CHAPTER 7. MANAGING PESTS

INTRODUCTION

The following section describes IPM programs for common turf pests found in the Atlantic region. It covers weed control and hairy chinch bug in depth because they are the most widespread and common problems; notes are also included on white grubs, which are less of a problem. Turf diseases are not covered because disease problems are rare in residential lawns and general use turf in this region. Each section follows the 6 main steps of an IPM program as outlined in the IPM/PHC of Canada definition (*see* Chapter 1).

MANAGING WEEDS

"Healthy grass is the best weed control." *Anon*.

A weed-free lawn is an artificial concept in nature. It requires significant amounts of energy, labour and materials to maintain. When lawns are on an inadequate soil base (which is common), the inputs required to maintain a weed-free appearance are even higher. This has environmental and economic costs—and suggests that we should consider other possibilities, such as growing biodiverse lawns better suited to the soil conditions existing under most lawns.

Figure 7-1. Healthy turf, on the left, suppresses weeds.

At the same time, we should recognize that there is a place for weed-free turf as a landscape design element (as there is for formal gardens and topiary). It is essential that we, as professionals, incorporate design and management practices that help achieve this while using fewer chemical inputs. We must promote new standards that focus on long-term management rather than just on annual pesticide and fertilizer applications. We must also work with municipal and provincial authorities to influence the public's perception of what constitutes an ideal lawn. This would allow us to move away from weed-free turf standards towards more environmentally benign models.

What is a Weed?

A weed is a plant in the wrong place. In a weed-free turf, both broadleaf plants and some off-colour turf species, like annual bluegrass, rough-stalked bluegrass, crab grass, or some creeping bent grasses, are considered weeds (for descriptions and control of these grasses, see Eggens[1]).

Some weeds, such as grasses with fine seeds, can come with the grass seed. While broadleaf plants may also come with the grass seed, most are from the 'seed bank' already in the topsoil. This is the accumulation of many years' worth of seeds that have blown in or dropped to the soil, remaining dormant until conditions are right for germination. Seeds that blow in from adjacent sites after the turf is established can also take root where the grass is thin enough to let the seeds drop to the soil surface.

The most common broadleaf plants in the region are dandelion, plantain, and clover (dandelions attract the most attention!) Less common are daisy, yarrow, devil's paint brush, creeping Charlie, buttercup, wild strawberry, stitchwort and creeping Jenny. These are all biennial or perennial plants meaning they survive from year to year. Annuals, such as mustard, lambs quarter, and pigweed, and some grasses, such as timothy, barnyard and couch (or quack) grass, are also often present in newly seeded lawns in good topsoil. (For descriptions of these plants, see publications listed under Further Reading at the end of chapter.)

Are Weeds Really a Problem?

The answer is…. yes…. no…. or maybe, depending on your point of view!
Some folks don't want any, while others could care less. More people are developing an appreciation for biodiversity in their lawns as well as a tolerance for higher broadleaf populations.

Natural Suppression of Weeds in Turf

Some weeds just disappear as turf becomes established. Annual weeds, as well as timothy and barnyard grass, normally disappear as mowing and competition from the turf plants eliminates them. If annual weeds persist, it is a clear indication of sparse turf. Over time, couch or quack grasses also blend with turf grasses in both colour and texture; they, too, seems to disappear in healthy turf.

Healthy, dense turf prevents light from reaching the soil and keeps dormant seeds in the seed bank from germinating. It also resists invasion by seeds blown in from adjacent sites. This is why turf management practices are key to the success of weed management programs. The photograph in Figure 7-1 was taken three years after weed-free sod was placed on a 'sustainable' soil base (it does not 'brown out' in midsummer). The weed-free appearance of the sodded turf to the left has been maintained for three years with no treatments, other than mowing. The area on the right, which was a turf seeding operation that failed, is a weed patch. This highlights the fact that healthy turf dramatically suppresses germination of the seed bank and blown-in weed seeds. Competition from healthy, vigorous turf also suppresses perennial weeds that have become established, as shown in Figure 7-2.

These examples show that where growing conditions suppress weeds, weed numbers are so low that removing them mechanically can be practical and cost effective, which would eliminate the need for herbicides.

Spring Summer Fall

Figure 7-2. Suppression of the same weed over the season, as health of the turf is improved. ***Photos courtesy of Bob Wick, Western Canada Turfgrass Assn.***

IPM PROGRAM FOR WEEDS

The basic steps in an IPM framework are described in Chapter 1. The following sections describe each step as it applies to managing weeds.

To make it easier to plan work and made treatment decisions, consider separating turf areas into Class A, B and C facility categories[2] (*see* Chapter 1).
Examples of the types of turf that might be included in each category are:

- **Class A –** High level of service: fine ornamental lawns, golf and bowling greens, irrigated sports fields.
- **Class B –** Moderate level of service: residential and commercial lawns, boulevards, recreational areas, golf fairways.
- **Class C –** Low level of service: Meadows, picnic areas, rough grass, undeveloped and naturalized areas.

1. Manage landscapes to prevent pests from becoming a threat.

First and foremost, it is important to remember that the presence of weeds is most often the result of poor turf, not the cause: **Weed invasion is the symptom of a weakened lawn**.

The main objective of an IPM program for weeds in lawns should be to create and maintain favourable growing conditions for turfgrass plants. When establishing new lawns, attention to the underlying soil foundation is critical in providing sustainable growth, while reducing the need for water and other inputs for the life of the site (*see* Chapter 5).

Since most turf management deals with existing sites, the first step is to assess site conditions and look for factors that affect the health and vigour of the turfgrass. Probably the foremost indicator is an area that browns out in midsummer, showing that the underlying soil profile is deficient in moisture storage capacity. This is a signal that it will require higher levels of inputs to produce healthy, vigorous growth. It may also mean that, unless underlying soil conditions can be improved, that it may be more realistic to classify such lawns as Category B or C. Achieving Class A standards on such soil will require supplemental irrigation as well as additional nutrients and chemicals.

Other factors to look for during the assessment, include:

- soil nutrient deficiencies,
- areas with compacted soil or poor drainage,
- patterns of wear from foot traffic or other encroachments, and
- shaded areas.

High weed populations generally indicate unfavourable growing conditions for turfgrass. The presence of particular weed species in a lawn may also be an indicator of a specific soil problem (*see* Table 7-1). Test the soil for pH and fertility; testing for organic matter levels also provides important information on soil health at little added cost.

After assessing the site conditions, determine the expectations of the owner or client. Use the information to develop a program of cultural practices that will provide the type of turf desired. Cultural practices include:

- taking soil tests (*see* Chapter 3),
- adjusting soil pH to 6.5 by adding lime (*see* Chapter 3),
- checking fertilizer rates, amounts and timing (*see* Chapter 3),
- raising mower heights to encourage deep roots (*see* Chapter 6), and
- recycling grass clippings (*see* Chapter 6)

2. Identify potential pests.

Some IPM training puts considerable emphasis on identifying weeds and knowing their biology, however, in practice, this may not be necessary for those managing general turf. It is important to be able to identify which are the objectionable grass species, and to be able to tell those that disappear under normal maintenance practices from those that usually persist and may require control. (For weed identification resources, see Further Reading at the end of the chapter and Appendix II for web sites).

