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Intuitive Forecasting of Turfgrass Insect Pests

by R. L. Brandenburg

IN THIS ISSUE

One of the most frustrating moments in turfgrass pest management comes when a pest catches you by surprise and causes significant turf damage before you can respond. This may not only be embarrassing; it can also be expensive in terms of lost clients and the cost of remedial measures. Insects are notorious for surprising us and creating a serious problem in a relatively short period of time.

Some insects such as chinch bugs and armyworms usually catch us by surprise as it is. Others such as white grubs may be a little more predictable in time of occurrence, but not necessarily in location. Since they are underground pests, and go about their business unseen to the casual observer, they too can catch us by surprise. With this in mind, one can assume that the most valuable tool a turfgrass manager could have to aid insect management (other than the products used to control the pests) would be a means of predicting their occurrence.

The ability to predict insect pest occurrence isn't necessarily a distant dream. Current research at several universities is providing insight into the making of such forecasts. In this article I'll attempt point out that you may already be doing some predicting of pest outbreaks. Even if you aren't, this article contains guidelines on how to take advantage of our knowledge of insect development and put it to use in your turfgrass business.

Computerized weather recording equipment and remote site sensors have made accumulating weather data much more convenient and has allowed for pest forecasting.

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Insect modelling

First, let's look at a bit of the history behind insect forecasting and prediction. Back in the 1970's, an area in the study of insects (entomology) that received a great deal of interest was insect modelling. Insect modelling wasn't the assembly of plastic or wooden parts into some facsimile of an insect. It was the collection and fitting together of information on insects that gave us a better understanding of their lives and their relations with their environments (ecology).

These models were often quite elaborate, encompassing variables such as egg-laying rates, growth rates, migration, dispersal, and mortality factors like predation. It should come as no surprise that these models were often complicated and required a lot of data collection and input to make them operate.

Many times these models were quite successful in enlightening us about a particular pest. It is a fact that the more we know about an insect, the greater the likelihood that we will be able to manage it in the most efficient manner. Knowing how various predators, parasites, or weather patterns impact various insect populations is very useful to both scientists and pest managers.

The benefits of the models have been many and their development has become a science in itself within entomology. A lot of time and energy has been invested in them over the last 25 years. They have a negative side though: they tend to require not only a lot of funding, but also many years to develop.

This long period of development has frustrated many of those involved in the development of pest management strategies for turfgrass managers. Improvements are needed today. A model that can't be used until 10 years from now is liable to be too late. In addition, the turfgrass industry has shown such growth in recent years that it has outstripped the small group of entomologists working on turfgrass. Regardless of how good and effective some of the original turfgrass entomologists were, the industry has expanded far beyond what a few individuals can effectively address.

Fortunately, universities have seen the value of shifting more research and teaching resources into turfgrass. We now have more entomologists working on turf (although there is certainly not a surplus) and this has allowed us to expand our research efforts. While modelling to enhance our understanding of insect lives continues, some entomologists have begun to take a slightly different approach.

Forecasting can be most useful in determining when to scout for hard-to-detect pests such as soil insects; it can also help you avoid being caught unprepared by pests.

Half the battle in protecting high quality turf, such as this golf course, from insect pests is knowing when to expect certain problems.

"Intuitive modelling" defined

This new approach is commonly referred to as "intuitive modelling." What is "intuitive modelling"? As the name would imply, it is basically what your intuition tells you is going to happen, backed up with a little bit of science. Turfgrass managers in the northeast United States have known for years that the annual bluegrass weevil begins egg-laying when the flowering dogwood blooms. In many areas, preemergence herbicides for crabgrass are applied using the same cue. Intuitive modelling is simply using temperature and growth to tell us when something should be done.

A brief review of the concept behind intuitive modelling makes it more understandable. First, all insects are cold-blooded creatures. That is, for the most part, their body temperature is regulated by the temperature of the environment around them, whether that is air, soil, plant, or water. Many insects have ways to manage their body temperature a little, but by and large they are at the mercy of their environments. If it is hot, then they are hot. If it is cold, then they are cold.

Second, this same cold-blooded insect's growth is very much regulated by the temperature of its environment. It if is warm, the insect develops faster. If it is cool, then the insect develops more slowly. There are upper and lower limits to this, however. If it gets too cold, the insect may stop growing altogether, or die. The same is true for many insects if it becomes too hot.

So an intuitive model would tell you "if the spring has been warmer than normal, then the insect should show up earlier than usual." This is the basis of intuitive modelling. "If something changes, then these are the consequences" is another way to state this modelling philosophy. The "if-then" relationship is the key to understanding how the model works.

Intuitive modelling applies to more than just insect pests. Diseases are controlled, in large part, by temperature and humidity. Germination of numerous weed seeds is determined by soil temperature. And there are factors other than temperature that may play a role in regulating pest presence and activity. Sometimes all these factors interact in a straightforward manner; at other times their interaction is very complicated and difficult to understand.

In intuitive modelling we seek trends that are associated with parameters that can be monitored easily. In other words, we look for straightforward guidance from measurements such as temperature, relative humidity, and precipitation. Prediction is usually much easier if there is a straightforward relationship, but interactions of temperature and rainfall, for example, don't prevent the use of a model. Some immature insects may develop to a pupal stage, but not emerge as adults until rain occurs. While development to this preadult stage may be dependent on temperature, no matter how warm it becomes, no adults will be observed until it rains.

