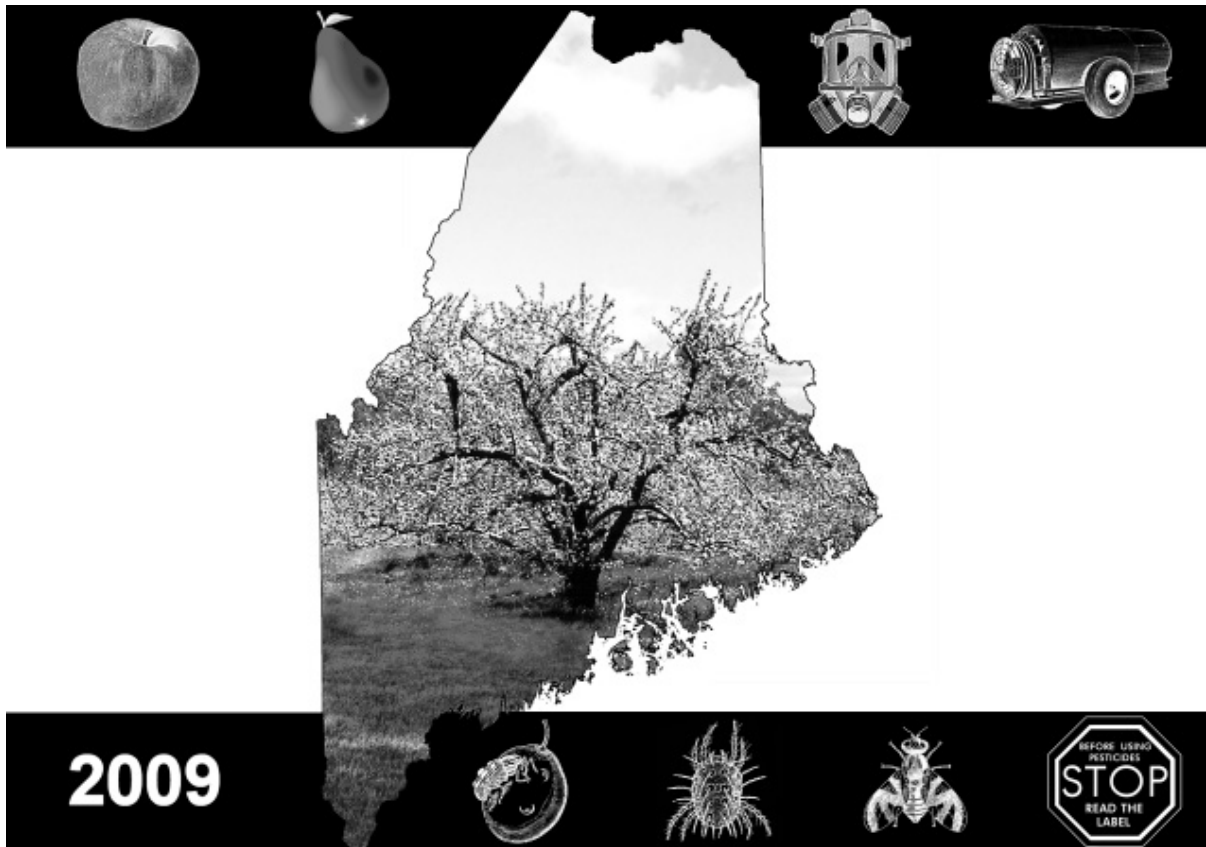

ORCHARD

FRUIT PEST

MANAGEMENT

Private Pesticide Applicator Training Manual



ORCHARD FRUIT PEST MANAGEMENT

Edited by Don Barry, University of Maine Cooperative Extension &

Gary Fish, Maine Board of Pesticides Control

2009

PREFACE

The Orchard Fruit category includes private applicators using pesticides in the production of orchard-grown apples, peaches, plums, and pears.

For private certification in this category, applicators are tested on this manual and the Pesticide Education Manual (Core Manual). If you can find the time, please fill out the evaluation at the end of this manual and mail it, as well as any questions or comments you have, to the Pest Management Office, Attn: PAT, 491 College Ave., Orono, ME 04473.

ACKNOWLEDGMENTS

Much of this manual is adapted from the *2003-2004 New England Apple Pest Management Guide*, William M. Coli, University of Massachusetts, editor.

The white tailed deer section is rewritten from *Wildlife Damage Management in Fruit Orchards*, Cornell Cooperative Extension Information Bulletin 236, by P.D. Curtis, M.J. Fargione, and M.E. Richmond.

This manual has also borrowed from the U.S. Environmental Protection Agency's pesticide pages: www.epa.gov/pesticides/index.htm; *Pruning Woody Landscape Plants* by Lois Berg Stack, University of Maine Cooperative Extension, Bulletin #2169. Fact sheets written by Dawna L. Cyr and Steven B. Johnson, University of Maine Cooperative Extension, as a part of the *University of Maine Cooperative Extension Farm Safety Program*; as well as *The Agricultural Pocket Pesticide Calibration Guide*, edited by Jim Dill and Glen Koehler, UMaine Cooperative Extension; and Pest Management Office pest fact sheets by Bruce Watt and Clay Kirby, UMaine Cooperative Extension.

PRECAUTIONS

Properly timing treatments and proper sprayer calibration are as important as the product used. Follow directions on pesticide labels. **READ THE LABEL!**

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Orchard Fruit Pest Management

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Chapter One

Integrated Pest Management

Integrated Pest Management (IPM) is a multifaceted approach to keeping crop damage from pests below economically damaging levels. Instead of trying to eradicate pests with pesticide sprays, IPM integrates the best available management options in a complementary way to create an overall management plan that is efficient, effective, and sustainable. The goal of IPM is not only to save money by organizing your management approach, but to provide safe, effective, economical, environmentally sound, and socially sensitive outcomes.

Within IPM, pesticide treatments may still play a key role but cultural practices such as sanitation and habitat management are the first line of defense in preventing pest problems. When chemical treatments are necessary, selective pesticides are given preference, and are applied in ways that minimize their detrimental effects on nontarget species, especially the predators and parasites that attack pests. This is why IPM is “integrated”—individual management decisions are not isolated but take into account, wherever possible, all aspects of the existing and potential pest situation in relation to the overall orchard operation to produce economically and environmentally optimum results.

INTEGRATED PEST MANAGEMENT

The specific techniques used for integrated pest management vary with each situation, but there are fundamental activities that define IPM:

1. **Identify the pests** that are the source of the problem. Correct pest identification is required to identify optimum solutions.
2. **Understand the biology and economics** of the pest and the system in which the pest exists.
3. **Monitor pests and natural controls.** Use standardized, tested monitoring methods rather than basing decisions on haphazard observation.
4. **Establish economic injury thresholds.** Pest management decisions are based on the potential damage from pest infestations, status of natural enemies, sensitivity of the protected site (such as stage of development of a crop), and the weather. Actions are taken only when the potential damage is sufficient to justify action.
5. **Select an appropriate strategy** of cultural, mechanical, biological, and/or chemical prevention or control techniques.
 - **Cultural practices** include habitat modification and adapting operating procedures so that pest damage is reduced and natural control is enhanced. Sanitation is the removal or cleaning of sources of pest infestation. Choosing plant varieties that are resistant to pest injury is a cultural control. Other agricultural examples are adjusting planting time, fertilization, mowing, and harvest operations to have the most beneficial or least detrimental affect on the pest management situation.
 - **Biological controls** are predators, parasites, and diseases that attack pests. Measures can be taken to conserve naturally occurring populations. In some situations where naturally occurring biological controls are not effective, they can be introduced from outside sources.
 - **Chemical control** involves selecting a pesticide with the lowest toxicity to humans and non-target organisms (including biological controls), and using it in such a way as to prevent or minimize undesirable environmental effects. The lowest effective amount of pesticide is applied from carefully calibrated spray equipment.
6. **Evaluate the pest management program** and improve it where possible. This requires keeping monitoring records, treatment records, and damage assessment and reviewing them on a regular basis.

YOUR IPM PLAN

The most effective use of IPM requires planning and forethought before problems arise. To get from merely knowing about IPM to actually doing IPM begins with formulating an IPM Plan. Plans may vary according to the unique characteristics of each farm but all IPM Plans include:

- The method of monitoring pest populations and keeping records
- The physical, mechanical, and cultural controls used to inhibit pests

- Action thresholds—pest conditions that demand control actions, including pesticide application.
- A list of available pesticides to be used when and if other management methods fail.
- Management restrictions, safety precautions, and other constraints.

To begin an IPM Plan, conduct a thoughtful overview of all likely problems and possible ways to manage them. Write down your plan to help organize your thoughts and preserve your ideas:

1. Review damage and spray records, and recollections of block history, to identify key pests and problem areas. A map of each block is useful to record pest hot spots, identify areas that may be sources for infestation, identify drift-sensitive areas, and to plan monitoring and treatment actions. Review the lessons learned from success and failures of the pest management actions of previous years. Set measurable objectives for your IPM program.
2. Read about the biology of pests and beneficial species. For each key pest, consider cultural and site management tactics that can reduce or replace the need to use pesticides. Be sure to schedule enough lead-time to implement the tactics you choose.
3. Determine what information is needed to make informed pest management decisions during the growing season. Decide which pests will be monitored, when, how, and by whom. If monitoring requires traps or other supplies, order them early. Locate key monitoring sites on the block maps. Blocks and pests with the most uncertainty for treatment decisions should receive highest priority for scouting.
4. For pests that typically require pesticide application, review the available options and choose materials that are most compatible with your operation and particular objectives. When choosing a particular pesticide, be sure to consider its impact on the local environment, especially if environmentally sensitive areas are present. Also consider the conservation of beneficial species, resistance management, and how you will comply with worker protection standards. Additional factors that can influence pesticide selection include, timing, spray concentration, tank-mix compatibility, phytotoxicity concerns, alternate or border row application, etc.

5. Establish an information system to record pesticide applications, pest, and weather observations. Organize this information so it complies with all regulations and it will be useful for making management decisions, clear and understandable for communicating with employees, and available for review in following years.

THE MAINE APPLE IPM PROGRAM

The University of Maine Cooperative Extension provides IPM support to apple growers by gathering and disseminating relevant pest observations. Apple scab fungus, one of the most serious pests of the New England apple crop, provides a good example.

An understanding of the apple scab disease cycle indicates that spores are released only during wet conditions. Moreover, new tissue becomes infected only if the proper combination of wetness and temperature are reached and maintained for a given time. These factors are ignored by historic control methods which rely on repeated fungicide applications to provide a continuous protective layer on early growth even if infectious conditions are absent.