3. Monitor environmental conditions, pest populations and pest damage.

A simple visual inspection of the type of weeds growing on site may indicate a specific problem with the underlying soil (*see* Table 7-1).

Table 7-1. Weed species as possible indicators of poor soil conditions.

Weed Species Present	Possible Soil Problem
Knotweed or plantain	Compaction
Sedge or buttercup	Poor drainage
Clover	Low nitrogen
Sorrel or wild strawberry	Low pH or poor fertility

Adapted from K. McCully.[3]

Weed Monitoring Methods

The transect method of monitoring and the grid method are the most common methods cited in the literature for counting weed populations.

Transect method: Walk along a series of lines or transects across a lawn, observing and recording the type and number of each visible weed at intervals. A commonly recommended method[2, 4] is to lay out a 10 m (30 ft) rope or line, then walk along it; at 10 places along the transect, observe the weeds in a 10 cm^2 (4 in^2) area. These observation points can be marked ahead of time on the line or you can take large strides along the line, noting the plants in the small area near your toe at each stride. By repeating the process on a series of transects, the percentage of each transect that was covered by weeds can be calculated. For example, if 1 transect is walked and weeds were found in 2 of the 10 observation points, that lawn area would have 20% weeds (80% turf). If enough transects are counted on a lawn, the average of the transect counts can be assumed to apply to the rest of the lawn. Although the number of transects may vary with the size of the lawn, it is advisable to walk at least 10 transects per site to make sure that the average of the counts reflect the real situation.

Grid Method: Place a 0.5- or 1-metre square frame randomly on the lawn; count the number of weeds inside the frame. Identify them if possible; this will be helpful in comparing results from year to year. Count at least 10 different locations on the lawn and average the results of the 10 counts. In this case, the counting method gives an average number of weeds per 0.5 m^2 (or per m^2), rather than the percentage of weeds in the lawn.

It is very important to realize that these two methods give two different measures. This means that the numbers from transect counts (percentage of weed cover) cannot be compared with counts from the grid method (number of weeds per m^2). To compare results from one year to the next, or between sites, the same monitoring method must be used each time.

4. Decide whether treatment is needed on the basis of population and damage thresholds.

In some regions, recommended weed tolerance and treatment (action) thresholds have been published for broadleaf weeds. Making decisions based on numbers, rather than on 'eyeballing' the weed infestation, moves the decision-making process away from subjective judgement to a more rational basis.

The following suggestions for treatment thresholds include both the percentage weed cover as used in British Columbia[5] as well as counts per square metre from research at the University of Laval[6]:

- **Class A Sites**-With an objective of relatively "weed free"; note that users often accept turf with 5 to 10% weed cover as "weed free". Action threshold: 10 to 15% weed cover, or 5 dandelions per m^2.
- **Class B Sites**- Action threshold: 20 to 50% weed cover or 10 dandelions per m^2.
- **Class C Sites**- Action threshold: >50% weed cover or >10 dandelions per m^2.

It is important for the professional turf manager to discuss these action thresholds with owners.
Most property owners are realistic in their expectations and want to take an environmentally responsible approach. This means that public is becoming more tolerant of higher broadleaf

populations (i.e., using Class B and C thresholds), especially since this substantially reduces maintenance costs and chemical use.

5a. Use biological and mechanical control methods to reduce pest populations to acceptable levels.

Biological Controls: At present, there are no biological controls for weeds in turf. A biological control for dandelion (a strain of the fungus *Sclerotinia minor*) has been selected by researchers at McGill University but is some time away from being generally available.

Mechanical controls:

Figure 7-3. Manual weeders.

Removing weeds by hand may be practical if dandelions are the main problem, or other weed numbers are relatively low. Hand weeding is easier when the soil is moist. Experience shows that dandelions can be removed at a rate of 5 to 10 plants per minute, using simple tools that cut the taproot (*see* Figure 7-3). This means that on a site that has an average of 5 weeds per m^2, one person can weed over 100 m^2 per hour, at a cost comparable to spraying.

It is a good idea to drop turfgrass seeds, or a mixture of soil and seed, into each hole created by weeding to speeds closure of the turf and prevent weeds from germinating.

Weeding with Heat

Two types of weeders that work by applying heat to the target plants are available. As they are relatively new tools, the turf industry has not yet enough experience to judge how well they work, or the best timing for using them. However, it might be worth trying out smaller, less expensive models to determine whether they could be useful.

Flame Weeders: Small hand held flamers, with backpack propane tanks, are available from suppliers for use in landscapes. Broadleaf weeds are more easily damaged by heat than grasses, which have their growing tips protected by a heat resistant sheath. This means that, with care and (lots of) practice, flamers can be passed quickly over weedy areas in turf without damaging the grasses. Heat is more effective at killing weeds if the plants are only slightly damaged (i.e., by a very quick pass of the flamer), than if they are fried on the spot. It is thought that this may be because the injured plant exhausts its root reserves attempting to recover from the injury, whereas a plant with the top crisped uses less energy by sending up new shoots from the roots.

Infrared Weeders: Hand-held infrared weeding tools are also sold in Canada for control of dandelions and other weeds. They work by burning propane fuel from a backpack tank to produce radiant heat. They have a probe tip that is inserted into the growing point to kill the weed.

5b. When necessary, use targeted applications of pesticides.

It is not normally necessary to apply blanket treatment with herbicides on general use turf. Broadleaf weed populations, particularly in Class A and B categories of turf, are often localized, therefore it is only necessary to treat the affected areas. Treating only where monitoring shows it is necessary is a key principle of IPM. One of the commitments made by IPM accredited firms (under the IPM/PHC Accreditation Program) is that when chemicals are required, they will be applied to 50%, or less, of the managed area.

Although applying herbicides twice a year controls broadleaf weeds, this practice is becoming less desirable because of concern about health and environmental impacts. If maintaining a lawn to a Class A standard is important, then any underlying conditions for poor turf performance must also be corrected so that the turf can suppress broadleaf weeds.

The Herbicide Treadmill

The use of herbicides alone, without attention to building up healthy turf, merely opens up the soil for re-infestation as the broadleaf plants collapse and leave bare soil areas behind.

This is particularly apparent when the target is dandelion and the turf is sprayed after the plants begin to flower. The treated dandelions are still able to go to seed, which then take root in the bare spots left by the herbicide. More herbicide is applied next year to control those new plants….which re-seed…..and the cycle continues.

Control of Grasses: Chemical controls for persistent grasses (crab grass, annual bluegrass, rough bluegrass and bent grasses) have shown erratic results in Fredericton. Glyphosate (e.g., Roundup™) works on these species, but kills all vegetation in the area treated. This means that overseeding is required, with follow-up watering, to quickly fill in the killed area and prevent weeds in the seed bank from becoming established.

Control of Broadleaf Weeds: A properly timed application of selective herbicides, such as 2,4-D blends (e.g., "Killex"™ and other products), will remove broadleaf weeds. After this, experience shows that a healthy, vigorous turf can usually keep the weed population low enough to maintain a Class A standard for several years. When supplemented with hand weeding for dandelions (which is efficient because weed numbers are so low), a Class A quality turf growing on a sustainable soil base can be maintained without herbicide applications for five to ten years.

