Deciding on Control of Scarab Grubs

by Jan P. Nyrop and Dan Dalthorp

Grubs, more properly the larvae of scarab beetles (Japanese beetle, European chafer, and Oriental beetle), feed below the soil surface. When they are abundant, management action must be taken to avert damage to turf.

Deciding whether a grub population warrants application of an insecticide is no simple matter, however. These insects cannot be seen without digging in the soil, and their distribution throughout a planting is rarely uniform. Nonetheless, turf managers need to assess their abundance, and should be making treatment decisions on the basis of those assessments.

This article presents information and techniques that can help managers determine whether a scarab grub population threatens a turf planting, and how best to cope with that threat. The article has three sections. The first gives an overview of pest management decision making and the role in this process of information on pest abundance. The second outlines a method for determining whether a significant scarab grub problem may exist on a site, and describes its use in evaluating residential or other small turf areas. The final section addresses the use of that method in assessing scarab grub densities on larger turf plantings such as golf courses and golf course fairways.

Crop protection decision making

The easiest way to manage an insect pest may be to make a preventative insecticide application whenever the beast is thought to be present. Ordinarily, this is not a good strategy, it is too costly. Applying insecticides to control a pest always incurs costs. Some of these costs, for the purchase and application of the necessary materials, for instance, are easily calculated. Others, such as environmental degradation, health risks or clients' opposition to pesticide use, while difficult to assess concretely, should still be considered. Crop protection decision making entails balancing the costs of insecticide applications with the benefits that result from their use. In most situations, this requires information on the abundance of the pest.

The pertinent concepts in crop protection decision making are best explained by illustration. We refer to the average number of insect pests per unit area (or per sample) as pest density. When pest density exceeds five individuals per square foot of turf, we can assume significant damage will begin to occur, and as it increases in severity its economic consequences will increase accordingly. This relationship is shown in Figure 1.

The point where the cost of insecticide application intersects the value of insect damage is the break-even point for pest control (meaning the value of damage prevented, usually measured in terms of the cost of repair or replacement, is equal to the cost of control). The pest density at which this occurs is called the *economic threshold*. When insecticides are applied to sites with pest densities below the economic threshold, the cost of control exceeds the cost of damage that the insecticide application mitigates, so there is no net benefit. When pest densities exceed the economic threshold, the benefit derived from an insecticide application equals the difference between the anticipated cost of the damage the pests would have caused and the cost of control.

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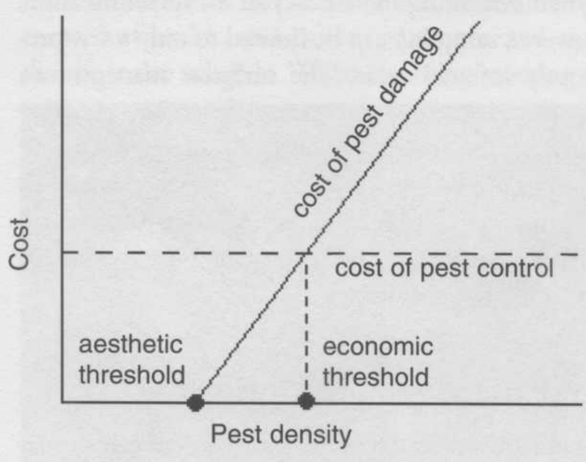

Figure 1. Economic and aesthetice thresholds for crop protection decision making

As mentioned previously, other, often intangible costs should also be considered in pest control decisions. These include aesthetic concerns and adverse reaction to unnecessary pesticide applications.

Clients may not wish any insect-caused damage to be visible. Then, even though the cost of eliminating even minimal damage is rather high, the pest density at which control should be initiated is low — well below the economic threshold. This point is referred to as an *aesthetic threshold* and is also shown on Figure 1.

Other clients might inveigh against all but absolutely necessary pesticide use. In such cases, the pest density at which control should be initiated could be well above the economic threshold.

This illustration has thus far assumed that pest density and the relationships between pest abundance, damage abatement costs and the costs associated with pesticide applications are all known — in other words that the decision maker has perfect information. The costs of acquiring this information have not been factored into this illustration, however. And, obviously, none of these assumptions applies in the real world.