Intuitive models can still play a role in providing insight into insects. If you know that the below-ground larvae have progressed to the pupal stage, then you know that the next substantial rain or irrigation will probably result in adults emerging. If the adult is a species that feeds on ornamentals, then this information may even be more important than knowing what the root feeding larval stage pest is doing in the turf.

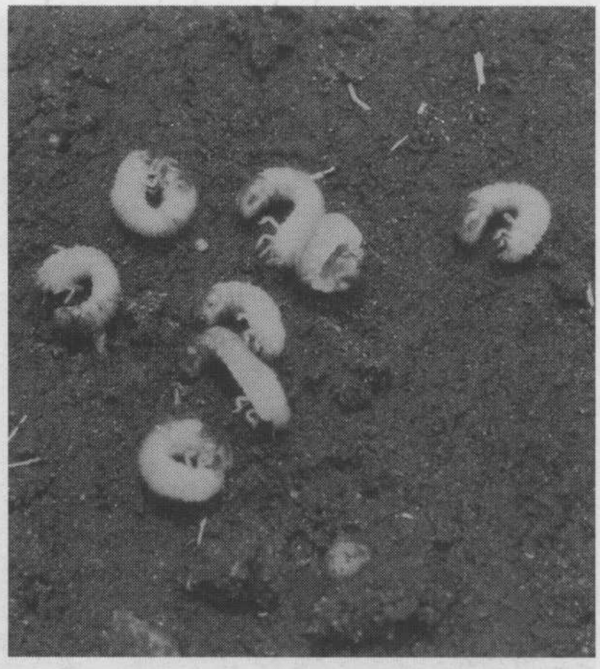
These interactions are often more common and more important with turfgrass diseases. Temperature and relative humidity and/or leaf wetness or dewpoints often work together to determine disease incidence.

Monitoring equipment and services

The ability to monitor such factors is critical. In this age of computerized weather stations, almost every environmental factor can be monitored and recorded. The cost tends to be reasonable. In fact, many insects can be forecast based solely on monitoring air or soil temperature. In some areas, such data can be obtained from local papers, phone services, or satellite dish weather services.

Many pests can be forecast with wide-area environmental information. In other words, the temperature from a site several miles away may be sufficient to accurately predict insects over a wide area. There will be exceptions to this: areas that have a southern slope or exposure, for example, will warm more rapidly in the spring and see accelerated insect development.

Tracking some pests, particularly diseases, may require more specific microclimate data. Sensors and monitoring equipment may be necessary in numerous locations throughout an area (i.e: in subdivisions, at golf courses, even at various locations within a single golf course). Another option is to monitor environmental conditions at the site considered most likely to experience pest problems. By monitoring environmental factors in this one location, advance warning is supplied for surrounding areas.



White grub development and the emergence of adults is closely related to temperature.

Dramatic advances in environmental monitoring technology have brought the equipment needed to model insect pests within everyone's reach. Not only has the capability of the equipment been enhanced, but the price has dropped significantly over the past few years. Equipment varies from the most basic, simply displaying current temperature, humidity and rainfall, to complex systems that monitor and record a wide range of environmental factors. Some have built-in computers, or are linked to a computer that accumulates a data base. Others have programs that record degree-day accumulations. Degree accumulations, as we will discuss shortly, form the backbone of intuitive modelling.

Other advances in environmental monitoring technology include the ability to monitor remote sites without hard-wired connectors. In the past, if you wanted information from a particular location, it was necessary to run a cable from your computer or data collection unit to the monitors or sensors in the field. That often limited flexibility in site selection. Now, however, we can rely on wireless communication.

The use of radio telemetry, cellular phones, and infrared signals allows the field sensors to communicate directly with your equipment in the office. This permits the placement of the sensors in those critical locations where environmental monitoring is essential, and your work station wherever you prefer.

Some sensor-recorder packages are "stand alone" units. Their sole function is to collect environmental data. Other systems may perform additional functions, such as controlling an irrigation system. More recently, still other information sources have been made available through satellite down-link. The latter, while relatively inexpensive and offering a wide range of services, may not provide sufficiently specific or localized information for pest forecasting. They are useful, however, for tracking general trends and detecting variations from the normal.

"Intuitive modelling" in action

Let's look at a specific example of intuitive modelling and its many levels of use. Mole crickets have become a serious pest of turfgrass throughout the southeastern United States. Management of this pest is difficult at best. Many turfgrass managers spend thousands of dollars attempting to control mole crickets and end up with less than satisfactory results.

One of the key elements in effective control of this pest is the timing of insecticide application. Control measures against mole crickets are most efficacious when about 50% of the eggs have hatched. This may sound relatively straightforward, but the underground habits of the mole cricket make it difficult.

Mole crickets spend virtually their whole lives underground, feeding on the roots of turfgrass. When egg hatch is occurring, June through July, warm-season turf looks very healthy. The severe damage caused by mole crickets only becomes apparent late in the summer and early fall. At that point, however, the mole crickets are large and chemical controls are much less effective against them.

Detection of the very small crickets right after hatching is consequently very important. A soap flush—a mixture of 2 tablespoons of liquid dishwashing detergent in 2 gallons of water, applied to an area a yard square—can be an effective technique for bringing small mole crickets to the surface. This procedure is very time-consuming and labor intensive, however. Add to that the fact that, since there are no obvious above-ground symptoms, large areas of turf must be inspected.* Most importantly, mole cricket egg hatch can vary as much as a month from one year to the next. This means turfgrass managers relying only on soap flushes to track the hatch must keep at it for weeks before discovering when to take control measures. They would be a lot better off if they had some guidance on when egg hatch is most likely to occur.