Tips for using 2,4-D blend herbicides:

- The products are most effective when the plants are growing rapidly: late May to late June, and late September to mid October.
- Products are more effective if applied in conditions of high temperature and high humidity. Under these conditions, the leaf pores have the largest openings and take in the most herbicide.
- Hot, dry weather increases plant resistance to herbicides because the pores close to conserve water and less herbicide is taken in.
- Rain shortly after an application will wash the product off the leaves and reduce the effectiveness of the application.

- Timing is particularly sensitive for dandelion control. For maximum effect, applications should be completed before the first flowers appear. Spraying when the flowers are in bloom doesn't stop seeds from forming and germinating in the bare ground left behind.

Tests with 2,4-D blends in Fredericton shows that broadleaf weeds can be controlled using half the label rates, when applied under optimum conditions. This suggests that label rates were established to assure control over a broad application-timing window, when the plants may be more resistant to the products. While using reduced rates is a way to reduce chemical use – and reduce risk - the practice violates federal pesticide label regulations. Given the current public concern over pesticide usage, this area of labeling needs attention.

There have been instances of pesticide resistance developing from reduced use of products in other areas (agricultural, and medicine). The authors have seen no evidence to suggest that this factor is a concern in this particular application.

A note about combined fertilizer and herbicide products:

Products that combine fertilizer and herbicides (commonly called 'weed-and-feed' type products) are popular with the public,[7] and can provide some weed control when applied under optimum conditions. When such products are used as the primary fertilizer for turf, as is common, they are out of step with IPM principles and lead to a significant overuse of herbicides.

This is because the product is being applied:

- over the entire lawn at each use, often on weed-free lawns, so the herbicide component is being used where it will have no effect,
- at times of the season when the herbicide component is ineffective,
- more frequently (because of the fertilizer timing), and
- at rates that are higher than liquid formulations.

Research at Guelph has shown that combination fertilizer-herbicide products are only about half as effective as liquid formulations.[8] This is probably because when they are applied, only a small proportion of the granules stay on the leaf surfaces. Granules must dissolve while still on the leaf so that the active ingredients can be absorbed through pores in the leaf surfaces; from there they move into the plant's system. Product labels shows that when applied at the manufacturers' recommended rates, the amount of active ingredients in granular 2,4-D formulations are 50 to 150% higher than liquid formulations.

4 annual applications of these products to a turf area, at label rates, applies 10 to 20 times more 2,4-D than a blanket liquid application every 2 years.

The overuse problem with these products is serious enough that the PMRA considered legislating the product off the shelves.[9] This approach was withdrawn after the industry argued that the problem lay with uninformed users rather that the products. At this point, federal efforts have been redirected toward consumer education.

Corn Gluten Meal Pre-Emergent Herbicide: One product (TurfMaize™) containing corn gluten meal has just been registered in Canada for use as pre-emergent herbicide and a slow release organic fertilizer. Corn gluten meal is a natural product derived from corn and commonly fed to cattle. Natural chemicals in the gluten kill seeds, just as they germinate, but do not affect growing plants. It is important to note that gluten only prevents seeds from germinating—it does not remove existing plants. Correct timing of application is key: if it is applied after weed seeds germinate, the product will not contribute to weed control.

The product is labeled for control of dandelion and smooth crabgrass on residential lawns, where Kentucky bluegrass is the predominant grass. TurfMaize™ has received temporary registration, with full registration, pending receipt of additional efficacy data. Further research is also required to determine the tolerance of other turf species. Data are not available on the appropriate interval between overseeding or re-sodding operations and application of TurfMaize™. Therefore, labels say not to use the product in spring if over-seeding or sodding is done in spring; if over-seeding or sodding in fall, the product is not be used in the fall.

6. Have a built-in evaluation process.

After any type of treatment, whether cultural method or herbicide, the lawn should be checked for results. This should be done at intervals appropriate to the type of treatment. For example, turf should be inspected one to two weeks after a herbicide application to check whether it was effective; results of cultural methods may take months to show effects.

This follow-up information will be valuable, along with monitoring records, feedback from customers, budget records, etc., for assessing how well the IPM program worked and what to improve. After several seasons, a long-term trend toward better quality turf and low weed populations should be noticeable.

MANAGING HAIRY CHINCH BUG

The hairy chinch bug *(Blissus leucopterus hirtus*) is a major pest on turfgrass in the Atlantic region. The following section describes the insect, its biology and damage, as well as an IPM program based on the most recent research for Eastern Canada.

Description: In the Atlantic Region, the adult is about 3 mm (3/16 in) long, with folded white wings that extend almost to the tip of the abdomen. The first and second stage immature bugs (nymphs) are bright red with a distinct white band across the middle and are wingless. As they mature, the nymphs darken in colour to brown and, finally, to black just before becoming adults.

Life cycle: Adults over-winter at the base of trees, under hedges or shrubs, at the edge of lawns, and probably in the turf. They emerge in the spring when the temperature reaches about 20^0C and mate. Over a month, each female lays 200-300 eggs in small batches on the inside the base of lower parts of the leaves or in the root crowns of turf. Adults may fly from lawn to lawn to lay eggs.

Nymphs hatch from the eggs in about 30-40 days, depending on the temperature. The nymphs grow and molt five times; the stage between each molt is called an instar. With the final molt, they become adults, which occurs in July or August. Their development is closely related to growing degree-days (GDD) – data compiled by Environment Canada related to temperature and its impact on plant growth. These adults become the overwintering population.

There is only one generation per year in Southern Ontario[10] and Quebec.[11] It is unclear whether there are one or two generations in a season for the entire Atlantic region. A partial second generation was found in the Saint John area in 2002 studies in New Brunswick,[12] but these had not matured, and would not likely survive the winter.

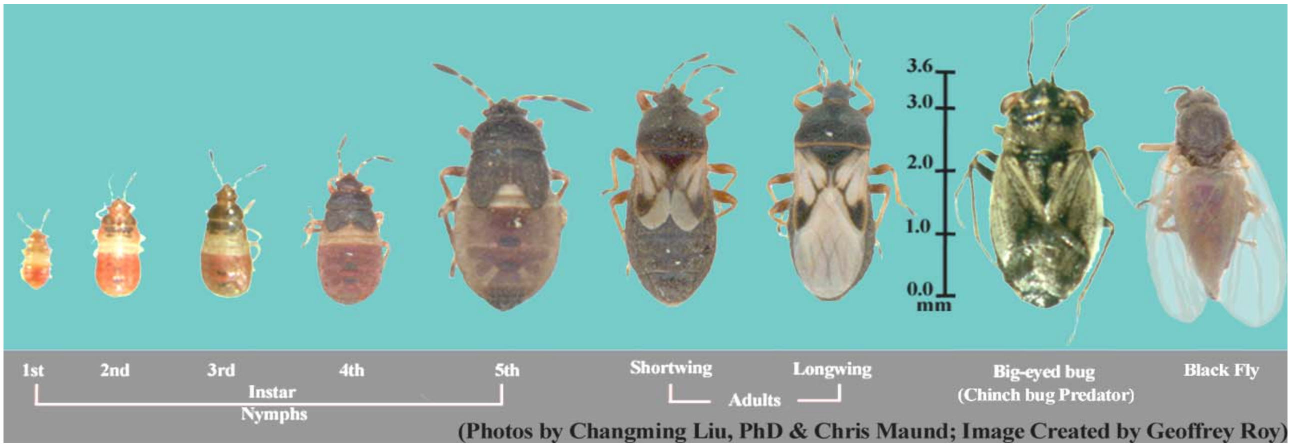

Figure 7-4. Chinch bug growth stages, with a Big Eyed Bug, an important chinch bug predator, to the right. (The black fly picture is included for size comparison.)