In actuality, the relationship between pest abundance and pest-caused damage is not known with precision. This should not impede using information on pest abundance to decide whether to apply an insecticide, however. Where economic or aesthetic thresholds have not been established, conservative approximations can be used. This can still result in reduced pest control costs.

Estimating pest abundance is of greater concern. Estimation itself incurs costs, and certainty regarding the actual density cannot be achieved. The effect of this uncertainty on pest control decision making can take several forms. On the one hand, a pesticide might not be applied when it is needed; on the other, a pesticide might be applied needlessly. Fortunately, given careful design and execution of sampling methods, the risks inherent in reliance on sample-based estimates of pest density can be controlled.

Collecting sample data to determine whether pest density exceeds a specified threshold, is the most common way information on pest abundance is used in crop protection decision making. This could be an economic threshold, an aesthetic threshold, or an approximation of one or the other. The actual sampling might be as simple as collecting a fixed number of samples, calculating the average number of insects uncovered, and comparing this average to the threshold. More sophisticated statistical procedures can also be used to determine how many sample observations will ensure the risk of incorrect treatment decisions remains acceptable, while minimizing the number of samples required. In general, the more samples taken, the lower the risk of an incorrect decision, but the greater the cost of acquiring samples. Well-designed procedures for assessing pest density balance these risks and costs appropriately.

We have found that the best treatment decisions for scarab grub control are those based on assessments of grub density. It has also been our experience that such assessments carry minimal risk of shaping erroneous decisions, and that, compared with "automatic" prophylactic applications, reliance on such assessments can reduce pesticide use significantly.

Rules for making treatment decisions for scarab grub infestations, and their application to residential turf plantings

As indicated, sample information on pest abundance is usually employed to determine the need for pesticide treatment by comparing pest density to some threshold. The economic threshold for scarab grubs in turfgrass is generally considered to be five to ten individuals per square foot. Given this, devising a procedure for determining grub abundance and the need for pesticide treatment would seem to be straightforward. It would be straightforward if scarab grubs were distributed evenly across a site. They tend not to be.

Scarab grubs are usually found in patches scattered throughout a turf planting, and when the number of larvae exceed densities associated with damage, they often do so only in limited areas of a site. At the same time, the mean density for the entire planting often wili be well below the damage threshold. This situation is illustrated in Figure 2. The area of turf depicted has one large and one small patch of scarab grubs. The density of grubs in the larger patch is high (peaking above 20/sq ft), but the average density for the entire planting is considerably less (4.4 grubs/sq ft). Thus, basing a treatment decision on the mean density for the entire location would lead to a patch that warranted treatment being left untreated.

Because it can fail to detect grubs in high-density patches, mean density over an entire site, by itself, is not a suitable criterion for determining the need for control. While it is certainly possible to sample a site sufficiently to map patches with high grub densities, this is too costly for wide scale use. A third approach is to use data from throughout a site to indicate whether it is likely to harbor patches with high densities, then treat the entire planting accordingly. This has the disadvantage that larger areas are treated when only portions of them actually require control. However, provided that only a modest fraction of sites require any control at all, and compared with "automatic" prophylactic treatments, use of this approach to crop protection will still lead to greatly reduced pesticide use.

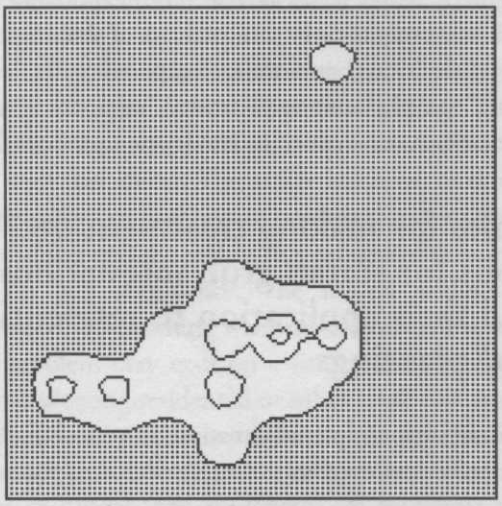

Figure 2. The patchy distribution of scarab grubs in a turf grass planting. Contours enclose areas of equal density in increments of 10 grubs/sq ft. The gray area is devoid of grubs.

We recently developed a procedure for determining whether European chafer infesting residential and other small turf sites required control. Based on the data used in elaborating this procedure, its use would eliminate pesticide applications at roughly 65% of the sites receiving prophylaxis.

