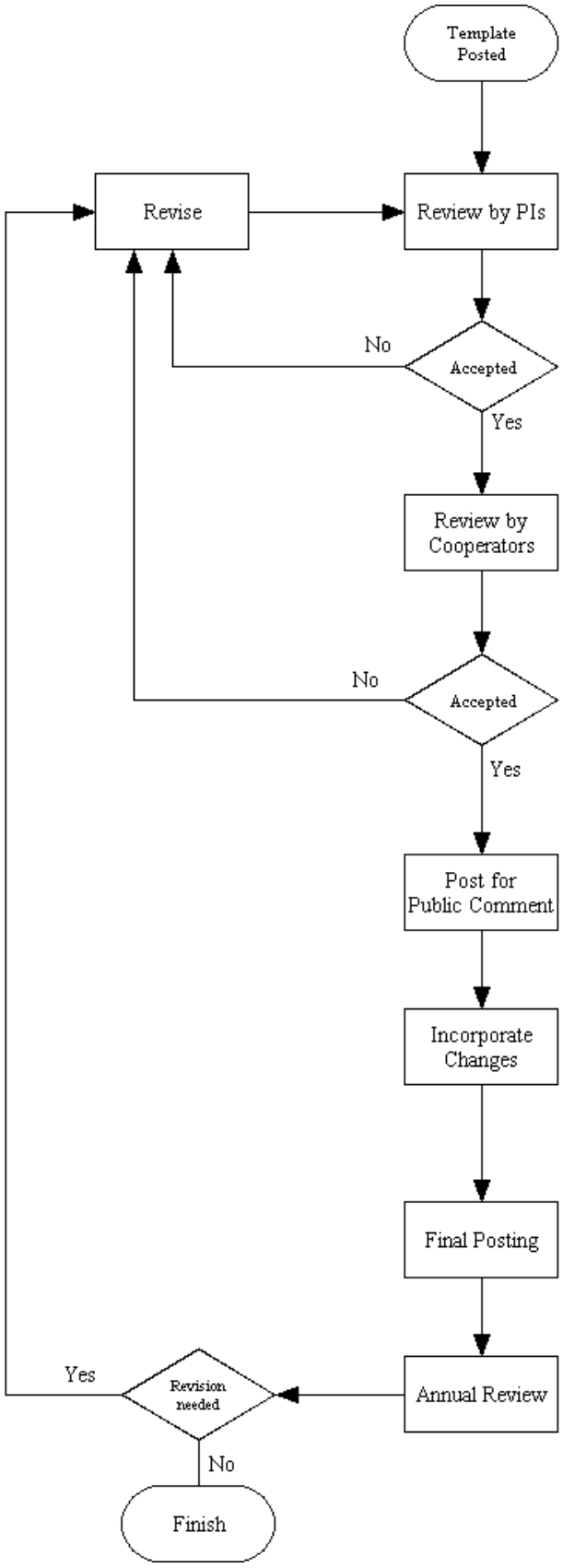
IPM Planner			JAN				FEB				MAR				APR				MAY				JUN				JUL				AUG				SEP				OCT				NOV				DEC			
			1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Cool Season Turf Stress																																																
Warm Season Turf Stress																																																
Tree maintenance																																																
Renovation																																																
Overseeding																																																
Aeration (D1-5; W-2,3)																																																
Heavy topdressing																																																
Venting (D1-5)																																																
Grooming																																																
Vertical mow																																																
Light topdressing																																																
Traffic control																																																
Soil testing																																																
Nitrogen																																																
Potassium																																																
Monitor salinity																																																
Leaching																																																
Irrigation water testing																																																
Irrigation maintenance																																																
Drainage improvement																																																
Hand Watering																																																
Aerial Photography																																																


Template Review Workflow
Template Posted
Revise
Review by PIs
No
Accepted
Yes
Review by Cooperators
No
Accepted
Yes
Post for Public Comment
Incorporate Changes
Final Posting
Annual Review
Yes
Revision needed
No
Finish

Project timetable

Action	Start	Complete	Status
Finalize preliminary timeline		Jun-06	Done
Get all existing documents in one location for evaluation, modification	May-06	Jul-06	Done
Identify repository for information exchange, documents		Jul-06	Done
Agree on editing/modification procedure (see workflow diagram)	May-06	Jul-06	Done
Agree on documents, templates that will be produced		Aug-06	Done
Report: brief 6 month		Nov-06	Done
Assign responsibility for production of each document		Dec-06	
Coordinating meeting for project PI's in Anaheim, CA		Feb-07	
Identify panel of superintendents for ongoing input		Feb-07	
Clarify role of programmers and agree on software platform		Feb-07	
Content generation: first versions	Aug-06	Mar-07	
Report: full annual		May-07	
Identify panel of superintendents for beta testing		Oct-07	
Interactive documents and templates	Nov-06	Nov-07	
Testable version available		Nov-07	
Report: brief 6 month		Nov-07	
Evaluation and refinement	Nov-07	Apr-08	
Recommend methods for dispersing templates		May-08	
Report: full annual		May-08	

Glossary: Terms used in constructing the IPM Template

Form: Documents to aid in record keeping, annual planning, monitoring, evaluating goals vs. results, financial planning. Includes spreadsheets, planning calendars, background information summaries and worksheets.

Integrated Pest Management (IPM): An Integrated Pest Management (IPM) program is an environmentally justifiable, cost-effective approach to pest control that utilizes a combination of approaches to best manage a pest population. A sound IPM program is based on:

- keeping pest populations below the level at which they become unacceptable
- reducing over-reliance on pesticides.
- monitoring of pest and natural enemy populations
- basing management decisions on pre-determined threshold or action levels and/or historical pest occurrence data to justify pest control practices used.

IPM Planning Procedure: Detailed written instructions for completing each section of the IPM Template

IPM Template: A group of documents, including planning procedures, reference materials and forms that will guide golf course superintendents towards development and implementation of IPM plans. All documents will be designed so that they are useful as either printed or electronic documents.

Reference: Turf management and agronomic data, information, guidelines and resources that will be utilized in IPM Planning Procedures.