Damage: The nymphs damage the turfgrass by inserting their slender beak into the crown or stem of the leaves, then sucking the sap. They also inject a toxin in their saliva into the plant, which causes a blockage of the plant's vascular system and eventually kills it. Damage first appears as irregular yellowing patches in the turf that increase in size as more turfgrass is affected. If left unchecked, the turf in these patches turns brown and finally dies several weeks later.

In lawns allowed to go dormant (turn brown naturally) through the dry summer period, severe damage from chinch bug feeding may occur, but not be noticed, until the turfgrass fails to turn green with the fall rains.[10] Re-seeding or renovation may be required for areas that have moderate to extensive damage.

The actual numbers of lawns infested to damaging levels is unknown. Studies based on counts in southern Quebec showed that 60% of lawns in the study were infested, but only 11% had high enough counts to warrant a treatment.[11] Although there have been no similar studies undertaken in this region, the situation is likely to be similar.

Habitat: The nymphs are found in patches throughout the lawn, and seem to prefer open, sunny, dry areas. High soil moisture is believed to increase the mortality of early nymph stages and could be a barrier to their movement. Carriere, et al,[13] reported that nymphs are rarely present on aerial plant parts, being more abundant in the thatch. The 3rd instar stage is found on the surface of the soil between the plants. Recent studies in Quebec by Majeau, et al,[14] and in New Brunswick,[12] found no correlation between thatch thickness and chinch bug populations. This contradicts a widely held idea, as well as earlier work by Kortier Davis and Smitley[15] that showed the insects were more common in thicker thatch. It is reported that the adults seek out thatch in which to overwinter.[10, 16]

It is not clear whether chinch bugs prefer some species of turfgrass over others. Majeau[14] found that population density was more closely associated with perennial ryegrass, but not creeping bentgrass. Kentucky bluegrasses are the main target in most of the Atlantic region, with fescues showing less damage.

IPM PROGRAM FOR CHINCH BUG

The basic steps in an IPM framework are described in Chapter 1. The following sections describe each step as it applies to managing chinch bugs, based on what we know of it's biology and the factors that appear to make turf more or less resistant to invasion.

1. Manage landscapes to prevent pests from becoming a threat.

There is no practical way of eradicate this pest, but sound turf management practices will produce a healthy turf that is better able to withstand high populations without showing damage. Good management practices start with establishment of the lawn on a good soil foundation. Getting the turf off to a good start, by amending the soil organic matter, pH and nutrients as required, and choosing the most suitable varieties is important. Follow up with sound maintenance practices (*see* Chapter 6).

There is anecdotal evidence to suggest that stressed turf – both underfed and overfed with nitrogen, for example – show higher levels of damage, but research supporting this observation has not yet been done.

2. Identify potential pests.

See Description, above. It is important to correctly identify chinch bugs while monitoring because there are other similar looking insects. One of these is the big-eyed bug, which is a predator of chinch bugs. It looks similar to chinch bugs in shape and size, but has much larger, prominent, eyes. Both are quick moving insects, however, the smaller eyes of chinch bugs are unmistakable.

3. Monitor environmental conditions, pest and beneficial organism populations and pest damage.

Regular monitoring catches problems before chinch bug numbers and damage to the turf reach unacceptable levels. There are currently two useful monitoring methods for chinch bug: the flotation method and the quadrat method.

Flotation Method: Push a cylinder, such as a tin can with both ends removed, about 2-5 cm (an inch or so) into the soil and fill with water. In 10 minutes all stages of chinch bug will float to the surface and can be counted. If the area of the turf inside the cylinder is calculated, the count can be mathematically converted to a count per 0.1 m^2 (or per ft^2). This number can then be compared to treatment thresholds (see below) to determine whether control is required. Repeating the sampling process in 10 or more locations throughout the lawn will give an indication of the general level of infestation.

Quadrat Method: A Laval University research team has developed a faster sampling technique called "quadrat" sampling,[17] based on sequential sampling methods developed by Wald[18] and Iwao.[19] Cariere[13] refined the methods with field research, and this evolved to the current process described by Rochefort.[11] This method uses a 0.1 m^2 (1 ft^2) frame or "quadrat" – 33 x 33 cm, 20 x 50 cm, or 12 x 12 in.

Place the frame on the lawn and count all of the chinch bugs that can be found in 45-60 seconds.

Sample weekly from the last week of June to mid August, counting 3 quadrats per 100 m^2 of lawn.

Figure 7-5. Monitoring for chinch bug, using a 20 x 50 cm quadrat or frame.

The process takes 10-15 minutes to sample an average home lawn, compared to several hours to use the flotation method.

It is important to note that counts from the flotation method cannot be directly compared to results from the quadrat method. While the Laval studies showed that counts using the quadrat method are about ¼ of the counts using the flotation process,[11] sampling in New Brunswick found that the quadrat counts were $1/10^{th}$ of flotation counts.[12] What is important is not the total number of insects counted, but that the sampling method is related to a treatment threshold. If thresholds are based on flotation counts they will be quite different than thresholds based on quadrat counts.

Sampling Locations: Hairy chinch bugs are not uniformly distributed in the turf.[11, 12] Populations are concentrated in "hot spots", and counts may drop to near zero less than 1m (3 ft) away. Therefore, monitoring should focus on likely sites, such as:

- known infested areas from previous years,
- dry, sunny slopes,
- areas with high counts from previous sampling programs, and
- areas with brown or wilting turfgrass in localized patches.

Sampling Frequency: The quadrat sampling method is based on taking 3 random samples per 100 m^2, repeated over the next several weeks, in areas of likely infestation. This provides one sample for every 33 m^2 on every sampling day. Given the localized nature of the chinch bug populations, this sampling frequency probably won't find many of them on any given sampling day. Monitoring for the full period of weeks, however, provides over 20 samples per 100 m^2, or one sample for every 4 to 5 m^2, which gives a reasonable probability of catching the hot spots.

If a quadrat sample shows a count of 10 or more bugs, indicating that it is a hot spot, it should be marked for checking the following week.

4. Decide whether treatment is needed on the basis of population and damage thresholds.

Although the insects are widely present in lawns, they only cause noticeable damage in some. (In the Laval research, while over 60% of the lawns were infested, only 11% required treatment.) Therefore, their visible presence alone is not necessarily an indication that treatment action is required. The damage threshold is the number of chinch bugs per area it takes to cause damage. Above this threshold there will be unacceptable damage to the turf if controls are not applied. Injury, or damage, thresholds are in the process of being developed and refined for Atlantic Canada. The following discussion gives examples of injury thresholds, but for the most recent information, consult extension or industry experts.