Preliminary data also indicate there are economic incentives for adopting this approach to pest control decision making. It costs $50 to $100 to treat a lawn for scarab grubs. We have found it requires about one minute to examine a soil sample for larvae. Our proposed procedure uses a minimum of 20 and a maximum of 40 samples per site. Assuming an average of 30 samples per site, a total sampling time, including setup, of one hour, and an hourly cost of $30, the expected net direct saving is $35 per lawn when the treatment cost is $100, and $2.50 when the treatment cost is $50. And this does not consider the environmental and health benefits that may accrue from reduced pesticide use.

The remainder of this section describes this procedure and explains how to use it. While the procedure was developed using only data for European chafer, subsequent work has shown it works equally well with Japanese beetle larvae.

Modeling the size and density of scarab grub patches

We began by mapping European chafer grub densities at over 300 residential sites, counting the grubs found in samples collected at regular intervals throughout each property. These samples consisted of 4-in. diameter plugs cut from the turf. Samples were taken from locations on a 10-ft x 10-ft grid.

European chafer larvae are capable of causing "economic" injury to turf when their density exceeds 10 grubs/sq ft. This equates to roughly one grub per 4-in. plug. When we examined grub density maps derived from the sample data, it was apparent that while there were areas of turf plantings where average density exceeded one grub per plug, the density throughout the property frequently averaged much less than one per plug. From a lawn care perspective, it is important to treat patches of turf in which European chafer grub density exceeds one per 4-in. plug. Based on our experience, we defined a patch necessitating treatment to consist of four or more adjacent sample locations, each showing one or more larvae per plug. And, extending this, we considered properties containing one or more of these patches to contain chafer populations requiring control. The problem was then to devise a way of identifying these properties.

It was our hypothesis that we would find a positive relationship between the size of the largest patch on a property (with patch size measured by the number of adjacent sampling locations showing grubs), the average density of grubs in that patch, and the average density of grubs throughout the property. If such a relationship existed, then average grub density from throughout a property could be used to predict whether there was a patch of grubs somewhere on this property that required control. Reliance on average density throughout a property as a decision criterion would allow the use of well-established sampling techniques. The only alternative was mapping grub presence throughout the property, which seemed impractical.

Figure 3 shows the relationship we established between the average size of patches, the grub density in each patch, and the average grub density over the entire property. Each data point represents a single property. All of the properties examined are separated by a dashed line into those where European chafer required control (plantings having four or more contiguous sample locations producing one or more grubs each) and those where control was not needed. We found that, as the average grub density over the entire property increased, the size of the largest patch and the average grub density in that patch also increased. This demonstrated that average density over an entire property could be used to predict whether it was likely the property contained a patch with a damage threatening density of grubs.

The plot of patch size against property-wide density indicated that the treatment threshold density (the reference value used to judge whether a property harbors at least one patch of grubs requiring control) should lie somewhere between 0.1 and 0.35 grubs per sample. Precisely what the threshold should be was not clear from the data, though. Therefore, we evaluated alternative sampling plans with thresholds set at intervals between 0.1 and 0.35 grubs per sample.

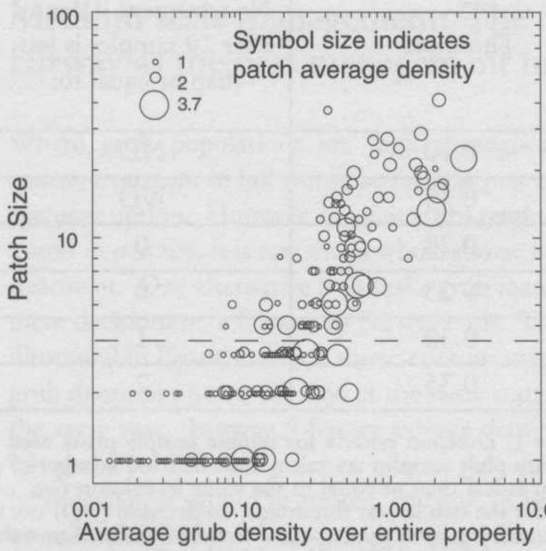

Figure 3. Relationship between patch size (vertical axis), average grub density over an entire property (horizontal axis). The dashed line separates properties that require control from those that do not.