The Apple IPM program collects spore release data from field monitoring stations as well as local weather conditions from satellites to accurately predict scab infection periods. Growers are alerted to apply protective fungicides only when conditions are favorable for the spread of primary scab infections.

In addition to efficient pesticide applications, IPM emphasizes other methods of scab control:

- Using apple varieties bred for resistance to scab.
- Removing fallen leaves and fruit to reduce the number of over wintering spores.
- Pruning trees to provide a more open canopy to allow faster drying of wet leaves and improving spray penetration.



For more information about the University of Maine Cooperative Extension Apple IPM Program: <http://pmo.umext.maine.edu/apple/index.html>

Chapter Two

Pesticides

CHEMICAL PESTICIDES

Organophosphate Pesticides affect the nervous system by disrupting an enzyme known as cholinesterase. This enzyme regulates acetylcholine, a neurotransmitter found in both insects and humans. Most organophosphates are insecticides; some are very poisonous. However, they usually do not persist in the environment.

Carbamate Pesticides also affect the nervous system by disrupting cholinesterase, an enzyme that regulates the neurotransmitter acetylcholine. The enzyme effects are usually reversible. There are several subgroups within the carbamates.

Organochlorine Insecticides were commonly used in the past; many have been removed from the market due to their health and environmental effects, and their persistence (e.g. kelthane).

Pyrethroid Pesticides are synthetic variations of the naturally occurring pesticide pyrethrin, which is found in chrysanthemums. They are chemically modified to increase their stability in the environment. Some synthetic pyrethroids are toxic to the nervous system.

BIOPESTICIDES

Biopesticides are from certain materials. For example, canola oil and baking soda can display pesticidal activity and are considered biopesticides. Biopesticides fall into three major classes:

Microbial pesticides consist of a microorganism (bacterium, fungus, virus or protozoan) as the active ingredient. These pesticides can control many different kinds of pests, although each separate active ingredient is relatively specific for its target pest. For example, there are fungi that control certain weeds, and other fungi that kill specific insects.

The most widely used microbial pesticides are subspecies and strains of *Bacillus thuringiensis*, better known as Bt. Each strain of this bacterium produces a different mix of proteins, and specifically kills one or a few related species of insect larvae. While some strains of Bt control moth caterpillars, other strains are specific for the larvae of flies, mosquitoes or beetles. The affected insect species are determined by whether the particular Bt produces a protein that can bind to a larval gut receptor, which causes the larvae to starve.

YOUR RESPONSIBILITY!

READ THE PESTICIDE LABEL FOR PRESCRIBED SAFETY EQUIPMENT AND PRECAUTIONS!

- Wear the appropriate personal protective equipment (PPE) listed on the label. At a minimum you should wear long sleeve shirt, long pants, shoes plus socks, chemical resistant gloves, and eye protection.
- Do not allow pesticides to contact your skin.
- After handling pesticide, wash hands and face before eating or smoking.
- Instruct your family, coworkers and farm laborers on pesticide safety procedures.
- Post safety rules and emergency information where workers will see them.
- Orchardists sometimes need to use pesticide in areas where residences, cropland, pasture, or bodies of water are nearby. Avoid application when conditions favor drift.



Pesticide product labels are legal documents that govern proper usage. Always read the label before using any pesticide. If you are unsure about any aspect of proper application, contact the BPC, the pesticide manufacturer or University of Maine Cooperative Extension before use.

PESTICIDE TOXICITY

Toxicity is a measure of a pesticide's capacity to cause injury. This hazard to humans varies by how it enters the body—the route of entry. These routes include the respiratory system (inhalation), digestive system (swallowing), and the skin (spraying or splashing on the skin or in the eyes).

The greatest hazard is through the respiratory system. The membranes in the lungs are so thin that absorption is very rapid (symptoms appear in seconds to minutes). Such rapid onset of symptoms is also expected if pesticides are splashed into the eyes. Oral absorption is the next most hazardous route of entry; symptoms typically appear within 30–90 minutes. Dermal (skin) absorption is less immediate but it is the most common route of entry; symptoms may not develop for 18 hours. There is considerable variation in the rate of penetration through the skin by different materials and formulations. Very high doses of certain pesticides can produce toxic symptoms within minutes after dermal exposure.

Acute toxicity

Acute toxicity is a measure of the immediate effects of a pesticide exposure in a short period of time. This is the basis for pesticide classifications used on product labels—the toxicity category and the signal word—that informs applicators of the potential hazards of a particular pesticide.

Chronic toxicity

Chronic toxicity is the capacity of a pesticide to cause injury, not immediately, but with repeated exposures over a period of time. These injuries include birth defects, nervous disorders and benign or malignant (cancerous) tumors. Chronic toxicity warnings are required for certain pesticides.

Cholinesterase inhibition is a widespread symptom of chronic toxicity associated with organophosphate and carbamate pesticides. Cholinesterase is an enzyme produced by the body to control the transmission of certain nerve impulses. Cholinesterase is essential to break down nerve impulses after a signal is transmitted from one nerve to the next. Without cholinesterase, these impulses flow continuously and may overload the entire nervous system. Prolonged exposure to organophosphate and carbamate pesticides inhibits cholinesterase activity and may result in a wide range of symptoms. Tests are available to measure the effects of this form of chronic exposure and are recommended for anyone who uses organophosphate or carbamate pesticides on a regular basis.

NORTHERN NEW ENGLAND POISON CENTER

The Northern New England Poison Center maintains a telephone hotline to respond to emergency calls from concerned citizens about poison prevention. Housed in the Maine Medical Center in Portland, this hotline is open 24 hours a day, 7 days a week by registered nurses or pharmacists with backgrounds in critical care. All specialists have passed a national certification exam in toxicology. The Poison Center staff has access to a 24-hour interpreter service, with over 140 languages available, so callers who do not speak English are able to receive immediate help for emergency calls.

The NNE Poison Center Hotline 1-800-222-1222 (emergency only)

http://www.mmc.org/mmc_body.cfm?id=2046
202-662-7224 (administration and materials)
email - miller@mmc.org

In case of emergency try to determine what the victim was exposed to and what part of the body was affected before you take action. Taking the right action is as important as taking immediate action. If the person is unconscious, having trouble breathing, or having convulsions, immediately give first aid and call 911 or your local emergency service. If the person does not have serious symptoms, contact the **Northern New England Poison Center** at **1-800-222-1222**. Have the product container with you when you call for assistance—remember to act fast!

During an emergency call, tell the physician the chemicals listed on the label, the EPA registration number, antidotes given on the label and other information about the accident that could aid in treatment.

Be prepared! Read and post safety rules. On the back of this manual, fill in the phone number of your local ambulance service, doctor and hospital. Inform your doctor of any *Notes to Physicians* on the pesticide label of the pesticides that you plan to use, and get his/her advice about what antidotes should be kept on site.

PESTICIDE SELECTION AND TIMING

Each pesticide has a unique set of characteristics that must be considered before selecting the best material, including:

- applicator and environmental hazards
- activity against the target pest
- effects on beneficial insects and mites
- restricted entry and preharvest intervals
- tank mix compatibility
- phytotoxicity risk
- interactions with previous pesticide applications and likely subsequent applications
- residual protection
- sensitivity to weather during application and to temperature for optimum performance
- resistance management

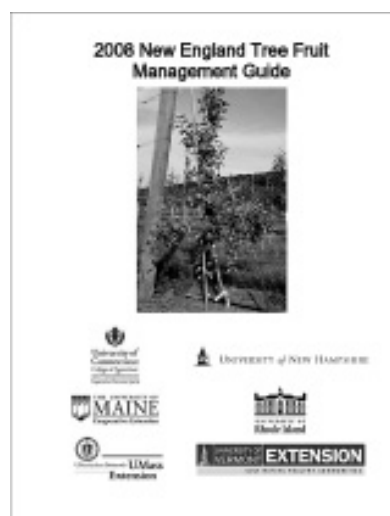
In addition, there are factors that affect the timing of every application:

- growth stage of tree or fruit
- scouting observations
- pest lifestage
- activity pattern of pest or of honeybees and other beneficial species
- the weather before, during and after application

Because of these complex interactions that play between the target pest, pesticide choice, and application timing, it is vital to become familiar with the currently available pesticide products. The best resource for Maine fruit growers is the latest *New England Tree Fruit Management Guide*, which covers pesticides used in the production of apples, pears, cherries, peaches, nectarines, apricots, plums and prunes. For more information, contact the UMaine Cooperative Extension, Pest Management Office. The 2008 edition is available online from UMass Extension: <http://www.umass.edu/fruitadvisor/2008/netfmg/index.html>

MANAGING PEST RESISTANCE

The potential for developing a pesticide-resistant pest population depends on interaction between biological and chemical factors. One consistently true rule is that reducing the number of times a pesticide is used decreases the potential for resistance to that chemical. Making full use of biological, cultural and other non-pesticidal controls is a key factor in preventing resistance because these methods suppress the pest population without the genetic selection pressure that leads to resistance. In addition, natural enemies of pest mites and insects can



For information about the latest version of the *New England Tree Fruit Management Guide*, contact:

**University of Maine Cooperative Extension
Pest Management Office**

207-581-3880, or toll-free (Maine only) 1-800-287-0279

actually reduce resistance because the enemies attack both resistant and susceptible individuals, thereby diluting the breeding advantage of the pesticide-resistant individuals.

Because of the differences among pests and pesticides, a resistance management strategy must be tailored for each situation. A strategy that works for one class of pesticides may increase the problem if used incorrectly for others. For example, combining two types of fungicide has worked to control resistant apple scab fungus populations. This is because individual scab spores that are resistant to one fungicide are still killed by the other. But combining two or more insecticides or miticides has been found to fail because the pest insect or mite population is likely to develop resistance to all of the combined materials creating a multiple-resistant pest. Rotating among products with different modes of action so that any one chemical is used as infrequently as possible is a better approach for preventing insecticide and miticide resistance. Chemical groups with shared mode of action and groups with examples of cross-resistant pests include:

- organophosphate and carbamate insecticides
- pyrethroid insecticides
- organotin miticides
- tetrazine miticides
- benzimidazole fungicides
- sterol inhibitor fungicides
- strobilurin fungicides

To manage the development of pesticide resistance:

- Develop and use an IPM plan that incorporates as many different control mechanisms as possible.
- Select early maturing varieties or varieties that are resistant to pests.
- Avoid broad-spectrum pesticides when a more specific pesticide will suffice.
- Maintain beneficial insect populations.
- Follow label recommendations for rotating or mixing products from different classes based on modes of action—this is not just different brands.
- When making multiple applications per season, use alternate products from different mode of action classes so that only one generation per season is exposed to a particular class of pesticides. If feasible, rotate products from different classes from year to year to reduce selection pressure when only one application is being made.
- Use insecticides and miticides at labeled rates and spray intervals. Do not reduce or increase rates from manufacturer recommendations; this can hasten resistance development.
- Sprayer nozzles should be checked for blockage and wear, and be able to handle pressure adequate for good coverage. Spray equipment should be properly calibrated and checked on a regular basis.
- Time applications against the most susceptible life stages to gain maximum benefit from the product.
- At the end of the season remove crop residues, as appropriate, to eliminate food sources and over wintering habitats for pests.