Based on the Laval research, it appears that a mean number of 10 chinch bugs or more per quadrat results in 5% damage to the lawn. An action threshold of 10 bugs per 0.1 m^2 quadrat seemed to work for New Brunswick conditions in 2002, and is useful as a starting point. Experience may show that action thresholds will vary slightly for other areas in the Atlantic Region and may be modified. Because a healthy lawn tolerates more feeding by chinch bugs than a stressed (under-fed or over-fed) turf, the damage threshold would be higher for a healthy lawn.

As described above, a New Brunswick study showed a ratio of 1 to 10 between quadrat counts and floatation counts. This means that a count of 10 bugs per quadrat may mean the actual population could be around 100 bugs per 0.1 m^2, which is much higher than previously published thresholds. This may be because the more favourable growing conditions found in the region enable the turf to withstand higher population pressures without visible damage. Flotation sampling in the Fredericton area in 2000 and 2001 found damage at counts of 50 chinch bugs per 0.1 m^2, while counts in “hot spots” ranged as high as 600 bugs per m^2. More detailed research in 2002[12] found there was little visible damage in biodiverse lawns with counts of bugs up to 1200 per m^2. Damage was apparent in 2002 in pure turf stands at flotation counts of 200 bugs per 0.1 m^2.

Table 7-2. Suggested treatment thresholds for two different sampling methods, based on the health of the lawn (New Brunswick data).

NUMBERS OF CHINCH BUGS		**TREATMENT REQUIRED**	
Flotation Method (count per 0.1 m^2)	Quadrat Method (count per 0.1 m^2)	Healthy Lawn	Stressed Lawn
0 – 50	0 – 5	None	None
50 – 99	6 - 9	None	None
100 – 199	10 – 19	Recheck, possible spot treatment	Spot Treatment
200 or more	20 or more	Spot Treatment	Spot Treatment

5a. Use biological, mechanical and behavioural control methods to reduce pest populations to acceptable levels.

Endophyte-Infected Grasses: Endophytes are naturally occurring fungi that live inside some grasses; the grass benefits because the fungi make the leaves toxic to insects that eat the shoots or sap. Ryegrasses and some fescues have been found with endophytes, but so far, no bluegrasses have been found - or successfully inoculated - with these fungi.

It is not known at this time, whether planting endophyte-infected grass cultivars can help manage chinch bugs. Studies at Laval[13] showed that endophyte-infected perennial ryegrass caused high mortality of 3rd instar nymphs of chinch bug. In mixed stands of endophyte-infected perennial ryegrass and Kentucky bluegrass, the nymphs showed a preference for the non-infected species. This may be because the highly mobile, 3rd instar stage can detect, and avoid, the toxic endophyte-infected cultivars. If perennial ryegrass in mixes used in the Atlantic region are really acting like annuals, then any benefit from planting the endophyte-infected perennial ryegrass would be lost after the first season.[20] Drawbacks to using endophyte-infected turfgrasses include:

- limited availability in the permanent species (some fescue varieties contain the fungus, but no Kentucky bluegrasses),
- loss of viability if not stored correctly,
- a demonstrated preference for non-infected species, and
- lack of a practical viability test.

Further discussion on endophytes may be found at the University of Rhode Island extension web site http://www.uri.edu/ce/factsheets/sheets/endophyte.html, and in *IPM for Turf Managers*.[32]

***Beauvaria bassiana*:** A biological control described in literature is the fungus, *Beauvaria bassiana*. This insect-attacking fungus occurs naturally in the soil under cool, wet conditions and is known to infect hairy chinch bugs. *Beauvaria* can be obtained commercially[21] although its use is likely to be limited since it must be kept moist to survive and be effective. More research is required to determine how effective this fungus is in Atlantic conditions.

In a study of manufactured topsoil at Fredericton in 2003, chinch bug infestations were only found in the plots of soil modified with peat.[22] It has been suggested that the low pH of the peat suppressed the naturally occurring *Beauvaria* populations in these plots, leading to the infestation.[23] Further investigation is underway to explore this possibility and its implications.

5b. When necessary, use targeted applications of pesticides.

If a monitoring program shows that the action threshold has been reached or exceeded, treatment may be required with insecticides. Treatments should be undertaken when the pest is most susceptible, using spot treatments on only those areas where monitoring has identified hot spots. It appears that to obtain control, it is sufficient to treat only an area 2 m (6 ft) or so around the hot spots. Treating the whole lawn is rarely justified; blanket insecticide sprays seem to be a significant factor in suppressing the soil life, and subsequent thatch build-up. Using this application approach, Laval researchers reduced insecticide use for chinch bug by 89%[9] (showing that 89% of the insecticide used in the past was unnecessary).

Lawns repeatedly treated with high levels of fertilizer and insecticides have fewer predators[24, 25] and more problems with hairy chinch bug.[24, 26] At the same time, many common insecticides have a debilitating impact on earthworms, leading to a rapid thatch build-up.[25] For example, in one case in this region, a sodded lawn, sprayed twice a year for chinch bug, had accumulated nearly 50mm (2 in) of thatch, three years after installation.

Insecticides are least effective if applied when the turf is very dry. Therefore, if possible, applications should be made during a gentle rain or the lawn should be lightly watered (at least 6 mm or ¼ in) before treatment. Soak the insecticide in, with an additional 6 mm of water, after treatment.[27] Insecticides should never be applied during a heavy rain as this might result in runoff of the chemicals. Follow all application conditions as required by Provincial permit or license conditions, with respect to posting the area, re-entry times, wind speed, and buffer zones.

Optimum Timing: According to Tashiro[10] and Majeau[14], insecticides are most effective when applied while the 3rd instar nymph stage is present. This is because most of the eggs will have hatched by that time and few of the insects have reached the 4th and 5th instar stages that appear to be more resistant to insecticides. Treatments applied too early or too late will not only be ineffective, but they will also reduce the numbers of beneficial insects that attack chinch bugs.

The rate that insects develop is correlated with temperatures above a certain minimum for growth, called temperature degree-days or growing degree-days.[28] Quebec studies[11, 29] found that calendar dates are correlated well enough with cumulative growing degree-days that it is practical to use calendar dates for monitoring chinch bugs. These studies reported that 95% of the 2nd and 3rd instars were found between July 8 and July 24; this was over the three-year period of the study. New Brunswick studies[12] and Newfoundland data[31] suggest that the peak period for these instars falls 10 days later than found in the Quebec studies. Given this observation, a recommended treatment window has been established as July 15 to August 15. A four-week window, rather than the shorter window in Quebec, is suggested at this time because:

- it provides a guide that improves control efforts significantly over current practice,
- it allows a margin of error for those becoming familiar with their first year of monitoring, and
- it provides a wider margin to take into account variations in chinch bug development around the region.

The recommended treatment window dates may be adjusted in the future as more data are collected.

6. Have a built-in evaluation process.

The final steps in any management program are the evaluation of the effects of the treatment and the documenting results for future reference. These contribute to the learning process and the evolution of the IPM program.

The New Brunswick Horticultural Trades Association has provided a coordinating role for this information. Reports forwarded to the NBHTA will be incorporated into future recommendations.

MANAGING WHITE GRUBS

Description: 'White grub' is the term used for the larva stage of several related species of beetles. The most common in the Atlantic region are May or June beetles (*Phyllophaga* spp.).
The adults are blocky, shiny reddish brown beetles, up to 2 cm (1.4 in) long with no distinctive markings on their wings or body. The larvae reach 8-12 mm (0.5-0.75 in) in length when full grown; they have six legs, a white to grayish body, and a dark brown head. They curl in a characteristic "C"-shape and are usually found within the top 5 cm (2 in) of the soil surface.