Work at North Carolina State over the past several years has monitored mole cricket egg-laying, egg hatch, and nymph (or immature cricket) development. At the same time, air temperature, soil temperature, and rainfall have been recorded at 15 minute intervals by a computerized weather station.

After several years, a clear pattern has begun to emerge. Above-average soil temperature during April, May, or June means the eggs will hatch earlier than normal. A cool month during that same period will have the opposite effect. By monitoring and recording soil temperatures, we can determine when the egg hatch is likely to occur: earlier than usual, or later. For the turfgrass manager with consistent mole cricket problems, this is invaluable information.

It's important to note that with a soil insect such as a mole cricket, monitoring the soil temperature, not the air temperature, is what's important. Air temperatures in southeastern North Carolina during 1991 and 1992 were almost identical. However, the mole crickets hatched 2 to 3 weeks earlier during 1991 (see figure 5). The reason for this was that, while the air temperature was about the same during the month of May in both years, May of 1992 was much cloudier and overcast.

*See the August 1995 *TurfGrass TRENDS* issue for in-depth discussions of scouting techniques that would be helpful here.

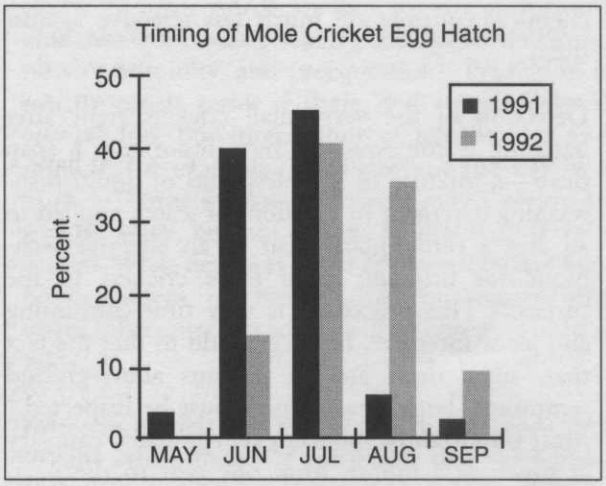


Figure 5. Mole cricket development (differences in egg hatch in two successive years).

As a result, the amount of solar radiation (sunlight) reaching the soil was much less. The soil didn't warm as quickly, and the crickets developed more slowly. Monitoring only the air temperature would have produced an inaccurate forecast of mole cricket development.

The end result of this work at North Carolina State University is that, through several years of monitoring soil temperatures and cricket development, we have constructed an intuitive model. Each year, we begin monitoring soil temperatures on January 1. We compare the degree-day accumulations for the current year with records of degree-day accumulations and cricket development from past years. This gives us a basis for predicting whether the crickets are going to be ahead of schedule, or behind.

"Degree-day" modelling

The term "degree-days" has been mentioned a couple of times. Degree-days are simply an accounting tool for recording how warm it has been. Most living organisms have a threshold or a minimum temperature for development. For insects, a common threshold is 50°F. Temperatures below this usually mean development does not take place; temperatures above 50°F usually mean development occurs. The higher the temperature above 50°F, the more rapid the development (within limits—insects can be cooked).

A simple way of calculating degree-days is to record the maximum and minimum temperature for the day, then add the two together and divide by 2 to get an "average temperature." From this "average" temperature, we then subtract 50°F, since this is our insect development threshold temperature. The resulting sum is the number of degree-days for that day. A negative number isn't used since it simply means no development occurred. If the minimum temperature for a day was 60°F and the maximum temperature was 80°F, then the average would be 70°F (80 + 60 = 140/2 = 70). Subtracting the 50°F threshold would yield 20. This is the number of degree-days recorded for that day.

Developmental models have cumulative degree-day targets that indicate when an important event is likely to happen (see table 1). For example, if mole cricket egg hatch is predicted to occur at 2,000 degree-days, and this usually occurs around June 17 here in Raleigh, then we base our current prediction on that model. Should we have 1,900 degree-days by June 1, and be accumulating about 30 additional degree-days each day thereafter, then we can estimate that egg hatch is going to occur earlier than the usual June 17. With this information in hand, we then know when to begin our all important soap flushes to verify the egg hatching. Once hatching has been verified, we can begin control measures in a timely and effective manner.

Similar intuitive pest models are already in use or under development in many states. These include models for sod webworms, masked chafers and Japanese beetles. The prediction of these pests includes both the appearance of the first and second generations (sod webworm) and appearance of the adults (masked chafers and Japanese beetles).

Of course, the real value of such predictions is dependent on the accuracy and completeness of the environmental information collected, and how specific the information is to the location of interest. Using a base 50°F, we see our first Japanese beetle adults in North Carolina at about 1,100 degree-days, which is the same for Ohio or New York. Only the time of year that target is reached is different for the different states.

As we look to the future of turfgrass pest management, intuitive modelling will likely take on an increasingly important role. One reason will be increasing regulations and legislation that will limit the amount of preventive pesticide application.