Selecting a treatment threshold and sampling plan

A risk-averse manager might choose a sampling plan based on a low threshold in order to minimize the likelihood that an incorrect decision to not treat would be made. A manager averse to applying pesticides needlessly might choose a sampling plan based on a high threshold. We suggest that the two types of error be balanced, and recommend use of a threshold of 0.25 grubs per sample.

The statistical method used to assess grub density in smaller plantings is known as double sampling. Let us first explain some of the logic behind this procedure, then present specific sampling plans. Whenever an observed density is compared to a threshold, uncertainty increases as the value being compared approaches the threshold value. A simple example can illustrate this. Suppose you are asked to determine whether a coin is "fair," meaning that when flipped it is just as likely to produce a "heads" as a "tails." To make your determination, you flip the coin and record the results. After flipping the coin 10 times you find you have produced six "heads" and

I	II	III	IV
Threshold	No treatment if count after 20 samples is less than or equal to:	Treat if count after 20 samples is greater than or equal to:	Treat if count after 40 samples is greater than or equal to:
0.10	ND	4	4
0.15	ND	6	6
0.20	0	8	8
0.25	0	9	10
0.30	1	11	12
0.35	2	12	14

Table 1. Decision criteria for double sample plans used to classify scarab grub density with respect to a threshold. Twenty plug samples are taken and the total number of grubs found is compared to columns two and three. If the count is less than or equal to the value in column two, no treatment is required and sampling can be stopped. Note that for the two lowest thresholds, no decision (ND) can be made at this point and another 20 samples are needed. If the count is greater than or equal to the value in column three, treatment is needed and no further samples are required. If the total count falls between the values in columns two and three, another twenty samples are taken and the number of grubs found in all forty samples is compared to the value in column four. Treatment is required only if the total equals or exceeds the value in column four.

four "tails." How willing are you to state that the coin is not "fair?" With these results, it is likely that the coin is "fair;" but one cannot be certain because a "fair" coin produces an equal number of heads and tails when flipped an appropriate number of times, and the results achieved are only suggestive of this. The same result could have been obtained if the coin were not "fair" to the extent that "heads" is slightly more likely to appear than "tails." Further flips of the coin should be made to improve the confidence with which a classification of the coin's "fairness" is made.

Double sampling plans for scarab grubs work in a similar way. Grub density at a site is sampled by examining 20 plugs collected throughout the planting. This number was selected because it appeared to be be the minimum needed to obtain a representative result. (If the planting is large — greater than a half acre — the area should be divided and the entire procedure carried out for each subdivision.) Depending on the outcome, a decision is made to treat, not treat, or take another sample. If the estimated density is close to the chosen threshold, a second sample of 20 plugs is taken and then, using all 40 observations, a decision to treat or not treat is made. Table 1 lays out the criteria for making these decisions for each of six alternative thresholds.

Since developing these guidelines, we have evaluated the protocol in two locations. We found the procedure to be very effective, even when Japanese beetles comprised a significant proportion of the scarab grubs at a site.

Rule-based treatment decisions for scarab grub infestations on golf course fairways and other large turf plantings

Golf courses have an abundance of irrigated, well-maintained turfgrass, interspersed with ornamental plants — ideal Japanese beetle habitat. As a consequence, they frequently have potentially damaging grub populations somewhere on the grounds.

Decisions about managing grub populations on golf courses can be made at any of three different scales. At the coarsest scale, the decision is whether to treat the whole course for grubs or not to treat any of the course. At a medium scale, individual fairways are treated on a case by case basis, which requires sampling the soil to determine which fairways harbor grubs. At the finest scale, individual grub patches within fairways are identified and treated.

Each scale has advantages and disadvantages. Each might be appropriate under certain circumstances. Which is appropriate and which is selected should depend on the past experience of grub infestation at the course, the distribution of grubs in the year in question, and on the goals and preferences of the turf manager. In most cases, regardless of the scale selected, acquiring sample information as a basis for treatment decisions is a sound investment.

Coarse scale management: The full course as the pest management unit

The coarsest management scale involves taking the entire golf course as the pest management unit, in which case treatment is all or nothing. For example, when there is a history of grub problems, and their recurrence is anticipated, the whole course is treated. Conversely, when there has never been a problem with grubs, indications of their presence might be met with a decision not to treat the course at all. This approach has the advantage of simplicity. Further, since treatment costs can be high, it could prove to be the most economical.