QUESTIONS ABOUT PESTICIDES?

The National Pesticide Information Center (NPIC) provides objective, science-based information about a variety of pesticide-related subjects, including pesticide products, recognition and management of pesticide poisonings, toxicology, and environmental chemistry. NPIC also lists state pesticide regulatory agencies, and provides links to their Web sites.

The National Pesticide Information Center

<http://npic.orst.edu/>
1-800-858-7378
email - npic@ace.orst.edu

LABEL COMPLIANCE

Federal laws warn that food shipments bearing residues of pesticide chemicals in excess of established tolerances will be contraband and subject to seizures as “adulterated.” This applies to both raw and processed foods.

The amount of pesticide residue in or on a food material at harvest must fall into established tolerances, expressed in *parts per million* (ppm). The actual amount of pesticide chemical found in foods at harvest depends, in part, on the amount applied to the crop and the length of time since the last application. Therefore, growers are responsible for strictly following label information

Under the current EPA regulations, it is legal to apply pesticides:

- at a different rate per 100 gallons dilute than stated on label as long as the application stays within the dose per acre limit;
- at a lower rate per acre than on label; or
- less frequently than on label.

It is illegal to:

- increase amount of pesticide applied per acre (overdosage);
- use shorter intervals between sprays than minimum interval stated on label; and
- shorten intervals to harvest (leaving illegal residues on crop).



For more information about State and Federal pesticide laws, contact:

The Board of Pesticides Control

28 State House Station
Augusta, ME 04333-0028
207-287-2731

<http://www.thinkfirstspraylast.org>
email - pesticides@maine.gov

Chapter Three

Airblast Sprayer Applications

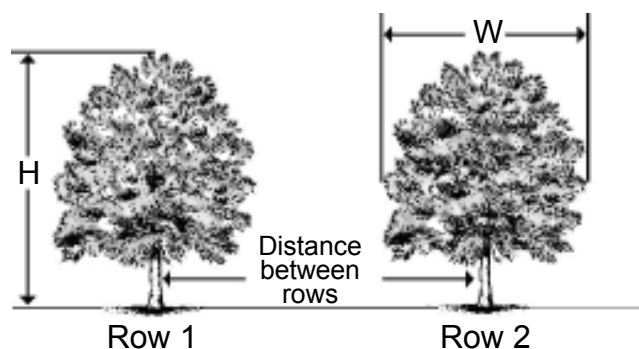
Although there are several application methods, orchard pesticides are most frequently applied using airblast equipment. These applications are often spoken of as either dilute or concentrated. A dilute application uses enough water to wet all foliage surfaces to the point where it just begins to drip from the leaves—additional spray would just run off onto the ground. Dilute applications may require a great deal of water and are rarely used in practice.

The more common method of application uses concentrate sprays. The fine droplets produced by airblast sprayers efficiently cover foliage without the large amount of water needed to reach the point of runoff. Because the volume of water in the tank mix is lower, the concentration or ratio of pesticide increases, hence the name concentrate application. Concentrate applications made with airblast sprayers commonly use 40–80 gallons per acre.

Even though orchardists rarely apply pesticides as dilute applications, it is necessary to know the amount of water needed for a dilute application because this is the basis for calculating how much pesticide to use.

TREE ROW VOLUME AND DILUTE GALLONS PER ACRE

Orchard blocks with different size trees and row spacings require a different dilute gallonage per acre. By making a few simple measurements and using the tree row volume (TRV) formula, growers can estimate how much water is needed for a dilute spray to different blocks.



Tree Row Volume (TRV)
= Tree Height x Tree Width x Row length per acre.

DEFINITIONS

All distance measurements are in feet.

Tree Height (H) = Distance from the ground to the top of the canopy. Except for trees trained to high clearance.

Tree Width (W) = Looking down a row from one end, the average maximum tree width.

Row Length per Acre (RLA) = 43,560 square feet divided by distance between rows.

Tree Row Volume (TRV) = Tree Height x Tree Width x Row length per acre.

Dilute Gallons per acre (DG/A) = TRV x 0.7 gallons divided by 1,000.

Concentrate Gallons per acre (CG/A) = Dilute gallons per acre divided by Concentration (or "X") factor.

Accurate dosage for pesticides applications or thinning, growth regulator, and calcium sprays is too important (and mistakes are too costly) to leave it to guesswork. Use a folding carpenter's ruler or tape measure, and a pocket calculator, to take relatively precise measurements and calculate accurate results.

$$TRV = (H \times W \times RLA)$$

TRV = Tree Row Volume

H = Average Tree Height

W = Average Tree Width (this is twice the distance the average tree extends from the trunk into the travel row).

RLA = Row Length per Acre

= 43,560 sq. ft. ÷ feet between rows (center to center).

$$\text{Dilute Gallons per Acre (DG/A)} = (TRV \times 0.7) \div 1,000$$

The dilute gallons per acre formula uses an average value of 0.7 gal. needed to cover each 1,000 cu. ft. of tree canopy area. This average value is adequate for practical use. The true value varies from about 0.4 gal./1,000 cu.ft. early in the spring to as much as 1.0 gal./1,000 cu.ft. on poorly pruned trees in late summer.

Example 1: If your trees are 13 feet high, 12 feet wide, and planted with 20 feet between rows, use the *Tree Row Volume* formula to calculate the *Dilute Gallons per Acre* (DG/A)—the amount of water that must be applied per acre for a dilute application:

$$\begin{aligned} \text{TRV} &= 13 \text{ ft.} \times 12 \text{ ft.} \times (43,560 \text{ sq. ft.} \div 20 \text{ ft.}) \\ &= 156 \text{ sq. ft.} \times 2,178 \text{ ft.} \\ &= 339,768 \text{ cubic feet of tree canopy per acre} \end{aligned}$$

$$\begin{aligned} \text{DG/A} &= (339,768 \times 0.7) \div 1,000 \\ &= 237,838 \div 1,000 \\ &= 238 \text{ gallons per acre} \end{aligned}$$

Caution: For very small trees, the TRV dilute gallons per acre can be below 100 gallons. However, these small trees are very inefficient at capturing spray deposit. Therefore, *always assume at least 100 gallons per acre is needed for a dilute application*, even if tree size indicates a lower amount.

CONCENTRATE SPRAYING

A dilute application is also called a 1X spray. The actual amount of water used to apply pesticide is usually much less than the dilute rate. The actual amount is the *Concentrate Gallons per Acre* (CG/A). An application that uses $\frac{1}{3}$ the dilute amount of water is called a “3X” spray. Commonly used spray concentrations are 2X, 3X, 4X, 6X, and 8X.

Concentrations above 8X increase the difficulty in getting adequate spray coverage and increase the potential for phytotoxicity (damage to the trees).

Example 2: For the previous example with 238 gallons per acre for a dilute application, what are the *Concentrate Gallons per Acre* for different commonly used concentration factors?

CG/A = DG/A ÷ Concentration (or “X” factor)

$$\begin{aligned} \text{For 2X, CG/A} &= 238 \div 2 = 119 \text{ gallons per acre} \\ \text{For 3X, CG/A} &= 238 \div 3 = 79 \text{ gallons per acre} \\ \text{For 4X, CG/A} &= 238 \div 4 = 60 \text{ gallons per acre} \\ \text{For 6X, CG/A} &= 238 \div 6 = 40 \text{ gallons per acre} \\ \text{For 8X, CG/A} &= 238 \div 8 = 30 \text{ gallons per acre} \end{aligned}$$

The advantages of spray concentrations of greater than 3X may be outweighed by a decrease in effectiveness for some pests (mites, aphids, scale, sporulating scab lesions). Dilute sprays are generally more effective for applying oil, growth regulators and foliar nutrients.

As gallons of water are reduced, errors in calibration or spray pattern become more critical.

Concentrate spraying creates greater sensitivity to wind speed (should be no more than 5 mph), drying conditions, sprayer speed (should be no more than $2\frac{1}{2}$ –3 mph), and accurate sprayer calibration. Problems with phytotoxicity and incompatibility between spray materials also increase with higher concentrate sprays. The amount of oil used should not be more than 3 times the recommended rate per 100 gallons dilute even if the spray concentration is over 3X. The increase in efficiency from using less water per acre reaches a point of diminishing returns and increasing problems when spray concentration is increased beyond 8X.

A 20% reduction from the recommended dilute rate pesticide dosage is typically made when the pesticide is applied in a 3X or higher concentrate spray. This is based on the idea that, compared to a dilute application, less pesticide is needed in a concentrate spray because less is lost to runoff. Concentrate spray dosage reduction seems to work well for most pests and pesticides, but it is not appropriate for some growth regulators.

DETERMINING PESTICIDE DOSAGE

The dosage amount listed on labels for pesticides used on fruit trees is stated in two ways. The first way is the amount per 100 gallons dilute spray. To determine how much pesticide to put in the tank using pesticide dosage per 100 gallons dilute, use this formula:

Amount of Pesticide =

$$\frac{\text{Amount of Spray Mix} \times \text{Pesticide per 100 gal.} \times \text{Concentration Factor “X”}}{100 \text{ gallons}}$$

Example 3: If the pesticide label calls for 4 oz. per 100 gallons dilute, and you are making 200 gallons of 3X spray mix, how much pesticide should you put into the sprayer?

$$\begin{aligned} \text{Amount of pesticide} &= (200 \text{ gal.} \times 4 \text{ oz.} \times 3) \div 100 \text{ gal.} \\ &= 2400 \text{ oz.} \div 100 \\ &= 24 \text{ oz.} = 1.5 \text{ lb.} \end{aligned}$$

The second way that application rates are stated is the amount to use per acre of trees. As shown earlier in the TRV formula, trees are a volume target for spray. Acreage is a measure of area, not volume. The number of acres does not indicate what the tree size is and the amount of foliage per acre that needs to be covered with spray.