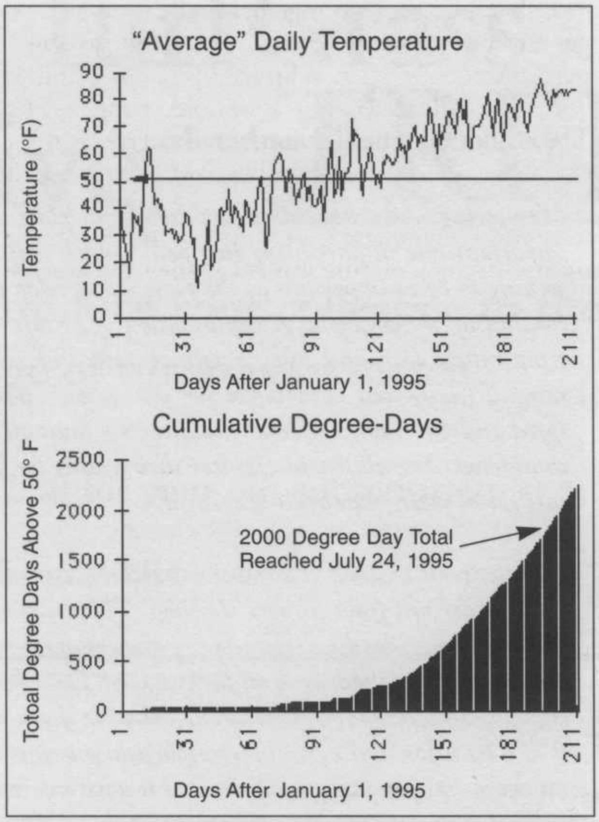


Figure 6. Degree-day accumulation at a representative site. (Data supplied by J. Michael Bailey, Automated Weather Source, Gaithersburg, MD.)

Future applications must be based more on the presence of a threatening pest population. Models that tell when the pest is most likely to appear will prove quite useful in helping meet those guidelines.

Additionally, we are seeing the production of more "biorational" or biological types of insecticides. Many of these must be targeted against a specific stage in the insect's development. Intuitive models can provide insight into the insect's growth patterns and help provide guidelines for the use of such products.

Suppose you have an interest in monitoring pest development, but aren't aware of any specific models for your area. How can you use the concept of intuitive modelling? The immediate answer is that you probably already are. Remember the flowering dogwoods mentioned earlier? In addition, with a little more record keeping, you can probably use it a lot more.

We have just reviewed intuitive modelling in making common sense decisions based on good information. If you have kept good records on the occurrence of a pest for several years, then you definitely have a good start on doing your own intuitive modelling. Should a certain pest typically occur in your area in early June, then you have a baseline from which to judge other years. If the weather in the spring is unusually warm, or cool, then record how this affects the occurrence of the pest.

Should you have access to weather data, be it from your own computerized system or simply by checking the daily newspaper, then the whole process can be quantified a bit more. You can even record your degree-days by hand. The bottom line is you can put as much time and effort into the recording of weather information and pest occurrence as you want. The more time you spend, the greater the likelihood of accurately determining if a pest going to show up earlier or later than usual.

It is important to note that not all pests need specific degree-day accumulations before they appear. In other words, it really doesn't matter how warm or cool it has been in the spring. Some pests may migrate in from other areas while others (and some diseases) may simply respond to the appropriate conditions of temperature, relative humidity and plant stress. The occurrence of many of the insects, however, can be predicted based primarily on temperature.

Intuitive modelling is continually being refined and models for additional pests are being developed. The real advantage to intuitive modelling is that it is straight-forward, simple, and useful. As turfgrass managers become more familiar with it,

Table 1. Degree-Day Targets of Various Species.

Species, Developmental Stage, Extent of Hatch	
Larger Sod Webworm (1st gen)	1050-1950
Larger Sod Webworm (2nd gen)	2600-3010
Bluegrass Sod Webworm (1st gen)	1250-1290
Bluegrass Sod Webworm (2nd gen)	2550-3010
Cranberry Girdler	1700-2750
N. Masked Chafer 1st adults	898-905
N. Masked Chafer 90% adults	1377-1579
S. Masked Chafer 1st adults	1000-1109
S. Masked Chafer 90% adults	1526-1679
Japanese Beetle 1st adults	1050-1180
Japanese Beetle 90% adults	1590-1925

Modelling tips

1. Always keep good records of the timing and location of each pest occurrence.

2. Keep or have access to good weather data.

3. Review the records and look for trends in insect occurrence.

4. Contact local or state turfgrass experts for existing models to predict turfgrass pests.

5. Always verify the occurrence of the pest with a careful scouting/sampling program—especially before taking control actions.

6. NEVER assume a pest isn't going to occur just because it doesn't show up on time. Other factors may be at work.

they are able to customize it to fit their needs. This is because intuitive modelling is based more than anything else on common sense. Intuitive modelling is a tool of the future that can be integrated into your turfgrass programs today.

Dr. Rick L. Brandenburg is a Professor of Entomology and Extension Entomologist at North Carolina State University. He has degrees in entomology from Purdue University and North Carolina State University. His research and extension interests include the use of biological control techniques, innovative insecticide application technology, pest forecasting, and public education on pesticide and the environment. This is his first contribution to *TurfGrass TRENDS.*

Some useful references:

- Brandenburg, R.L. and M. G. Villani (eds.), *Handbook of Turfgrass Insect Pests*, Lanham, MD: Entomological Society of America, 1995 $30 (ISBN:0-614-05664-0) [telephone (301) 731-4535 to order].

- Watschke, T.L., P. H. Dernoeden, and D.J. Shetlar, *Managing Turfgrass Pests (Advances in Turfgrass Science)*, Ann Arbor, MI: Lewis Publishing, 1994 $69.95 (ISBN: 0-87371-999-9) [telephone (800) 272-7737 to order]

Collecting local weather data

Monitoring your immediate environment plays an important role in forecasting turf pests, which is itself coming to be as important as the plan you develop for controlling the problem. A combination of factors — temperature (air and soil), moisture (air and soil), rainfall (daily and cumulative for the season), wind speed and direction, and solar radiation — must all be considered. The ability to monitor their values for the turf stand you're managing is critical.