Life Cycle: Adults emerge in late spring, feed for a limited time, then mate. They fly at night and are often found around outdoor light sources. Females lay eggs about 12–50 mm (1–4 in) beneath the soil surface. Eggs hatch in about 3 weeks and the young larvae start feeding on roots and decaying matter. This continues until the fall, when they migrate deeper into the soil to spend the winter. The feeding sequence is repeated the following year, with the larvae again migrating deep into the soil for the second winter. The following spring they move up to just below the surface and feed on roots until May. Then they pupate in a cavity in the soil and remain there as a pupa through the fall and winter. The adults emerge from the pupae the following spring, completing a 3-year life cycle.

Damage: *The Gardener's Handbook*[30] suggests that 5 or more larvae per 0.1 m^2 (one square foot) is sufficient to warrant treatment. The larvae cut the turf roots so that it can be lifted like thick sod. This has rarely been observed in this region. The main damage is caused by skunks, raccoons and birds digging up the lawn to feed on the larvae.

Management: May or June beetles are not considered a pest in most turfgrass; homeowners rarely request treatment programs for the larvae. No control programs should be carried out for adults, although they are annoying, and pest control operators may get requests for their control. Naturally occurring predators, nematodes, bacteria, and fungi pathogens attack the eggs and larvae, usually keeping their numbers below aesthetically annoying levels in most areas.

Chemical Controls: Some products containing carbaryl are registered for control of white grubs. Note that diazinon and chlorpyrifos used for white grubs in the past can no longer be used in, or around, residential areas.

Jeff Morton, formerly the Provincial Horticulturalist with the NS Department of Agriculture and Marketing, provides the information in the following two sections – Managing Sod Webworm and Managing Crane Fly.

MANAGING SOD WEBWORM

Sod Webworms are occasional pests of turfgrass in the region. These are lepidopteran pests identified mainly as various species of the genus *Crambus* and *Chyrsoteuchia toparia* the cranberry root girdler.

Description: The sod webworm larvae are off-white or tan-coloured caterpillars, about 10-20 mm long with a brownish head when mature. The larvae have legs on each abdominal segment and move forward or backwards very rapidly when disturbed. The larvae move through a series of molts usually having 7 or 8 instars. The early instars are very tiny 2-3 mm and usually have black heads. The *Crambus* species have dark circular patches along their backs. A picture may be found on-line at: http://www.biologicco.com/newsletter/vol_1_5.htm.

The adults are most often observed as small whitish-brown moths flying low over the turf in the early evening from late June to early August. The adults are about 10mm long with a wingspan of 20mm. When at rest on turf leaves, they hold their wings close to their bodies giving a long narrow appearance further accentuated by two mouthparts, forming a shape like a snout, that protrude from their heads. The moths are weak flyers and the zigzag fluttering activity ceases quickly after they are disturbed resting on grass blades, weeds or neighboring trees.

Life Cycle: The sod webworms over winter as mature larvae in their ground burrows or in the soil. As the temperature increases the instar becomes active and feeds and begins to pupate with the onset of long days. The pupal stage is in a new burrow in the soil and lasts approximately 21-28 days. The adults emerge, mate and lay eggs within 10-12 days. Moths are nocturnal, resting on grass during the day or in shrubbery nearby. They drop their eggs on the grass by mid - June. Eggs hatch in a week, but dry out easily and many do not develop. The tiny webworm can eat only soft, succulent portions of the grass blade. If the grass blade is tough, it may starve. As it grows, it begins to eat the tougher parts of leaves and stems. At this stage, it lives in the thatch layer, constructing a woven tunnel reinforced with plant debris, soil particles and its own excrement. Eventually, it is large enough to chew grass blades off, dragging them into its burrow to be eaten.

If there is more than one generation in any one year, webworm damage will be more severe.

Damage: The first signs of sod webworm injury are small patches of yellow or brown grass on the lawn. If the infestation worsens, the brown patches join together, producing large, irregular areas of dying grass. The patches are noticeable in sunny areas, while weeds and shady areas of lawn usually remain green.

The most severe damage occurs is association with late summer drought. Severe damage may not be evident on drought stressed turf until the areas fail to green up in September.

Habitat: Sod webworms prefer sunny lawn areas protected from strong winds. Well-drained areas are also more prone to attack most likely due to the suitability for the larval burrows. Webworms prefer rapidly growing grasses with heavy thatch levels and are more evident in thick lawns receiving medium to high levels of fertility.

IPM PROGRAM FOR SOD WEBWORM

The basic steps in an IPM framework are described in Chapter 1. The following sections describe each step as it applies to managing sod webworms, based on their biology and development in Eastern Canada.

1. Manage landscapes to prevent pests from becoming a threat.

Sod webworms are pests in more aggressively growing turf areas later in the season. Turf managers should prevent thatch levels from becoming heavy as it causes stresses on the turf and provides more suitable habitat for the insect to grow to damaging levels. Managing the pH at levels above 6.0, and minimizing pesticide usage, will encourage more soil microorganisms and insects that help to break down thatch and/or prey on the larvae. Fertility management is critical especially ensuring that nitrogen levels are reasonable and available in low amounts throughout the season. Removing excess thatch may be required by mechanical means or through regular aeration and topdressing to mix soil through the thatch layer.

2. Identify potential pests

Sod webworms are caterpillars that damage lawns by feeding upon the grass blades.
The Cranberry girdler tends to feed more heavily on root portions and often cause more severe types of damage.

Make sure you identify the pest as sod webworm and assess how much damage it may do before you decide to apply a control. Many of the moths and caterpillars on your property are part of a healthy ecosystem, providing food to birds and other predators.

Turf injury resembling sod webworm damage can result from many different causes such as heat stress, other insects such as chinch bug and grubs, and - rarely - disease problems. Insufficient soil depth or surface rocks may also appear like the injury from webworms.

3. Monitor environmental conditions, pest and beneficial organism populations and pest damage.

Identify potential high levels of adult flights in late June and record potentially damaging populations. Initiate sampling 20-30 days later. Extreme dryness and heat in this period may severely limit the survival of the hatching larvae.

Check the thatch layer just above the soil surface. You may see signs of webworm feeding. Early in the season (July), small webworms eat only the tender parts of the grass blades, so that the blades appear skeletonized. Larger webworms will chew off the entire blade and drag it away. Observe carefully while teasing the turf and thatch apart looking for signs of green excrement and silk-lined tunnels. Generally the tunnels point downward, and the caterpillar is found inside. If you do not see signs of feeding, perhaps something else, such as poor drainage, a gas spill or the over-application of a pesticide, fertilizer or herbicide has injured the lawn.

Estimate the webworm population by drenching areas where webworms are likely to be found, such as the edges of damaged areas, with a lemon detergent solution. This will cause the larvae to become active and crawl to the surface. Mark off several squares measuring 30 cm by 30 cm. Using a rate of two liters of water for each 15 ml of detergent (2 tablespoons per gallon); apply as much solution as you need to saturate each test square. Watch each square for about 10 minutes. If no webworms appear, check other areas of the lawn. Although webworms may have injured the lawn, if they are no longer feeding upon the grass any controls you undertake will be ineffective.