There are conventions used to translate acres into a volume measure. For example, for apple trees,

DEFINITIONS

All distance measurements are in feet.

Travel Speed (TS) in miles per hour = 60 divided by the number of seconds required to travel 88 feet.

Swath (S) for spraying every row = the distance between rows. For alternate row spraying, swath would be twice the row spacing if you want the full pesticide rate per acre. It would be only the distance between rows if you want half of the full pesticide rate per acre, applied more frequently.

Gallons per minute (GPM) = the gallons of water pumped out of the sprayer each minute. This equals the product of concentrate gallons per acre x Swath x Travel Speed) all divided by 495.

$$\text{GPM} = (\text{CG/A} \times \text{S} \times \text{TS}) \div 495$$

treating an acre of standard root stock apple trees is assumed to require 400 gallons of solution per acre for a dilute application. Since very few orchards with trees this size remain, the “standard” rate must be adjusted to current production practices for dwarf and semi-dwarf rootstocks.

To convert a label amount per acre of “standard” apple trees to the amount needed for your orchard, use the following formula:

$$\text{Amount of Pesticide per Acre} = \frac{\text{Amount per acre for "standard" trees} \times \text{DG/A in your orchard}}{400 \text{ Gallons per Acre}}$$

Example 4: If the label calls for 3 lbs. per acre when treating standard trees, how much pesticide should you use per acre for trees where the dilute gallons per acre is 180?

$$\begin{aligned} \text{Amount of pesticide} &= (3 \text{ lb.} \times 180) \div 400 \\ \text{to use per acre} &= (540 \div 400) \\ &= 1.35 \text{ pounds per acre} \end{aligned}$$

Note: Some pesticide labels recommend a minimum rate per acre regardless of adjustment for TRV.

Always follow the label!

NOZZLE SETUP

Airblast nozzles should only be used within their specified pressure range. Airblast sprayer pressure is usually between 100 and 200 pounds per square inch (psi). Using pressures above 200 psi creates superfine spray droplets, which significantly increases the risk of spray drift. In addition, hot weather can cause superfine droplets to evaporate before hitting their target. Using pressures below 100 psi may create droplet sizes too large to reach their intended target increasing the risk of poor coverage. However, this pressure guideline will not apply to your sprayer if it is one of the alternate designs, such as an air shear sprayer that uses low pressure nozzles.

For trees over 10 feet tall, a general guideline is to select nozzles that direct ²/₃ of the sprayer output to the upper half of the tree.

AIRBLAST SPRAYER CALIBRATION

1. Mark out a test course of 88 feet.
2. Fill the sprayer with clean water only.
3. With a moving start, pull the airblast sprayer at the speed you would use to apply pesticide through the length of the test course.
4. Record the time it takes to travel the 88 feet.
5. Repeat steps 3 & 4 on the return trip.
6. Average the two travel times together.
7. Calculate Travel Speed (TS):

$$\text{TS} = 60 \div \text{average time in seconds to travel 88 feet}$$

8. Calculate the Swath Width (SW):

For spraying every row,

$$\text{SW} = \text{the distance between rows.}$$

For alternate row application,

$$\text{SW} = \text{twice the distance between rows.}$$

9. Calculate the desired Gallons Per Minute (GPM) from all the nozzles combined:

$$\text{GPM} = \frac{(\text{CG/A}) \times \text{SW}(\text{ft.}) \times \text{TS}(\text{mph})}{495}$$

Example 5: For the same orchard as described in Example 5 and a sprayer that takes 20 seconds to travel 88 feet, what is the desired gallons per minute for a 3X application applied every row?

$$\begin{aligned} \text{Time(sec) to travel 88 feet} &= 20 \text{ sec.} \\ \text{Travel Speed (TS)} &= 60 \div 20 = 3 \text{ mph} \\ \text{Swath Width (SW)} &= 20 \text{ ft. for every-row} \\ &\quad \text{application} \\ \text{CG/A (from Example 1)} &= 238 \div 3 = 79 \text{ gal. per acre} \end{aligned}$$

$$\begin{aligned} \text{Gallons Per Minute} &= \frac{(79 \text{ CG/A} \times 20 \text{ ft.} \times 3 \text{ mph})}{495} \\ &= 9.58 \text{ GPM} \end{aligned}$$

Checking sprayer output

Sprayer output can be measured using a nozzle flow meter or by the sprayer refill method. A combined approach using a flow meter to detect worn or plugged nozzles, and the sprayer refill method to measure overall sprayer output is recommended. Another method of checking nozzle output is by attaching hoses to the nozzles and collecting the output in a bucket or calibration jar. This allows you to determine individual nozzle output and deviation.

Nozzle Flow Meter: Using a flow meter allows you to find individual nozzles that deviate more than 5% above or below the desired output. (If a nozzle deviates more than 5% below the average, it may need cleaning. If it deviates more than 5% above the average, it may have a worn orifice and needs replacement. Recalibrate the sprayer after cleaning or replacing nozzles). Adding together the flow meter measurements for all of the nozzles on the sprayer gives you the total sprayer output.

Sprayer Refill Method:

1. Fill the sprayer with water.
2. Spray water at normal sprayer pressure for 3 minutes.
3. Turn off the sprayer.
4. Determine the gallons per minute (GPM) discharged by the sprayer:

$$\text{GPM} = \text{gal. needed to refill the sprayer} \div 3 \text{ min.}$$

Making adjustments

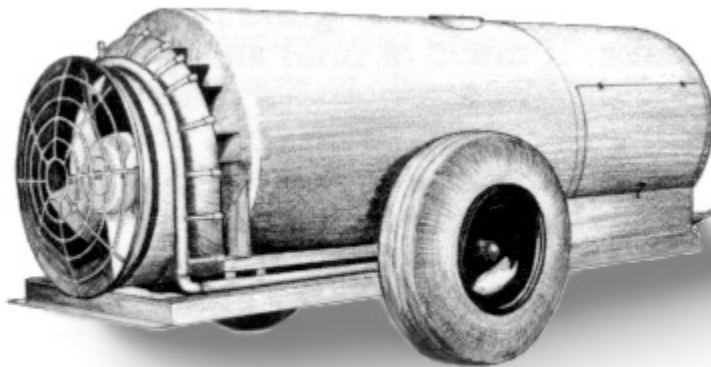
After the actual output is calculated, compare it to the desired gallons per minute output (calculated

in Example 3). Adjust and recalibrate until the volume is within 5% of the recommended volume. For small adjustments, you can adjust the pressure within the recommended range suitable for the nozzles being used. You also can adjust travel speed. If other settings remain the same, increasing travel speed decreases the amount of spray per acre. The application rate is inversely affected by travel speed. For example, doubling the travel speed will halve the amount of spray mixture applied. However, travel speed should remain in the range of 1½–3 mph for best coverage. For large adjustments, you may need to add or subtract nozzles, or change to nozzles with a different output rate.

After adjustments are made, repeat the calibration steps until the desired gallons per minute output rate is reached. Refer to your operator's manual for methods of adjustment.

Adjusting for different sized trees in the same orchard

One way to do this is to use “flip nozzles” that give you two nozzle configurations on the same sprayer. More commonly, growers calibrate the sprayer for the largest trees they will spray, and then shut off nozzles not needed to get good coverage of small trees. This approach may be practical, but it usually results in overspraying smaller trees. A more exact nozzle configuration for small trees can easily pay for itself in spray material savings, less risk of drift, less risk of phytotoxicity, less risk of illegal residues, and other problems associated with inaccurate dosage.



For more information about sprayer calibration, see the latest version of the New England Tree Fruit Management Guide: UMaine Cooperative Extension, Pest Management Office, 491 College Ave., Orono, ME 04471-1295. Phone: 207-581-3880, or 1-800-287-0279 (toll-free in Maine only) .

APPLE BUD STAGES

Many orchard production activities parallel the stages of growth that apple buds pass through as they develop into fruit. These named stages are often used as benchmarks for timing pesticide applications.



Dormant

This is the overwintering stage. No swelling visible.



Silver Tip

Swelling noticeable. Bud scales separate at tip to reveal light-gray leaf tissue.



Green Tip

Green leaf tissue of the first leaves (spur leaves) is visible along the side of the bud.



Half-inch Green

One half-inch of green tissue is visible. Spur leaves begin folding away from the bud.



Tight Cluster

Spur leaves have folded back exposing a tight cluster of growing flower buds.



Pink

Individual flower buds have separated. Pink petals are visible. Stems fully extended.



Bloom

A typical leaf whorl has 5–8 blossoms; the king bloom is the first to open.



Petal Fall

The stage during which flower petals are falling from the tree.



Fruit Set

Distinct swelling of set fruit in each cluster.

Chapter Four

Fungal and Bacterial Pests

APPLE SCAB

Apple scab is caused by the fungus *Venturia inaequalis*. This disease can be devastating to apple crops; severe foliar infection can lead to premature defoliation with reductions in fruit quality and yield. Because many commercial cultivars are highly susceptible to this fungus, and because the Maine climate provides favorable conditions for infection, apple scab is the most important disease of apples in our area.

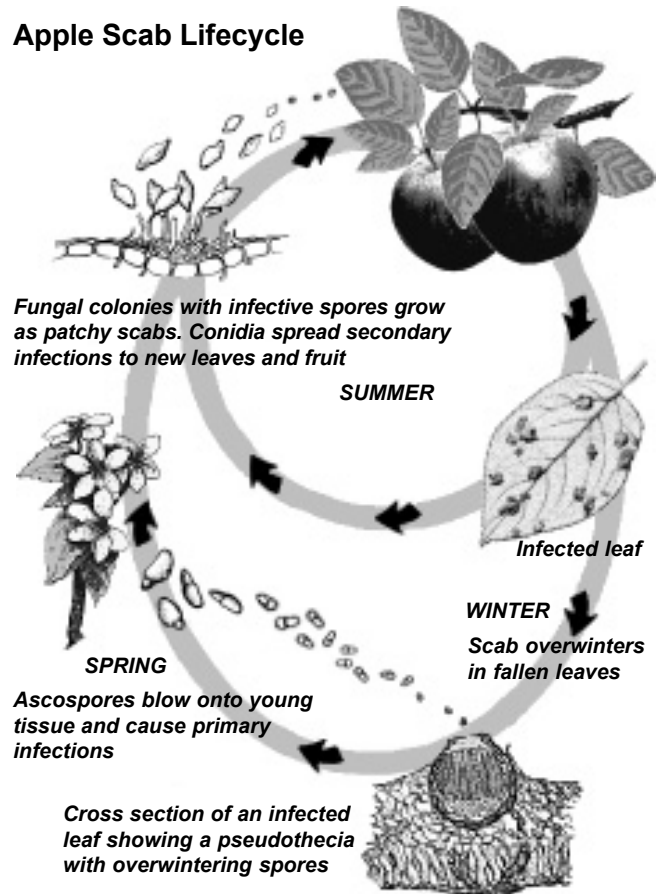
The apple scab fungus overwinters on fallen apple leaves that were infected during the growing season. In autumn, scabby leaves on the orchard floor grow fungal reproductive structures, known as a pseudothecium or a perithecium, and overwinter in the leaves. The next spring, usually around green tip, infective fungal spores (ascospores) are produced and discharged into the air when there is sufficient rain (at least 0.01 inch) to wet the leaves. The period of time that ascospores are released from overwintered, infected leaves is referred to as the primary



Above: Apple leaves infected with apple scab. Dark areas of fungal growth often follow leaf veins. Early scabs may have a halo of yellowed tissue, later they appear velvety as conidia develop. Below: Apple scab lesions on fruit. The fungus is edible but not very appealing.