To date, most weather information available commercially is derived from airport readings. This "canned" data can be misleading. How many airports have you been to that had shade trees on the runway? Data from regional or national vendors can be valuable if you use it as a basis for your overall meteorological monitoring program, but you have to supplement it with information on your immediate environment.

There are many weather stations on the market today that you can use to obtain local data. They range in cost from $400 to $50,000. Of course, the more you pay, the more you receive. A soil temperature and moisture probe can easily be integrated into most of the sensor suites in low cost weather stations, however, so you can get by with less than the most expensive. A weather station that periodically logs a complete set of environmental data, and records daily minimum and maximum values, provides all the capability you need to monitor and predict the onset of many pests. The additional benefits of real time reporting and PC-based tracking and modelling can be acquired for an additional $2,000 to $4,000, depending on the sensors, communications links and computer you choose. And any number of programs are available that permit users to tailor data reporting, aggregation and analysis functions to their particular requirements.

Contributed by J. Michael Bailey, Automated Weather Source, Gaithersburg, Maryland

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Robert Mitchell, Exec. Dir. of Golf and Grounds, The Greenbrier

■

Winter Weed Control in Southern Turf — Early Detection, Recognition and Action are Key

by Lambert B. McCarty

Weeds in winter are a distraction due to their color and leaf textural differences from the brown-colored, dormant turf. In addition, weeds shade the dormant turf, thus delaying "green-up" in spring.

In order to be effective, weed control should be a carefully planned and coordinated program. Understanding how and why weeds are present is important in developing a weed control strategy. Knowing what chemical options are available and using proper timing and application techniques round out a successful control program.

Provide healthy turf

Providing the agronomic practices that promote a healthy, dense turf is the first, best defense against weeds. Most annual weeds require a certain amount of direct sunlight for optimum germination. Dense turf reduces sunlight penetration, thus inhibiting weed establishment. Thick turf also insulates the soil, which helps maintain soil temperatures outside the optimum germination range of many weed seeds. Table 1, on the other hand, lists commonly found growing conditions favoring weed invasion.

Sound agronomic practices promoting healthy turf include using the proper mowing height and frequency, providing adequate fertilizer rates and appropriate ratios, and watering. The last major nitrogen fertilization for most warm-season turfgrasses should be applied no later than September, and should contain at least a 1:2 nitrogen to potassium ratio to promote rooting before winter. The mowing height at this time of year should also be raised to the maximum recommended level for your particular turfgrass, as this serves to promote healthy turf rooting and also continues to shade the soil surface, as mentioned earlier. Water should be applied at rates to provide good (but not excessive) soil moisture. Weeds such as annual bluegrass, goosegrass, and nutsedge love wet soils. Watering should be stopped once the turfgrass has gone dormant for the winter season.

Traffic on warm-season turfgrasses also should be minimized in fall, as the turf does not have time to recuperate before cooler temperatures arrive. Damaged turf provides an opening for weeds to invade.

Identification and biology

Positive identification of weeds appearing in turf is the first step in understanding why they occur and how to control them. In the past, turf managers found this frustrating because of the lack of an adequate turf weed identification guide. *Weeds of Southern Turfgrasses*, a highly recommended identification guide, is now available. It was published

Table 1. Growing conditions which favor certain weed infestation and growth.

Growing Condition	Weeds Favored
Low Soil pH	Red Sorrel
High Soil pH	Plantains
Droughty Soils	Spurge, Black Medic, Woodsorrel Lespedeza, Knotweed
Wet Soils (Overwatering)	Annual Bluegrass, Sedges, Goosegrass, Alligatorweed, Moss, Algae
Sandy ('Poor') Soils	Quackgrass, Poorjoe, Sandspur, Yellow Sneezeweed
Low Mowing Height	Annual Bluegrass, Chickweed, Algae
Compacted Soils	Goosegrass, Annual Bluegrass, Knotweed
Low Soil Nitrogen Levels	Legumes (Clover, Black Medic), Chickweed, Speedwell, Chicory, Broomesedge, Yellow Sneezeweed

for turfgrass managers and can be obtained through the Florida, Georgia, or Alabama Cooperative Extension Services. This guide provides over 400 color photographs of almost 200 weeds common to Southern turf. Additional means of identifying weeds include consultations with county extension agents, lawn-care operators, and industry representatives

Winter weeds germinate in late summer through early fall, when daytime temperatures are in the 70° F range. They grow throughout the winter months, and flower or produce seedheads during late winter and early spring. In this, winter weeds are sneaky: they blend with the turf in the fall and early winter months, not becoming noticeable until late winter when growth spurts, along with seedheads and flowers, make them stand out in the turf.

Scouting

Information on weed identities, where they occur, and the level of infestation are needed for informed management decisions on whether control is required, and if so which option(s) to consider. Scouting simply means dividing the service area into logical sections or units, then determining which weed(s) are present at what level in each division. Residential plantings are normally divided into front, back and side yards. For appearance' sake, front lawns generally receive priority control implementation, followed by the sides and then the back. Golf courses are sectioned, by hole, into tees, fairways, greens, and roughs. Roughs receive the least attention for weed control; greens and tees receive the most. The weeds present in each unit, and a general notation on cover patterns, are recorded. Weed pattern notations can be as elaborate as estimating the percent cover for each monitoring division, or more realistically, involve only simple verbal ratings like "widespread," "spotty," or "single patch."