Grub populations, moreover, are rarely high enough throughout a course to warrant the whole being treated. When the entire complex nonetheless receives treatment, not only is much of the effort wasted but it results in pesticides being introduced needlessly in public areas. Unnecessary applications also contribute to the development of insects' resistance to insecticides, which can render a previously effective treatment ineffective. (Paradoxically, insecticide resistance develops most rapidly against the most effective treatments.)

Medium scale management: The fairway as the pest management unit

Where grub populations are high throughout a course, treatment in full would be the best pest management option. However, because grubs tend to be found in patches, it is rare that a whole course needs treatment. One alternative is to make grub management decisions on a fairway by fairway basis. This is illustrated in Figure 4, which shows contour maps of grub densities on two fairways at the same course in the same year. Fairway 8 has an average density of 13 grubs/sq ft, and patches where the density exceeds that. It should be treated. Fairway 18 has an overall density of only one grub per square foot, and does not require treatment.

Experiments have shown that distinguishing between fairways that do and do not need treatment is relatively easy, and that there is little risk of significant grub populations going untreated. Making these distinctions can often reduce pesticide use by 50–60%, and treatment costs by nearly as much. Such discrimination is not difficult and requires only a minimal amount of soil sampling. Taking a sample involves using a 4-in. cup cutter to remove plugs from the fairway. Each plug is broken apart, and the grubs are counted as the soil is put back in the hole. The sod is replaced, the number of grubs recorded, and the next sample is taken further down the fairway. This process takes about one minute per sample, and does not injure irrigated turf. Depending on the size of the fairway, the sam-

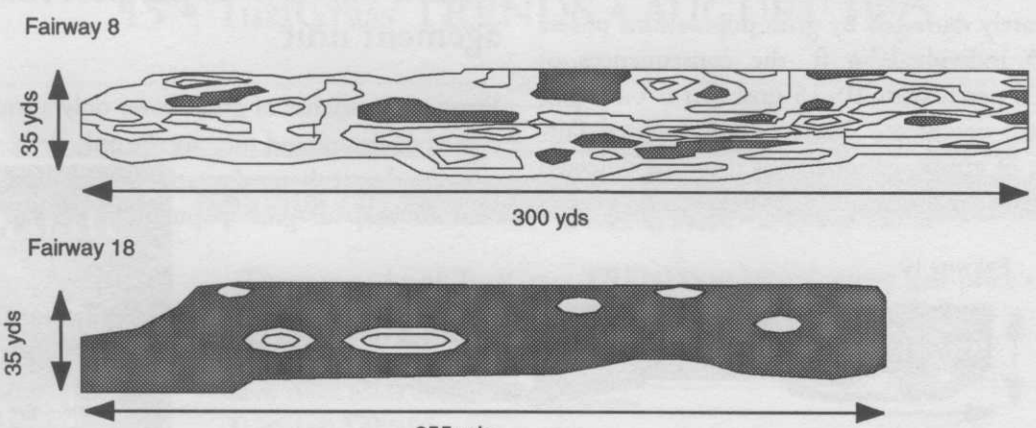

Figure 4. Not all fairways are equal when it comes to grub populations. Fairway 8 has uniformly high grub populations. Scarcely a grub can be found on Fairway 18. These maps are based on a 5-yd x 15-yd sample grid. The grey represents grub-free areas. Contour intervals are one grub per sample cup or 10 grubs/sq ft.

pling interval used (a 10-yd x 30-yd grid is normally sufficient) and the density of grub populations, a maximum of 30–60 samples is required to make a decision whether a fairway needs treatment. Fairways with high grub populations can often be identified after only four to eight samples.

The rules for deciding whether to treat are simple. Fairways with two or more potential patches should be treated. When two adjacent samples each contain grubs, the area is considered a potential patch. A single sample containing two grubs also represents a potential patch. The patterns of grub counts in the samples depicted in Figure 5 illustrate these points.

With two patches on a fairway, it is likely that one of them is a real patch

Two potential patches combine to make one probable patch

Figure 5. Illustrative potential patch configurations

In addition, any sample containing three or more grubs is a strong indication of a problem, so the whole fairway should be treated!