Apple Scab Lifecycle



scab season, and lasts roughly 6–8 weeks depending on temperatures and frequency of rain.

The first infections of the season, known as primary infections, can occur on susceptible apple tissues (young leaves, petioles, sepals, pedicels and young fruit) only if the temperature is favorable and the tissue remains wet for a certain amount of time after the ascospores land; this is known as the incubation period. If an infection occurs, scab lesions become visible in 9–17 days, depending on the average temperature during the incubation period.

New scab lesions continue to spread the disease by growing and releasing another type of infective spore known as a conidiospore. These spores (or conidia) are dispersed by rain or heavy dew, usually to other areas of the same tree. If they land on susceptible tissue, they can cause secondary infections. Each scab lesion can produce conidia for 4–6 weeks. After the primary scab season has passed, conidia from new scab lesions are the sole source of spores for the remainder of the growing season.

Managing apple scab

Scab-resistant cultivars are cultured for disease resistance and offer the possibility of greatly reducing or eliminating fungicide use. Contact your local UMaine Cooperative Extension Office for more information about scab-resistant cultivars; offices are listed on the inside of the back cover.

Prune trees to open the tree canopy and promote air and light penetration. This reduces the amount of time leaves and fruit surfaces remain wet enough to support a potential infection. Opening the canopy also permits greater penetration of pesticide sprays.

Remove alternate host trees that are untreated, such as flowering crabs and abandoned apple trees, from within 100 yards of an orchard. This reduces the number of ascospores entering the orchard from outside sources to an insignificant level.

Manage fallen leaves. Flail-mowing fallen leaves in autumn or early spring (before bud break), or applying 5% urea to fallen leaves can decrease the amount of spring ascospores by 50–75%. This means that for any one infection period, there would be approximately 50–75% fewer scab lesions compared to the number of lesions that would develop with no sanitation practice.

If leaf fall is very late, then flail-mowing should be delayed until early spring, but as soon as possible after snow cover is gone. If flail-mowing is not possible, a 5% urea solution (42 lbs. urea/100 gals. water) should be applied to fallen leaves at 100 gals. per acre so that the leaf litter is thoroughly wet.



Apple scab on young fruit and leaves. Primary infections occur on young leaves, petioles, sepals, pedicels and young fruit, but only if the temperature is favorable and the tissue remains wet for a certain amount of time.

Another option is to flail-mow and then apply urea to the “in-row” area that could not be reached by the flail mower.

Chemical control. Chemical control is essential in orchards planted with cultivars rated moderately or highly susceptible to scab. On these cultivars, the best strategy is to use fungicides based on leaf-wetness and orchard temperature measurements during the primary season. This allows for reductions in fungicides later in the growing season and less overwintering inoculum for the following spring. For more information, see latest version of the *New England Tree Fruit Management Guide*.



Black rot limb canker



Leaf spot from black rot is known as frog-eye



Black rot on fruit

Black rot infections can occur at three different sites.

BLACK ROT

Black rot is caused by the fungus *Botryosphaeria obtusa*. Three sites of infection produce three different symptoms: a limb canker, a leaf spot, and a fruit rot. The name black rot refers to the appearance of the fruit rot and limb cankers; the leafspot is known as frog-eye leaf spot. The fungus can also cause a core rot around the seed cavity in developing fruit.

Frog-eye symptoms on leaves first appear about 1–3 weeks after petal fall. Early leaf infections look like small purple flecks that rapidly enlarge into lesions about $\frac{1}{8}$ – $\frac{1}{4}$ inch in diameter. These spots resemble “frog eyes” in that they retain a purple margin and have a light brown-tan center. Fruit (sepal) infections can occur as soon as bud scales begin to loosen. These early infections can result in blossom-end rot later in the season.

After petal fall, infections of young fruit begin as reddish flecks that turn into purplish pimples; these enlarge into dark-brown necrotic areas when the fruit begins to mature. Later infections of mature fruit are characterized by black, irregularly-shaped lesions surrounded by a red halo. As these lesions expand, they become patterned with alternating brown and black concentric bands. The flesh of the decayed area remains firm and leathery.

Infected areas of branches and limbs are reddish brown and slightly sunken. These cankers can expand to several feet in length. Black rot will rapidly colonize locations with previous damage, including old fire-blight cankers and cold-damaged tissue. Fruiting bodies (known as pycnidia) are abundantly produced on dead bark, dead twigs, and mummified fruit. Throughout the growing season, infective spores are released when it rains, often infecting nearby tissue. Infected leaves and fruit are regularly found below mummies and old fire blight cankers.

The optimal temperature for leaf infection is 80°F. The optimal temperature for fruit infection ranges from 68°F–75°F. At these temperatures, a minimum of 4½ hours of leaf wetness and 9 hours of fruit wetness must occur for infection.

Managing black rot

Removing cankered wood, mummified fruit, and chopping or removing pruned wood are important steps in the management of this disease. If a black rot problem persists after implementing these sanitation tactics, then multiple applications of fungicides may be needed from after petal fall through mid- to late-August to prevent fruit infections.

WOOD ROT FUNGI

Orchard trees are susceptible to many wood-rot fungi. These fungi are usually opportunistic pathogens that they invade stressed and/or weakened trees through wounds. Infecting the wood within, these fungi grow up and down the limb or trunk in the oldest wood. Wood rotting fungi will cause a tree to slowly decline for years.

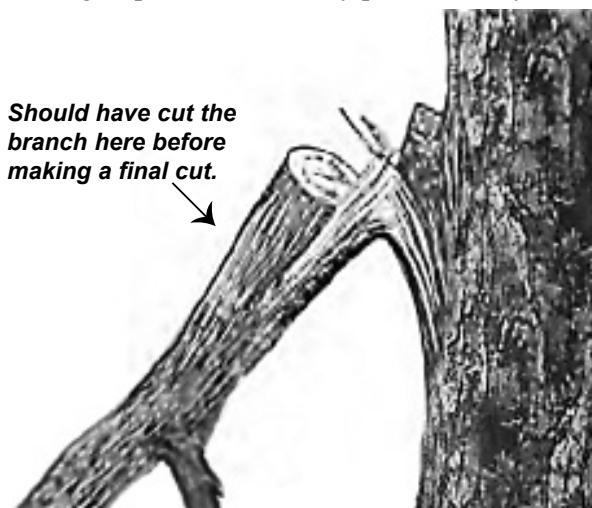
Typical wood-rotting fungi include *Chondrostereum purpureum*, *Trametes versicolor*, *Schizophyllum commune*, and *Polyporus hirsutus*. These fungi can be found on the edge of discolored heartwood present in most older apple trees. When the fungi move from older wood into younger wood near the bark, they can create a canker in the bark.

Managing wood rot fungi

The infective spores that spread wood rot fungi come from dead or decaying limbs, trees, or stumps on which bracket mushrooms have developed. This group of fungi attacks many species of trees and is common in the woods surrounding most orchards. This makes it very difficult to reduce the naturally present inoculum. However, practices that promote the health of trees (i.e., proper nutrition and adequate water) and that decrease the potential for wounds or broken limbs (i.e., proper training and pruning) will decrease the potential for infection and disease development by wood rot fungi.

Proper pruning

Pruning out dead or diseased limbs is an important part of disease management but, because infective fungal spores are naturally present, every cut

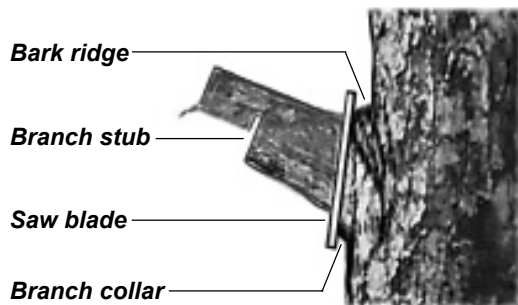


It may seem quick and easy to remove larger branches with a single saw-cut but to avoid damaging the tree, first cut the branch back to a stub.

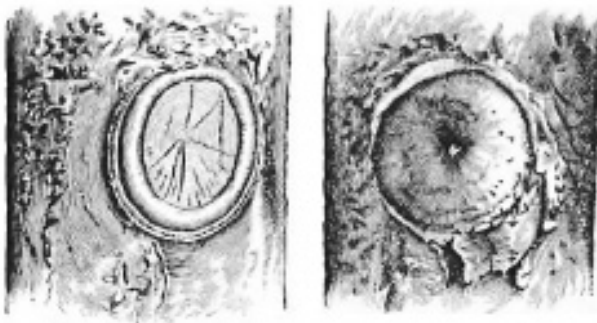
includes the risk of infection by wood rot fungi. Successful pruning requires that all cuts are made in a way that allows the plant to compartmentalize, or close off, the wounds and resume healthy growth. Always use the right tool for the job, and make sure it is clean and sharp.

Before removing a branch, look closely at its structure. You will recognize the branch collar, a slight swollen area at the base of the lower side of the branch, and the bark ridge, a V-shaped region in the top angle between the branch and the main stem to which it is attached. In order for the plant to compartmentalize the wound successfully, both the branch collar and the bark ridge must remain intact after the branch is removed.

Branches an inch or more in diameter should be removed with three cuts, because their bark may tear if they are removed in one step, causing irreparable damage. First cut upward halfway into the branch, one to two feet away from the final cut. Second, cut downward into the branch one inch out from the first cut. This will remove most of the branch. Third, make the final cut based on the location of the branch collar and bark ridge.



The final cut leaves no stub but runs nearly parallel to the trunk, from the the outer edge of the bark ridge in the branch crotch, to just outside of the branch collar at the base of the branch.