Early fall (September/October) is the optimum scouting timing for winter weed control, with a follow-up in early spring (March/April). The fall scouting allows early detection and pressure level (weed frequency) assessments for each monitoring area. The early spring scouting identifies the weeds that have not been controlled, and where they can be expected to occur the following winter season.

The threshold levels that must be reached before treatment becomes necessary are generally determined by the owner or manager of the turf site. This level of tolerance tends to be rather low for high traffic or visibility areas such as golf tees and greens, and home front lawns.

Herbicide selection and use

Based on weed germination timing, herbicides are generally classified as preemergence or postemergence materials. Preemergence herbicides are applied prior to weed seed germination, and inhibit development of the germinating seed. If applied after germination, preemergence herbicide effectiveness diminishes greatly. Preemergence herbicides also should be activated by 1/4 in. to 1/2 in. inch rainfall or irrigation after application.

Postemergence herbicides generally are effective only on visible weeds. Young (two to four leaf stage) and actively growing annual weeds are the most susceptible, and require the least amount of herbicide. At this stage, herbicide uptake and translocation are favored and weeds have less developed, more tender root systems. Delaying application results in poorer translocation of herbicides in plants, more difficulty controlling mature plants, and possible setback of turf during green-up.

Postemergence herbicides should only be used when weeds are actively growing. This occurs primarily when temperatures are between 40° and 80°F. Material applied outside this temperature range tends to work too slowly to be effective or to result in excessive turf damage.

Broadleaf weed control

Preemergence broadleaf weed control is provided by the herbicide isoxaban (Gallery®). Gallery® must be applied before broadleaf weeds germinate, and it should also be tank-mixed with another preemergence herbicide such as prodiamine (Barricade®), Dithiopyr (Dimension®), pendimethalin (Prowl®), or oryzalin (Surflan®) if annual bluegrass is expected.

Atrazine (AAtrex®) and simazine (Princep®) are the backbone products for postemergence winter weed control for warm-season turfgrasses such as centipedegrass, St. Augustinegrass, zoysiagrass, and bermudagrass. These materials should be used in mid fall (October/November) for optimum control. A follow-up application may be needed

3 weeks later for total control. These herbicides become less effective when applied after January and also tend to increase the potential for turfgrass damage if applied later.

For those broadleaf weeds that these herbicides do not effectively control, a single or combination applications of 2,4-D, 2,4-DP, MCPP, MCPA or dicamba are needed (see Table 2). These herbicides are selective, systemic, foliar-applied herbicides. Several considerations should be noted before using one or more of these materials. First, few broadleaf weeds, especially perennials, are controlled with just one of these herbicides. A combination of two or more is generally necessary for satisfactory results. Control also depends on the maturity of the weed. Younger weeds are easiest and cheapest to control. Ideally, applications should ideally be initiated in November to take advantage of these plants being in younger, more succulent stages of growth. Waiting until March or April to attempt control requires sequential applications, spaced 10 to 14 days apart. This not only puts a greater burden on the environment, but also increases labor costs, outlays for herbicides costs and wear and tear on equipment. Later applications also may delay green-up, and it may take longer for herbicides to work.

Until recently, these herbicide combinations were used as the main control chemicals for broadleaf weeds. "New chemistry" materials such as triclopyr + clopyralid (Confront®) have been introduced as alternatives to the traditional herbicides mentioned above. Although this new chemistry provides a wider array of materials to choose from, economics and turf tolerance must still be considered before they are used.

Grass weed control

In winter, the predominant annual grass weeds in southern turf are annual bluegrass and clumps of ryegrass that have escaped from sites that were overseeding. Annual bluegrass can be controlled

Table 2. Turfgrass tolerance to postemergence herbicides.

Weed	Atrazine/ Simazine	2,4-D	Mecoprop (or MCPP)	Dicamba	2,4-D + MCPP	2,4-D + 2,4-DP	2,4-D + MCPP dicamba	2,4-D + triclopyr
Betony, Florida	S-I[1]	I	I	I-S	I	I	I-S	--
Bittercress, hairy	--	S	I	S	S	S	S	--
Black Medic	--	R	I	S	I	S	S	--
Burclover	--	I-R	S	S	S-I	S	S	--
Buttercups	I	S-I	I	I-R	S	S	S	--
Carrot, wild	--	I	I	S	I	S-I	S	--
Chickweed, common	S	R	S-I	S	S	S	S	S
Chickweed, mouse-ear	I	I-R	S-I	S	S	S	S	S-I
Chicory	--	S	S	S	S	S	S	--
Clover, hop	S	I	S	S	S	S	S	S
Clover, white	S	I	S	S	S	S	S	S-I
Dandelion	I-R	S	S	S	S	S	S	I-S
Garlic, wild	--	S-I	R	S-I	S-I	S-I	S-I	--
Geranium, Carolina	--	S	S-I	S	S	S	S	--
Healall	--	S	R	S-I	S	S	S	--
Henbit	S	I-R	I	S	S-I	S	S	
Ivy, ground	--	I-R	I	S-I	I	I-S	S-I	--
Knawel	--	R	I	S	S-I	S-I	S	--
Mustard, wild	S	S	I	S	S	S-I	S	--
Onion, wild	--	I	R	S-I	I	I	S	--
Parsley-piert	S	R	S-I	S-I	S-I	R	S-I	S
Pennywort	S	S-I	S-I	S-I	S-I	S-I	S-I	--
Pepperweed	--	S	S-I	S	S-I	S	S	--
Shepherd's-purse	--	S	S-I	S	S-I	S	S	--
Speedwell, corn	S	I-R	I-R	I-R	I-R	I-R	I-R	--
Spurweed (lawn burweed)	S-I	I	S-I	S	S-I	I	S	S
Strawberry, India mock	--	R	I	S-I	I	R	S-I	--
Thistles	--	S-I	I	S	S-I	S-I	S	--
Violet, johnny-jumpup	--	I-R	I-R	S-I	I-R	I	I-R	--
Yellow rocket	--	S-I	I	S-I	S-I	S-I	S	--