4. Decide whether treatment is needed on the basis of population and damage thresholds.

Low numbers of webworm may not need to be controlled. Injured grass can recover if feeding is not severe. A lawn growing from a fertile, well-aerated soil that has received moderate amounts of fertilizer or nutrients will be best able to withstand an infestation. A wet summer will reduce the damage. Watering a dry lawn will help keep the grass growing (*see* Watering, Chapter 6).
As a general guideline, a range of 8-10 webworms in the test area will cause some damage to a previously healthy lawn. A lower number (3-4) in the area sampled can damage a lawn in poor condition before the outbreak.

5a. Use biological, mechanical and behavioral control methods to reduce pest populations to acceptable levels.

Thatch control is a key management technique in the reduction of sod webworm infestations. Management processes such as reduced pesticide usage, pH adjustment, moderate fertilization, proper irrigation, compost topdressing and core aeration result in lower levels of thatch and thus reduced potentials for webworm outbreaks.

Avoid stresses on the turf especially in hot conditions. Manage mowing practices to leave turf about 6-7.5 cm. This encourages deeper rooting and a more stress resistant plant able to recover from some defoliation.

Natural enemies including certain microorganisms, parasitic wasps and flies, and predators such as beetles, ants and birds reduce sod webworm populations. A good long-term strategy for pest control is to maintain an area where these webworm enemies can find the mixture of foods they require and shelter. Avoid repeated use of insecticides that can suppress natural enemies. Webworm outbreaks will often occur on areas treated for control of other insects earlier in the season. Leave room on your property for nectar sources such as daisies, Queen Anne's lace, black-eyed Susan, dill, caraway and fennel.

Turfgrass infected with endophytes---natural fungi that grow inside grass and affect the animals chewing it--- are resistant to sod webworms that chew on the leaves. Types of perennial ryegrasses, tall fescues and fine fescues are available with this resistance (*see* Chapter 4, Seed Containing Endophytes). Perennial ryegrass and tall fescue are marginally hardy in most areas and may require reseeding after periods of prolonged snow cover or ice. These grasses may be utilized as a portion of an overseeding mix to help diluted the population of susceptible turf in a specific area.

5b. When necessary, use targeted applications of pesticides.

The microbial product Bt (*Bacillus thuringiensis*) can be used to control webworm, and should be the first choice for a control product in this application because of its environmentally benign characteristics. This naturally occurring bacterium acts as a stomach poison when it is eaten by caterpillars, but does not damage other insects.

Application timing is important: Bt is not effective on moths, nor on larger webworms. Large numbers of moths signal the start of the monitoring period in the control cycle, not the time to start spraying. There is no point in applying control products at this time, because the product will not kill the moths. The best time to apply Bt is two weeks after observing moths – typically late July to early August. By this time, most of the resulting eggs should have hatched and the webworms are small and easily killed.

Remember that Bt will kill all caterpillars, including the caterpillars of butterflies, so avoid spraying it on any plants where pest control is not needed.

Parasitic soil nematodes are microscopic organisms that kill sod webworm larvae. Two species of nematodes *Heterorhabditis spp.* and *Steinernema* spp. are introduced predators that will reduce population levels. *Heterorhabditis* is a more aggressive predator actively moving through the top 15 cm of soil. Both types of nematodes move in the film of water in soil or plants. They are most effective when applied in warm conditions when water is freely available on the surface of the plant. Applying the product on a warm evening followed by a light irrigation improves the effectiveness of the application. Cold-hardy strains are available that promise better activity where a past history of infestation has occurred and/or high levels of adults have been detected; a fall treatment may be warranted.

Eliminate thatch if it is over 1.5 cm thick so that the nematodes will reach the soil. Avoid using chemical fertilizers or pesticides for at least one week after applying nematodes. These nematodes will not overwinter in Nova Scotia, so the product must be reapplied if you want control the following season.

If other management techniques have been found ineffective, a few chemical products are registered for use in controlling sod webworm infestations. If you decide chemical control products are necessary, treat only the affected area, so that predators and other insects can repopulate the area. The choice of products may also have an influence on the non-target effects to the general soil insect population. Always choose the least harmful product for the given situation.

6. Have a built-in evaluation process.

Pest management programs should monitor the effectiveness of the treatments and control strategies. Treated areas should be re-inspected in late August or early September to determine the extent of the damage and subsequent repair activities that may be required in the spring. Often undetected levels of infestation in the fall are misreported as winter injury the next spring.

EUROPEAN CRANE FLY

The European crane fly (*Tipula paludosa)* is an occasional pest of turfgrasses in Atlantic Canada.

Description: In Eastern Canada, the adult is 15-40 mm in length and has one pair of membranous wings equivalent to the length of the body. The adult is often described as an oversized mosquito with a grey-green slightly translucent abdomen. The adult is most often observed in flight low over turf and grass areas in the early evening and resting on building window screens. The larva known

as leatherjackets cause damage to turf and pasture areas. The name comes from the tough pleated grayish green skin that is covered with various black specs of different sizes. The larva are 20-40 mm in length and 5-8mm in diameter slightly tapering at each end. The insect was introduced to Sydney, Nova Scotia from Europe in 1955 and has since spread to the rest of the province. Pictures of adults and larvae may be seen at:
http://www.ent3.orst.edu/smartkey/display.cfm?pagename=Crane%20flies&groupname=nogroup

Life Cycle: The adult stage is the European crane fly, *Tipula paludosa*. It looks like a giant mosquito, but does not bite or sting. Crane flies emerge from the soil in late summer. They do not eat, but mate, lay eggs and die soon after emergence. The eggs, which are laid in the upper 3 cm of soil, are black, oval and about 0.1 cm long. Dry soil conditions may cause the eggs to die; otherwise they hatch into larvae, known as leatherjackets, within two weeks. The first two instars feed heavily for 6-8 weeks and the larva overwinter as third stage instars. The larva move deeper into the soil for the winter, and many die if the winter soil temperatures are low or conditions are dry. Heavy snow cover usually increases survival rates. As the soil temperature increases in the spring they move to the surface and resume feeding and molt to a fourth instar (most damaging stage) stopping in early summer to form pupa. The pupa can move up or down in their burrows, through the use of spines depending on environmental conditions. The pupae hatch in late summer or early fall, emerging as adult crane flies.

Damage: Leatherjackets may damage a variety of landscape plants with turf grasses most frequently attacked. Injury in turf becomes noticeable in slopes and stress prone areas in late spring to early summer as the over wintered larvae begin to mature. Weak or thin lawn areas marked by a large number of small holes are indicators of the presence of European crane fly larvae. Holes from the burrows are noticeable and usually spaced 25 mm to 100 mm apart in damaged areas. The damage is often localized to small patches but can encompass several hundred m^2 when infestations become severe.

Often the damage can be more severe in protected areas where good snow cover has been experienced. The population reaches a peak between mid-June and early July. Larvae may be noticed first after a heavy rain, when they are washed out of the soil and onto sidewalks and driveways. The pest may exist in large numbers with several thousand larvae observed on driveways and walkways in the evening. While these high population levels may not damage lawn areas, the slippery surfaces may become a problem when the larvae are crushed on smooth asphalt or concrete.