A properly pruned branch suffers no splintered wood or peeled bark, and heals before the heartwood rots.

FIRE BLIGHT

Fire blight, caused by the bacterium, *Erwinia amylovora*, is a sporadic disease in Maine, but it can be devastating to susceptible cultivars and rootstocks when it occurs. The bacteria overwinter in bark tissues along the edges of cankers that were produced the previous season. Rain or insects can disperse the inoculum from the cankers into the blossoms where the bacteria multiplies profusely, spreading from blossom to blossom by pollinating insects. The bacteria penetrate host tissue in the presence of water, through wounds or natural openings. Once inside the host, the pathogen continues growth and kills plant cells.

Flowers, fruit, shoots, branches, roots, and trunks can become infected. Recently infected tissues looks water-soaked and may leak a watery, milky to light orange ooze on humid days. As the tissue dies it turns from dark green to brown and black.

Managing fire blight

Successful management of fire blight requires an integrated approach including resistant cultivars and rootstocks; removing sources of inoculum; attention to proper nutrition and irrigation so trees are not overly vigorous; effective timing of blossom treatment, when warranted, to prevent infection; and when possible and necessary, rapid response to remove infected tissue before disease progression and spread.



Fire blight takes its name from the crisp, burned appearance of affected tissue – flowers brown and wilt, and twigs shrivel and blacken.

FLYSPECK AND SOOTY BLOTCH

These diseases are caused by different fungi - flyspeck is caused by *Leptothyrium pomi*, sooty blotch by *Gloeodes pomigena* - but both are normally present on the same fruit. They cause only surface blemishes but this detracts from fruit appearance which lowers fruit quality and market value.

Sooty blotch appears on fruit surfaces as sooty or cloudy blotches with indefinite borders. Blotches are olive green to black and can be removed by rubbing vigorously. Flyspeck looks like true "flyspecks," characterized by sharply defined, small, black, shiny dots in groups of a few to nearly 100 or more.

Both fungi overwinter on the twigs of woody plants, including apple and pear trees. During spring, spores of the fungi are windblown into and throughout the orchard; fruit infection can occur anytime after petal fall, although these diseases usually appear on fruit late in the season.

Disease outbreaks are favored by extended periods of above-normal summer temperatures, combined with frequent rainfall and high humidity. In drier air they apparently remain inactive. Many conditions can contribute to maintaining high humidity in apple tree canopies, and therefore increase incidence of sooty blotch and flyspeck.

Managing flyspeck and sooty blotch

These two diseases usually occur at a time when growers would like to minimize pesticide applications with their restricted entry intervals and days-to-harvest limits. Cultural practices can significantly reduce these disease problems, but fungicides are generally required to maintain commercial fruit quality in all except the most northern orchards.



Flyspeck and sooty blotch cause only surface blemishes but this detracts from fruit appearance and lowers both fruit quality and market value.

Cultural practices that improve air circulation and drying will reduce the diseases—summer pruning, thinning to break up fruit clusters, mowing, and cutting dense hedgerows or nearby woods.

Using fungicides, sooty blotch is easily controlled. In most cases, one or two summer applications provide adequate protection. Flyspeck is more difficult to control. Timing of fungicide applications depends on rainfall and the fungicides used. To prevent flyspeck infection, fungicide coverage should be renewed on or before the depletion date of the previous spray.

BROWN ROT

Brown rot, caused by the fungus *Monilinia fructicola*, is a minor disease of apples and pears but the most serious disease of stone fruits (cherries, plums, and peaches) in Maine. The disease is highly destructive and can ruin half or more of all fruit before harvest, while the remaining fruit is subject to post-harvest infection.

Brown rot is first seen as brown spots on the blossoms in spring; they are soon entirely blighted. The infection may grow into the woody tissue producing cankers which can kill the entire twig. Infections of mature fruit first appear as brown spots that rapidly consume the entire fruit. Tufts of tan conidia are produced on infected fruit which eventually shrivels and dries into "mummies."

The fungus spends the winter in mummified fruit on the tree, and on the ground in infected twigs. In



Brown rot overwinters in mummified fruit or infected twigs. These sites release spores during spring to continue the disease cycle.

the spring spores are produced which infect the blossoms and renews the disease cycle.

As with most fungi, the severity of brown rot is dependent on the weather. Summers with high rainfall and humidity lead to the greatest disease incidence. The fungus can grow slowly at near-freezing temperatures but it grows best at about 70-75°F. The fungal spores require free water to germinate and infect tissues and this water can come from rainfall or dew. Periods of 30 hours of wetness are required to initiate fruit infection and fruit injured by insects, hail, etc. are more susceptible.

Managing brown rot

Fruit infections arise from spores which are produced on recently blighted blossoms and cankers. It is important, therefore, to control the blossom blight phase of the disease.

- Remove all fruit from an infected tree, and from the ground, and prune out infected twigs after harvest. Burn, bury, or otherwise remove material from the orchard. This will reduce the number of spores present in the following season.
- Destroy wild *Prunus* spp. in the vicinity of the orchard. These wild hosts may harbor the fungus.
- Prune the trees to maintain good air circulation which will promote rapid drying.
- Fungicide applications to control the blossom blight phase are important. Fruit should also be protected during the three week period before harvest.

BLACK KNOT

Black Knot, caused by the fungus *Apiosporina morbosa*, is one of the most common diseases of plum and cherry in Maine. It can severely limit the production of these fruit trees.

Symptoms first appear during Autumn as an inconspicuous swelling on the current season's shoots. The fungus over-winters in the stem and erupts during the next spring. As the bark splits, knots emerge, greenish and soft at first but becoming hardened and black by the end of the second year.

The fungus produces infective spores during spring rains which are splashed by the rain and

blown by the wind to land on susceptible plant tissue. These spores can germinate and infect new tissue during wet periods as short as 6 hours. Infection occurs from April through June especially on the current season's growth.

If the knot has girdled the stem sufficiently to cause its death the infection will stop. Otherwise the knot will continue to expand and produce new spores in successive years.

Managing black knot

Black knot can be controlled using a combination of prevention and sanitation.

- Remove all knots and swellings by pruning 3-4" below the knot during the dormant season; before April 1.
- Burn, bury, or otherwise remove prunings from the area as they may still be an active source of spores.
- Severely infected trees should be removed entirely.
- Cut and remove wild hosts of the disease.
- Use resistant varieties if disease pressure is high.
- Preventative sprays may be necessary if nearby disease sources cannot be eliminated or when bringing a heavily infected tree back to health. Fungicide treatments should be applied at budbreak and every week to two weeks, especially before rain until terminal growth stops.



Black knot appears as obvious hard, black and elongated swellings or knots, 1-6" or more in length. The knots are scattered throughout the tree, increasing if left untreated.

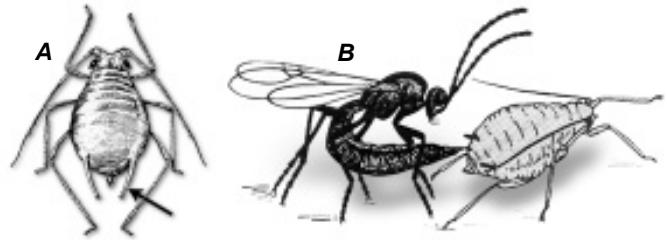
Chapter Five

Insect and Mite Pests

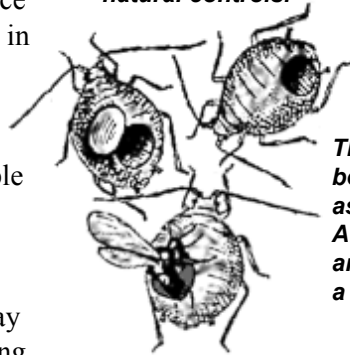
APHIDS

There are five species of aphids commonly found on apples: apple grain aphid, rosy apple aphid, apple aphid, spirea aphid and the woolly apple aphid. The species can be distinguished by their color, the time of year when they are present, and by differences in the cornicles, which are small, paired projections at the rear of the abdomen. Aphids feed on foliage using needle-like mouthparts to suck out plant juices. When present in high numbers, certain species can cause leaves to curl and cup and reduce tree growth and vigor. Aphids usually overwinter in the egg stage on twigs, around buds or in bark crevices.

Woolly apple aphids, *Eriosoma lanigerum*, have a complex life cycle that involves either apple or elm trees, or both. On apple trees they can be found at feeding sites above the ground in bark crevices, pruning cuts, wounds, leaf axils, and occasionally the stem or calyx of fruit, or they may be below ground feeding on the roots. Root feeding produces knotty galls; extensive feeding can stunt root growth. Larger nymphs are about $\frac{1}{16}$ of an inch in length and have a purplish body, concealed by tufts of "wool" which are actually fine wax strands. Woolly apple aphid populations are usually most noticeable in late summer but the above-ground woolly apple aphid population is not a reliable indication of the root-feeding population.



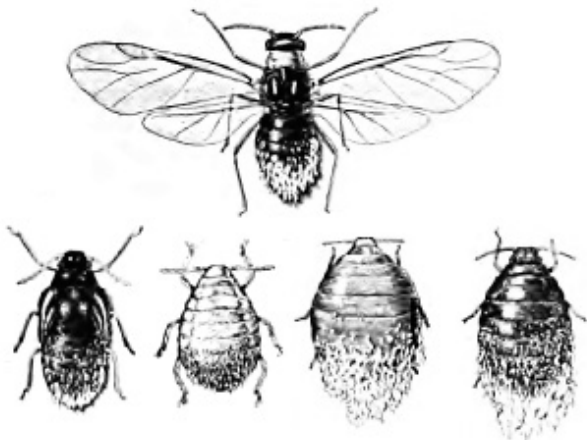
(A) A rosy apple aphid. The arrow points to one of the cornicles which secrete defensive fluids to repel parasitic wasps. (B) The defense is not perfect however, and parasitic wasps are important natural controls.



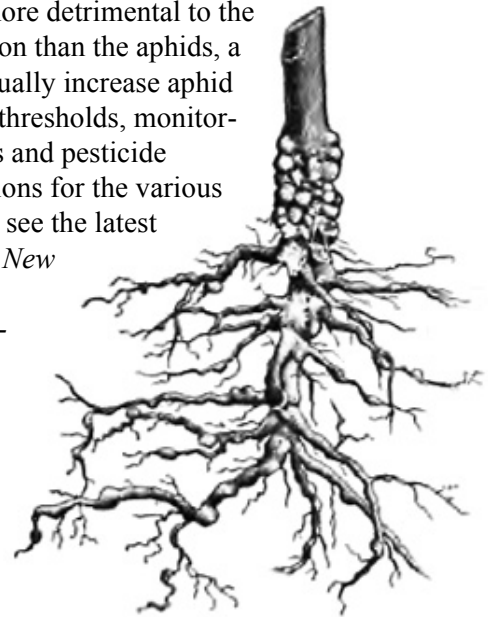
The bodies of parasitized aphids become enlarged and rounded as the parasite grows within. After the wasp cuts an exit hole and flies away, all that remains is a hollow shell.