[1]S = susceptible; I = intermediately susceptible, good control sometimes with high rates, however a repeat treatment 3 - 4 weeks later each at the standard or reduced rate is usually more effective; R = resistant in most cases. Not all weeds have been tested for susceptibility to each herbicide listed.

effectively with postemergence herbicides, assuming the turf is not overseeded with ryegrass or other cool-season grasses. In non-overseeded turf, atrazine (AAtrex®), simazine (Princep®), and Kerb® provide excellent control of annual bluegrass and ryegrass. The key to the use of these materials is timing. The first applications should be made in mid fall, when weeds are smaller and easier to control. A follow-on application is necessary in January to control the second flush of seed germination that normally occurs at this time, especially with annual bluegrass. Atrazine and simazine have the added benefit of also controlling many winter annual broadleaf weeds such as lawn burweed, chickweed, and henbit (Table 2). However, as mentioned earlier, if control is attempted later, in March or April, problems with herbicide efficacy and turf damage may occur.

Sedge control

Purple and yellow nutsedges are the most prominent in turf. Although both are perennials, they tend to die-back with the onset of frost, and become relatively unnoticeable in winter lawns. If herbicidal control is not initiated by late summer, these nutsedges should be allowed to remain in the lawn for treatment the following spring. Yellow nutsedge can be suppressed in spring with the preemergence herbicide Pennant®. Postemergence control of yellow nutsedge is with Basagran T&O® or Manage®. Purple nutsedge is suppressed with the postemergence herbicides Manage® or Image®. Image®, however, should be used only when the turfgrass is actively growing (mid-summer for warm-season grasses). If hard-to-control weeds persist, Prompt®, which is a pre-packaged combination of atrazine and bentazon, can be used. Repeat applications, spaced four to six weeks apart are recommended.

Overseeded turf

Weed control in overseeded turf is more difficult because the winter weeds' susceptibility to herbicides is similar to that of the overseeded ryegrass (see Table 3). Until fully established, ryegrass is somewhat sensitive to many postemergence herbicides.(Preemergence herbicide control choices are limited, and each has its strengths and its weaknesses. Bensulide (Betasan®, PreSan®), Balan®, and Kerb® provide good preemergence annual bluegrass control, but must be used 60 days before overseeding. This means the application must occur in mid-summer in most areas. Applications made closer to overseeding may result in an unacceptable ryegrass stand.

Rubigan®, a fungicide with selective herbicide activity, also is available for preemergence annual bluegrass control and does not affect overseeded ryegrasses or bermudagrass adversely. A series of two or three applications provides the best results in control of bluegrass. The last application should be made two weeks prior to overseeding. Successive applications provide the best control, but require appropriate timing, multiple passes and careful planning.

Postemergence control of annual bluegrass in overseeded situations is limited . Prograss® is the only material for this purpose available to be used in overseeded bermudagrass turf. However, to prevent undesirable turfgrass injury, careful attention to herbicide application rate, application timing and application frequency are necessary. Prograss® should be used 30 to 45 days after overseeding, when the bermudagrass is completely dormant. If applied earlier, delayed green-up the following spring may occur. A follow-up application may be made, but not after January or, again, delayed spring green-up may result. For this reason, Prograss® is not recommended in subtropical areas like Florida where bermudagrass does not normally go completely dormant. Selective postemergence annual bluegrass control in other overseeded warm-season turfgrasses is not currently available.

Postemergence control of broadleaf weeds in overseeded turf is also provided by 2,4-D alone or combined with 2,4-DP, MCPP, or dicamba. Normally, to prevent damage, lower rates are used, and these materials are not applied until the ryegrass has become fully established. Generally, the ryegrass has been mowed at least three times before this is achieved. Only the lowest recommended rate of the chemical should be used on overseeded ryegrass, and the application usually must be repeated in 10 to 14 days. These herbicides also should be used when temperatures are above 40°F.

Henbit

White clover

All photography supplied courtesy of authors.

Table 3. Suceptibility of broadleaf weeds to turf herbicides.

Southern Turfgrass Tolerance to Postmergence Herbicides							
Herbicide	Bahia-grass	Bermuda-grass	Carpet-grass	Centipede-grass	St. Augustine-grass	Zoysia-grass	Overseed Ryegrass
atrazine (AAtrex + others)	D[1]	I[2]	I	S-I	S-I	I	D
Basagran T/O	S	S	S	S	S	S	S-I
Confront	I	I-S	D	I	D	I	S-I
2,4-D	S	S	I	S-I	I	S	S-I
2,4-D+dicamba	S	S	I	S-I	I	S	S-I
2,4-D+dichlorprop (2,4-DP)	S	S	I	S-I	I	S	I-D
2,4-D+MCPP	S	S	I	S-I	I	S	I-D
2,4-D+MCPP+dicamba	S	S	I	S-I	I	S	I-D
2,4-D+MCPP+2,4-DP	S	S	I	S-I	I	S	I-D
dicamba (Banvel + others)	S	S	I	S-I	I	S	I
MCPA+MCPP+2,4-DP	S	S	I	S-I	I	I	I-D
MCPP	S	S	I	S-I	I	S	I
Kerb	D	S	D	D	D	D	D
simazine (Princep + others)	D	I[2]	I	S-I	S-I	I	D

[1]S=Safe at labeled rates; I=Intermediate safety, use at reduced rates; D=Damaging or is not registered for this turfgrass, do not use.
[2]Atrazine and simazine should be used on bermudagrass only during fall and early winter months. Do not use during spring green-up.