During the day, leatherjackets feed on grass roots near the surface of the soil. Dry soil conditions cause the larger larvae to migrate deeper in the soil to depths of 150 mm. The larvae crawl to the surface in the evening to feed on grass leaves crowns and stems.

Habitat: The European crane fly prefers a climate with high rainfall and low winter temperatures. Much of the Atlantic Provinces are suitable for potential infestation. Adult Crane fly is present in abundant numbers as s each fall and feed on a variety of grasses both in pastures and on turf areas. The larva is often present in shady areas where slightly higher soil moisture is expected and on slopes from the north and east sides of buildings.

IPM PROGRAM FOR EUROPEAN CRANE FLY

The basic steps in an IPM framework are described in Chapter 1. The following sections describe each step as it applies to managing crane fly, based on its biology and development in Eastern Canada.

1. Manage landscapes to prevent pests from becoming a threat.

Crane fly rarely causes severe damage to turf areas that are growing very vigorously. The first step is to employ sound turf management techniques to prevent injury in turf from reaching damaging levels. The major effect of the larval feeding is thinning of the turf causing the area to be more susceptible to weed invasion and other turf stresses such as drought, potentially discouraging the growth of desirable species.

2. Identify potential pests

See the description above. The pest may be confused with a variety of cutworm species in both planting beds and turf areas. Cutworm larvae are usually more solitary and do not occur in the numbers that crane fly often do. Cutworm larvae also have small feet on each abdominal segment while crane flies have none.

Large numbers of crane fly adults are often present in the fall but do not necessarily lead to severe infestations. Identification of the potential pest stage and resulting control strategies should be based on sampling for the larval stages in Mid-June.

3. Monitor environmental conditions, pest and beneficial organism populations and pest damage.

Turf areas suspected of potential infestations or showing early symptoms such as turf thinning or burrow holes should be sampled for the presence of larva. Examine several areas of soil underneath the grass. Cut three 30 cm (one foot) sides of a square of turf about 7.5 cm (3 inches) deep. Carefully fold the square back, using the uncut edge as a hinge. Scrape the soil from the roots to expose the leatherjackets and count them. When you have finished, firmly press the grass back in place, and water it.

Adult populations may be sampled in August and September but are poor indicators of potential pest infestations because of the susceptibility of the eggs and larva to death from poor environmental conditions. High levels of rainfall in late August and Early September will encourage good egg hatch. Dry surface and soil conditions will also contribute to death of the newly hatched larvae or eggs. Monitoring environmental and soil conditions will aid in predicting potential damaging pest levels.

4. Decide whether treatment is needed on the basis of population and damage thresholds.

Low numbers of leatherjackets do not need to be controlled. A lawn growing from a fertile, well-aerated soil that has received moderate amounts of fertilizer or nutrients will be able to withstand a mild infestation. If higher numbers (over 25) are found in the sampling area, expect that the lawn will be damaged. A lower number, 15 in the area sampled, will likely cause damage to a lawn that was in poor condition before the outbreak.

Damaging levels are often measured by the severity of the thinning of the turfgrass. Turf can tolerate significant injury before an entire area is destroyed. Often infestations are limited to very small areas and only those areas may need increased levels of management.

Direct control measures should only be considered in the spring as late summer drought or severe winter temperatures may significantly reduce the populations of the young larva in the preceding fall.

5a. Use biological, mechanical and behavioral control methods to reduce pest populations to acceptable levels.

Predator populations are generally insufficient to handle large infestations of European crane fly. Predatory arthropods, birds, and snakes all feed on the larvae in their burrows or as they emerge to feed in the evening.

Egg laying preference has been noted in the past where infestations occur on property boundaries where two different types of grass exist. While this may not be currently used for control strategies it does indicate that infestations may be limited due to preference of egg laying sites and species bio-diversity will reduce large-scale infestations.

Physical removal is possible in the evening as the insects are exposed on the surface of the soil. Large numbers can easily be intercepted at this time and disposed of in soapy water. Heavy rainfall events also drive the insects from the soil area lessening the populations in a specific area.

Large numbers of crane flies in late summer indicate a possible infestation of leatherjackets in the spring. However, eggs are sensitive to soil moisture, and quickly collapse if it is dry. Newly hatched larvae also require moisture; drought during late August and September will kill them. Since both eggs and larvae dry out easily, avoid irrigating a dry lawn in the fall if you suspect a leatherjacket infestation.

5b. When necessary, use targeted applications of pesticides.

Parasitic soil nematodes are microscopic organisms that kill leatherjackets. Two species of nematodes *Heterorhabditis spp.* and *Steinernema spp.* are introduced predators that will reduce population levels. *Heterorhabditis* is a more aggressive predator, actively moving through the top 15 cm of soil. Both types of nematodes move in the film of water in soil or plants. They are most effective when applied in warm conditions when water is freely available on the surface of the plant. Applying the product on a warm evening followed by a light irrigation to improve the effectiveness of the application. Cold hardy strains are available that promise better activity where a past history of infestation has occurred and/or high levels of adults has been detected a fall treatment may be warranted.

The effective treatment window for crane fly is early June as the fourth instar larvae are beginning to feed. Eliminate thatch if it is over 1.5 cm thick so that the nematodes will reach the soil. Avoid using chemical fertilizers or pesticides for at least one week after applying nematodes. These nematodes will not overwinter in Nova Scotia, so the product must be reapplied if you want control of crane fly the following season.

Most effective control of leatherjackets is achieved by making applications so the insect may intercept the products as they emerge for the evening feeding. Irrigating 2-3 days prior to treatments also encourage the pest to be close to the surface.

If other management techniques have been found ineffective, a few chemical products are registered for use in controlling grub infestations. Many control products will also destroy natural predators of lawn pests; an infestation of another insect, such as sod webworm or chinch bug, may follow. If you decide pest control products are necessary, treat only the affected area, so that predators and other insects can repopulate the area. The choice of products may also have an influence on the non-target effects to the general soil insect population. Always choose the least harmful product for the given situation. The effectiveness of most products is dependent on application techniques and timing.

6. Have a built-in evaluation process.

Pest management programs should monitor the effectiveness of the treatments and control strategies. Treated areas should be re-inspected in late August or early September to determine the effectiveness of the management strategies and identify future schemes to manage the areas.

KEY POINTS

Managing Weeds

- Consider growing a biodiverse lawn and raising tolerance levels for broadleaf weeds.
- Provide the best growing conditions so that the healthy turf suppresses weeds.
- Monitor weed populations, using transect or grid counting methods and keep records.
- Make treatment decisions based on monitoring results and treatment thresholds.
- Where weed numbers are low, use mechanical removal methods.
- If herbicides are used, target the use to the areas with the weed populations; avoid routine herbicide applications and mixed herbicide-fertilizer products.
- Evaluate the effect of any treatments and the overall IPM program.

Managing Insects

- Investigate the problem. Is it really insect damage?
- Identify the insect.
- Monitor population levels. Are damage thresholds exceeded?
- If control measures are needed, apply when they are most effective.
- Use spot treatments where possible.

Review the program annually to determine whether sampling procedures, locations and threshold levels need adjustment.

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