Managing aphids

Biocontrols, especially certain species of tiny parasitic wasps, play a key role in keeping aphid populations below pest status. If an insecticide treatment is more detrimental to the wasp population than the aphids, a spray may actually increase aphid numbers. For thresholds, monitoring techniques and pesticide recommendations for the various aphid species, see the latest version of the *New England Tree Fruit Management Guide*.



Woolly apple aphids. Winged females can migrate to different host trees. Wingless forms have a purplish body concealed by tufts of "wool," which are actually fine strands of bluish-white wax.



Crown and roots of a young apple tree with the characteristic galls produced by woolly apple aphids.

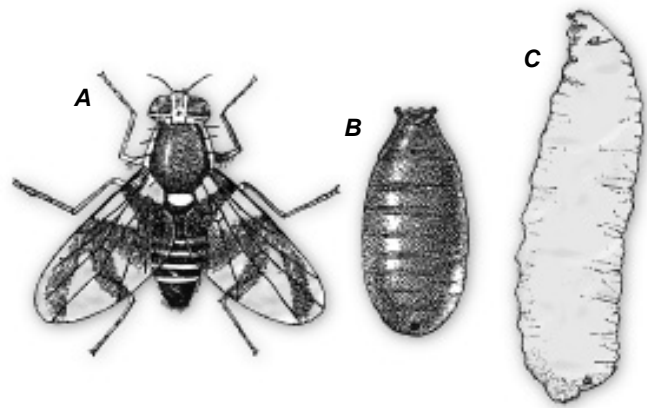
APPLE MAGGOT

The apple maggot, *Rhagoletis pomonella*, lives on wild and cultivated apple, crabapple, and hawthorn trees. The adult fly is a little smaller than the common housefly with wings conspicuously marked by four dusky, wavy bands. The abdomen of the female has four narrow, white, cross stripes; the male has three. There is also a distinct, small white spot at the base of the thorax. The life span of a female apple maggot fly is about 30 days.

Adult emergence begins in June or July, numbers peak in mid-July to early August. Adult flies mate and begin laying eggs beneath apple skin 7–10 days after emergence. Eggs hatch in 5–10 days and the larvae, or maggots, randomly tunnel throughout the fruit, usually avoiding the core. The maggots are legless, creamy white, sometimes yellowish or greenish, and about $\frac{3}{8}$ of an inch long when mature. Signs of infestation on the outside of the fruit include the tiny, brownish egg punctures—small, distorted, or pitted areas in the skin, sometimes with a bit of white wax covering the puncture. In addition, rapid decay occurs along the interior feeding trails which may be visible through the skin. After tunneling for 2–4 weeks, the maggots bore out of the fruit and drop to the ground where they burrow into the soil, change to the pupal stage, and spend the winter. There is only one generation per year.

Managing apple maggot

Adult flies are monitored with sticky traps, either red spheres or yellow traps. The red spheres mimic ripening apples; yellow traps mimic apple leaves. For increased effectiveness, the traps can be baited with apple volatile lures. Place traps in early July using three traps per block hung about head high in trees along the edge of the orchard. The traps should be surrounded by fruit and foliage but not touching



The apple maggot. (A) Adult fly. The wings of the adult are marked by four dark bands and there is a distinct white spot at the base of the thorax. The abdomen of the female has four white stripes; the male has three. (B) Pupa. (C) Larva or maggot.

anything and not obstructed from view. Inspect traps weekly until the end of August; count flies and remove them from the trap at each visit.

Because the eggs and larvae are protected within the fruit, control measures are aimed at the adult flies. Treatments should be based on trap counts. Apply a control treatment if an average of 5 flies per trap is caught within a week (using apple volatiles); use an average of 2 flies per trap if apple volatiles are not used. Suspend monitoring for 14 days following an insecticide treatment, then clean any flies off the traps and begin counting again from zero to see if the threshold is reached again, indicating the need for another treatment.

Important cultural controls include, removing unsprayed apple, crabapple, and hawthorn trees that are near the orchard to help to reduce the local apple maggot population. Collect dropped fruits 2–3 times a week for early varieties and at least once a week for later varieties.



(A) Apple maggots tunnel throughout the fruit, usually avoiding the core. (B) Rapid decay occurs along the feeding trails of apple maggots and eventually becomes visible through the skin.

BORERS

Round-headed apple tree borers, *Saperda candida*, are boldly striped beetles about $\frac{5}{8}$ inches long that emerge in the month after petal fall. Females generally lay their eggs from late June to early August, usually within a couple hundred yards of the tree from which they emerged. Trees less than 10 years old are preferred for egg laying. Larval tunneling occurs on the trunk from about 4 inches below ground to 1–2 feet above the ground. Their presence is often revealed by reddish-brown sawdust pushed out of small pinholes in the bark, as well as sunken or darkened areas of bark, sometimes oozing sap, that overlay areas of feeding damage. If not removed, or eaten by woodpeckers, larvae continue to tunnel through the trunk, slowly growing for 2–3 years before emerging as adults. Affected trees have poor growth or yellow foliage, and may break off at the soil line.

Flat-headed apple tree borer, *Chrysobothris femorata*, adults are dark brown beetles about $\frac{1}{2}$ inch long with a metallic luster. They are primarily active in June and July, on the sunny sides of trees. Eggs are laid in bark crevices. The sinuous trails in the bark are visible without cutting into the tree. Eventually, the grubs bore into the wood, leaving tunnels that are oval in cross-section. The grubs are legless, with a broad, flattened head end, and a cylindrical body. Weakened, stressed or strongly leaning young trees are most frequently attacked.

Dogwood borer, *Synanthedon scitula*, and **apple bark borer**, *Synanthedon pyri*, are both small wasp-like moths that lay eggs in bark crevices, especially

in burr knots and callus tissue around graft unions. Burr knots are rough areas on the bark, usually at or below the graft union, where new, secondary roots are trying to develop. The caterpillars are usually less than $\frac{3}{4}$ inches long, with an orange tinge. They bore in the bark, not the wood. Reddish frass (excrement) on the surface indicates infestation. Adults fly from mid-June through late-August, but most activity is usually in July. The life cycle takes one year.

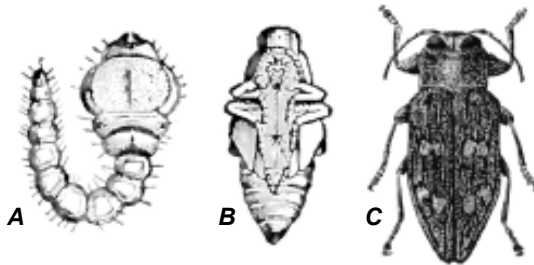
Managing borers

Roundheaded apple tree borers. September, and again in the spring, are the best times to check trunks above and below the soil line for small pinholes exuding reddish sawdust or dark, sunken areas indicating the presence of boring larvae. Shallow larvae may be dug out with a knife. Larvae in deeper tunnels may be killed with a wire or by injecting a suitable insecticide with a grease gun.

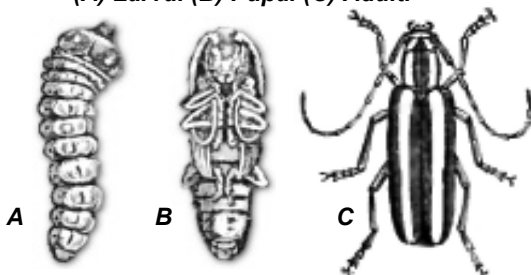
Trees injured beyond recovery should be removed and burned, and nearby trees checked for infestation. If possible, remove alternate hosts (wild and crab apple, choke cherry, hawthorn, mountain ash, shadbush) within 100 yards of the orchard.

Insecticide sprays made against plum curculio and apple maggot also help control adult borers as they feed on apple foliage. July and August applications that reach trunks not shielded by vegetation or guards also help control hatching larvae. Without summer insecticide coverage there is increased risk of attack, especially to trees less than 10 years old.

Brushing diluted white latex paint onto the lower trunk may deter egg laying. A white coating also makes it easier to detect larval tunnels. Another way to prevent damage is to ring the lower trunk with a loose fitting barrier (for example, hardware cloth). The barrier should be closed at the bottom with mounded soil, and tied with a cord around the top. Remove barriers after harvest.



Flat-headed apple tree borer
(A) Larva. (B) Pupa. (C) Adult.



Round-headed apple tree borer
(A) Larva. (B) Pupa. (C) Adult.



The adult dogwood borer is a small wasp-like moth.

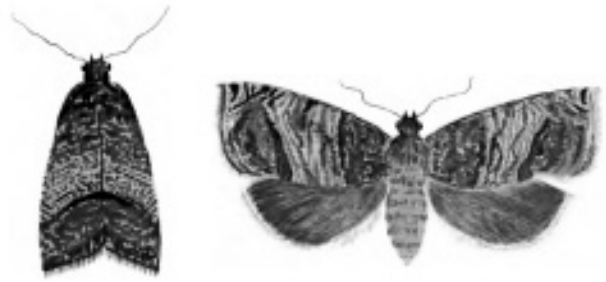
Dogwood borer and apple bark borer. Controlling burr knots helps prevent problems with these borers. Plant trees with the graft union not more than 1–2 inches above ground. Be careful not to bury scion wood. If trees are already in the ground, soil may be mounded around the trunk in a wide mound (not a narrow cone which may increase winter injury). Avoid shading and increased humidity at the trunk due to weeds, sucker growth, opaque vole guards, or debris trapped in vole guards. Diluted latex paint applied to the lower trunk before egg-laying may be an effective deterrent.

CODLING MOTH

The codling-moth, *Cydia pomonella*, is a pest of apples, pears and occasionally of other fruits. The adult moth is small, with a wingspread of only about $\frac{3}{4}$ of an inch. The brown fore-wings are crossed by irregular gray and brown lines. Adult moths are seldom seen; they fly only at night and are not attracted by lights.

Codling moths overwinter as full-grown caterpillars in a protected place, usually under the bark of the tree where the insect fed. In the spring it pupates and the adult moth emerges a week or two after petal fall. After mating, female moths lay 50–75 eggs, singly on leaves, sometimes on twigs or small fruit.