Summary

Controlling weeds in fall requires pre-planning, as the weed are not readily noticeable at this time, and many people are more concerned with other things. Weeds are opportunistic and will take advantage of neglected turf. Good turf, plus use of selective herbicides at the correct rate, and at the correct time and temperature, will ensure greater success in weed control.

Dr. L. B. (Bert) McCarty is an Associate Professor in the Department of Environmental Horticulture at the University of Florida. He has degrees in Agronomy and Soils from Clemson University, in Turfgrass Management from North Carolina State University, and Plant Physiology and Plant Pathology from Clemson University. Dr. McCarty's research has concentrated on weeds and the use of plant growth retardants in turfgrass management. His extension responsibilities cover all aspects of commercial turf production for golf courses, athletic fields, sod farms and pest control operations. This is his first contribution to *TurfGrass TRENDS*.

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Winter Weed Management Schedule for Warm Season Turfgrasses

Late summer	*Apply turf winterizing fertilizer which supplies adequate potassium; mow turf at the upper recommended mowing height; water to just wet the turf soil rooting zone. Apply preemergence herbicides if scouting the previous spring warrants it; do complete weed scouting for the upcoming winter season.*
Early/mid fall	*If needed, apply postemergence herbicides for annual bluegrass control.*
Mid fall	*If needed, apply postemergence herbicides for broadleaf weed control.*
Early winter	*Reapply postemergence herbicides for broadleaf weeds and annual bluegrass, if necessary.*
Winter	*Calibrate and repair sprayers; evaluate the previous year's weed control strategies; plan for the upcoming year's strategy.*
Late winter	*Apply preemergence herbicides for crabgrass control. Apply postemergence herbicides for broadleaf weed control for new customers.*
Early spring	*Apply preemergence herbicides for goosegrass control. Repeat broadleaf weed control application, if necessary, for new customers. Follow-up scouting for remaining winter weeds for formulating the upcoming fall control strategies.*
	Turf Grass TRENDS (202) 483-TURF *Dr. Lambert B. McCarty*

Ask the Expert: Common Questions on Weed Control

by Lambert B. McCarty
Professor of Environmental Horticulture
The University of Florida

Question. I've heard a lot of talk from sales people on a new herbicide called halosulfuron (Manage®). Can you tell me about this product and what it is supposed to do? *South Carolina.*

Answer. Manage® is a new herbicide recently released by the Monsanto Chemical Company. It is targeted specifically for nutsedges with some broadleaf weed activity. Unlike some older products, Manage® appears to have good activity on most nutsedges (including yellow and purple nutsedge). It also has good to excellent turf safety for all warm-season grasses. Manage® belongs to the sulfonylurea herbicide family, meaning it is used at extremely low rates, generally needs a repeat application three to six weeks after the initial application for complete control, and is somewhat slow to develop control symptoms (typically, 10 to 21 days). As with any new material, price and availability must be considered before using this or any product.

Question. The past two years have seen an enormous increase in weeds such as dayflower, doveweed, and certain nutsedges. Can you speculate on why this has occurred and what are our control options? *Alabama.*

Answer. Several factors have contributed to the severe increase in the populations of the weeds you speak of. One involves the general reduction in use of older herbicides such as MSMA, DSMA, and the phenoxy herbicides (such as 2, 4-D and dicamba), which, help keep these weeds in check. However, with the release of newer herbicides, such as Illoxan® and Confront®, these older herbicides are used less; thus, these weeds have proliferated. Secondly, we have had two consecutively wet summers, which have favored the growth and development of these weeds. These weeds generally do not like dryer areas. They are, consequently, likely to subside somewhat when we experience periods of less rainfall. Control in bermudagrass is by several means: one is with repeat applications of MSMA, DSMA, or the phenoxy herbicides every seven days until control is achieved. Secondly, MSMA plus Sencor® will provide quick burndown, but may also result in some short term turf phytotoxicity. Preemergence control is provided with a mixture of Gallery®and one of the grass herbicides, such as pendimethalin, Surflan®, Barricade®, Dimension®, or Ronstar®. These should be applied in early spring and repeated in 90 days for season-long control.

Question. Dollarweed continues to be our worst weed problem in home lawns. What are your latest thoughts on controlling it? *Florida.*

Answer. Dollarweed (also called pennywort) generally prefers wet, poorly drained areas. Obviously, the first line of defense is to monitor soil moisture by regulating the irrigation schedule and provide soil drainage, if possible. Herbicides can provide control, but timing is everything. My experience indicates that fall is the best time of year to control this weed with least turfgrass problems. Herbicides containing atrazine, simazine, Image®, Prompt®, or the phenoxy herbicides can be applied in October and repeated three to four weeks later. This follow-up application is very important to providing complete control. Read the herbicide label carefully for your intended turfgrass, as some tolerance differences exist between turf species to these materials.

In Future Issues

- Risk-taking and Pest Management
- High Altitude Turf Management
- Annual Bluegrass Management
- Herbicide Effects on Bermudagrass
- PGR and Annual Bluegrass
- Herbicide Resistance
- Reduced Herbicide Usage for Crabgrass and Goosegrass
- Anthracnose
- Root Stengthening
- Biostimulants

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