These have shown themselves to be reliable decision rules. They are also conservative, in the sense that treatment is often recommended when it is not actually necessary. Fairways that are only marginally in need of treatment are correctly identified 75–90% of the time. Because high-maintenance turf is rarely damaged by grub populations of less than 15 individuals/sq ft, the consequences of missing a patch with 10–15 grubs/sq ft on a golf course are not great. More heavily-infested fairways are of greater concern, but these are detected with almost 100% certainty. For example, fairways with only one relatively small patch of grubs at densities of 20 and 25 individuals/sq ft are correctly identified as needing treatment 96% and 100% of the time, respectively. Fairways containing moderate to large patches with populations of 10 grubs/sq ft are also flagged for treatment with over 90% certainty.

Therefore, there is very little risk of misclassification of a fairway leading to grub damage. On the contrary, fairways with a population density of one grub per square foot are incorrectly identified as needing treatment 30% of the time. Thus, management errors resulting from use of these decision rules are much more likely to lead to treatment when it is not necessary than failure to treat when it is necessary.

One of the major strengths of using these rules is that detection of heavily infested fairways normally requires taking only a few (four to eight) samples before two potential patches are detected. Under these circumstances, a decision to treat can be reached in short order. Figure 6 illustrates this point.

Taking the individual fairway as a pest management unit can be especially valuable for the course that normally receives full treatment. If most of the fairways are indeed heavily infested, then sampling takes little time. On the other hand, the fairways that do not have high grub populations can be identified with little effort.

Fine scale management: Patches within fairways as the pest management unit

Frequently, patches of grubs cover only a small fraction of a fairway, and they are the only parts of those fairways that truly need treatment. For example, the contour map of grub populations on fairway 17

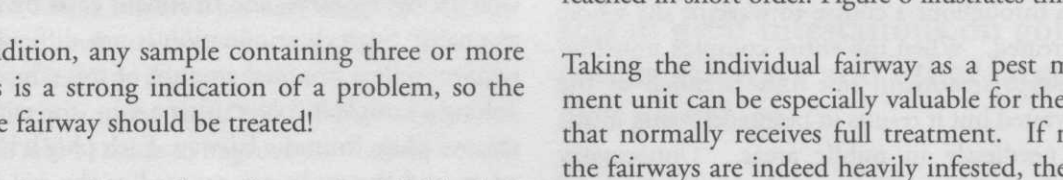

Figure 6. If sampling begins on the left side, a decision can be made to treat Fairway 10 after just one sample is taken. If sampling begins on the right, the decision to treat is made after just eight samples are taken.

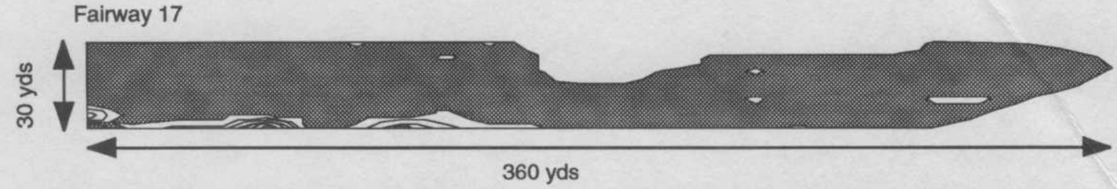

Figure 7. Intense sampling can serve as the basis for clear resolution of patch boundaries. Use of a 5 yd x 15 yd grid is depicted here.

shown in Figure 7 reveals a few dense patches on one side, but almost no grubs in the rest of the fairway. Mapping the boundaries of such patches requires sampling at an intensity of about 5 yards by 15 yards, however. To identify individual patches within fairways therefore requires about four times as many samples as simply identifying infested fairways. The payoff for making this extra effort can be substantial, though, since on some fairways the resulting reductions in pesticide use can exceed 90%.

Such dramatic reductions cannot be expected on every fairway, but a new research program has begun at the New York State Agricultural Experiment Station to determine the economic and environmental costs and benefits of spot treatments based on this kind of heavy sampling. Results will be out within the next few years. At that time, we will be in a position to make recommendations about sampling intensities and decision rules. Also, we should have more detailed estimates of potential cost savings and pesticide reductions.

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- Pesticide Fate in Turfgrass
- Relationships between Insects, Insecticides and Soil
- Nematodes
- Winter Weed Control
- Degree-day Modeling
- Risk-taking and Pest Management
- Rewriting (?) the Rules at EPA