The eggs hatch in about a week, and the caterpillars eventually crawl to and enter developing fruit. Considerable frass (excrement) is normally associated with entry holes, which are often near the calyx end. Larval “stings” are shallow holes caused by a codling moth larva taking a few bites but not burrowing. A “sting” causes a surface blemish but does not result in interior breakdown of the fruit. Caterpillars usually tunnel into the core of the fruit and feed for a month or so until mature. Tunneled fruits usually fall with the “June drop.” Full-grown caterpillars burrow out of the fruit and pupate under a loose piece of



The adult codling moth.

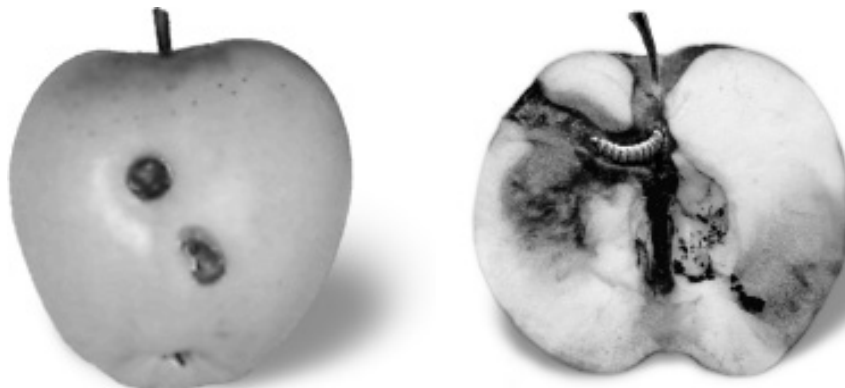
bark. Some larvae enter hibernation while others continue development and emerge as second generation adults from the latter half of July into September. Second generation codling moth larvae cause more damage than first generation. However, some damage attributed to second generation codling moth may actually be caused by oriental fruit moth, lesser appleworm, redbanded leafroller or obliquebanded leafroller.

Managing codling moth

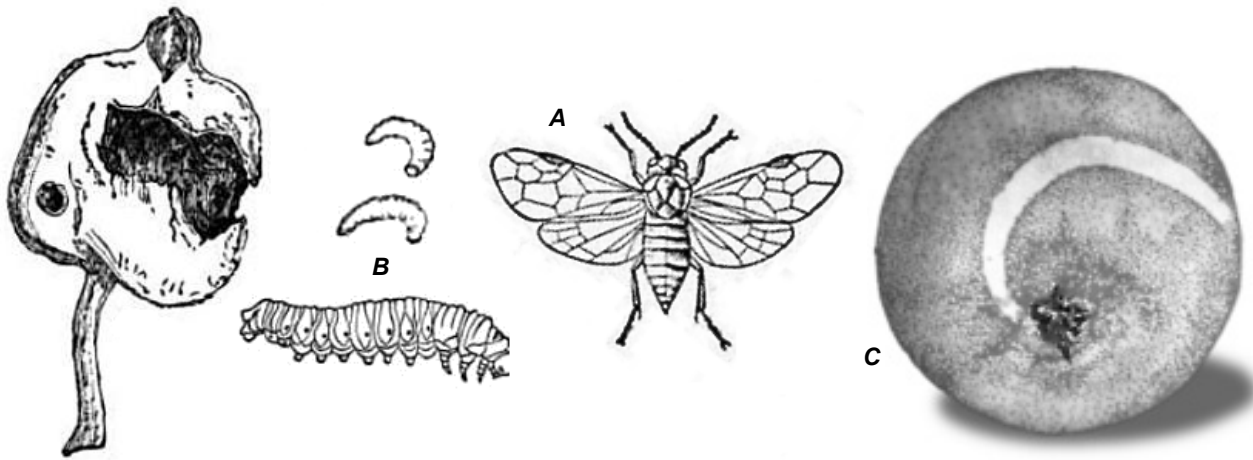
Problems with codling moths are infrequent in Maine because the adults and larvae are usually killed by insecticide sprays made for other pests. Where specific codling moth treatments are needed, insecticide applied when egg hatch begins is the most effective strategy. Optimum spray timing can be estimated by setting up pheromone traps during bloom to detect the beginning of adult emergence.

EUROPEAN APPLE SAWFLY

Sawflies are a group of thick-bodied wasps that do not possess defensive stingers like yellowjackets or bees. The sawfly’s stinger is an ovipositor (a structure for laying eggs) adapted to saw or drill into plant tissue, so they only “sting” plants, and then only to lay eggs.



Codling moth damage, outside and inside.



(A) Sawflies are a group of thick-bodied wasps that do not possess defensive stingers like other wasps or bees. (B) The larvae look much like caterpillars but there are seven pairs of prolegs on sawfly larvae and only five pairs on caterpillars.

(C) European apple sawfly damage. Young larvae feed along the surface of the fruit leaving a curved feeding scar; older larvae bore deep inside the fruit.

The European apple sawfly, *Hoplocampa testudinea*, overwinters as a larva in the soil; it pupates in the spring, and adults emerge during late pink and bloom. Adult sawflies can be seen flying around blossoming apple trees especially on bright, sunlight days. When they land, sawflies move rapidly with quickly vibrating antennae. The average adult life span is 1–2 weeks.

Eggs are laid during bloom, at the calyx end of the fruit. Young larvae feed just below the skin of the fruit, following a spiral path usually toward the calyx. In mature fruit, this injury persists as a visible, curving scar. Older larvae bore deep inside the fruit and may leave conspicuous amounts of wet, reddish-brown frass (excrement) on the infested apple and nearby fruit. When mature, sawfly larvae drop to the soil and construct cocoons in which they remain as pupae until the following spring.

Managing sawflies

Insecticides applied at pink and/or petal fall control this pest. White sticky traps placed before bloom can help determine the need for a treatment at petal fall. Traps should be placed near blossoms at head height on the south side of at least one tree per 3 acres.

LEAFMINERS

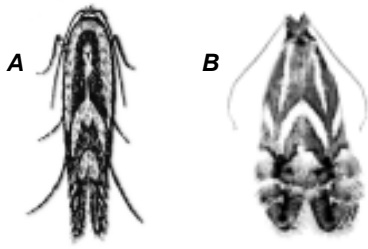
Two species of leafminers are commonly found in New England apple orchards: **apple blotch leafminer**, *Phyllonorycter crataegella*, and **spotted tentiform leafminer**, *Phyllonorycter blancardella*.

For many years the apple blotch leafminer was the dominant species in commercial orchards. However in the past several years, the spotted tentiform leafminer has shown a tendency toward more explosive population growth and has displaced the apple blotch leafminer in many orchards.

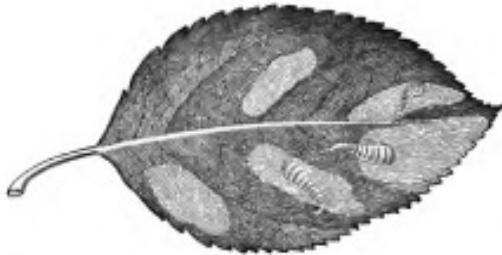
Leafmining describes the feeding habit of many types of insects. Both of the leafminers discussed here are small moths that lay eggs on apple foliage; the caterpillars are so small that they can feed on the tissue within the thickness of the leaf. From the outside of the leaf, the damage they leave is a pale, winding trail or a blotch in the normally green color of the leaf. The biology and management of both the spotted tentiform leafminer and the apple blotch leafminer are similar.

Both species overwinter as pupae within the mines in fallen leaves. Adult moths emerge from the leaf litter and move into tree canopies to mate, generally when trees reach half-inch green to pink. Adult flight and mating activity are most evident on warm, calm evenings when the temperature exceeds 48°F; adults are primarily active at night. Eggs are deposited on the undersides of leaves and hatch 5–16 days later.

Both species of leafminers usually complete 3 generations per year. Newly hatched larvae cut their way between leaf layers and feed on foliar fluids, creating sap-feeding mines which appear as small whitish patches on the undersides of leaves. Heavy feeding damage reduces leaf area which can indirectly affect fruit quality leading to smaller fruit, premature ripening and fruit drop, and reduced fruit.



Above: Leafminer moths are only about 1/8 of an inch long. (A) The apple blotch leafminer. (B) The spotted tentiform leafminer moth. Below: Leafminer damage.



First-generation larvae are active from petal fall through June, second-generation larvae from mid-July to mid-August, and third-generation larvae from mid-August through October. Because generations often overlap due to extended periods of egg laying and larval development, it is often difficult to distinguish between broods.

The two species of leafminers respond differently to traps and exhibit slightly different timing of emergence and adult flight. For more information concerning monitoring, see the latest version of the *New England Tree Fruit Management Guide*.

Managing leafminers

Naturally occurring biological control agents play a major role in keeping leafminer populations below economic significance. Maintenance of these biocontrol agents through insecticide selection and minimization is an important component of leafminer management. When biocontrol fails, there are numerous pesticide options for leafminer control, falling into three basic strategies: prebloom treatments, first-generation mine treatments, and second-generation mine treatments.

For maximum effectiveness with any of these materials, treatment decisions should be based on monitoring of mine density and developmental stage. The best timing for control of first or second generation mines is when sap-feeding mines are visible but before more than 10% of the mines progress to the tissue-feeding stage (when mines become visible on the top surface of the leaf).

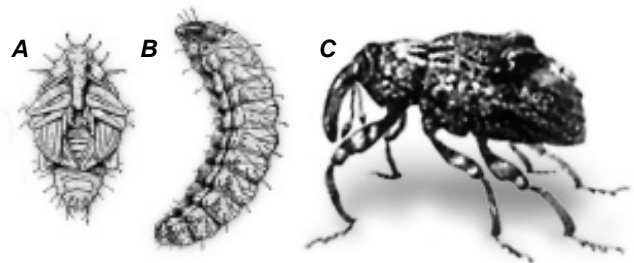
PLUM CURCULIO

Plum curculio, *Conotrachelus nenuphar*, is a native pest that attacks apples, pears, peaches and other stone fruit. This insect is a weevil (a type of beetle) with a prolonged snout about 3/16 of an inch long. Adults are dark brown-black with flecks of grey on their bumpy backs. The larvae are C-shaped, white and legless. The adults overwinter in leaf debris in woods and hedgerows near the orchard, and in the orchard itself.

Plum curculio emerge and begin migrating to apple trees during bloom but peak migration usually occurs from petal fall to 14 days after petal fall. Female curculios chew a small cavity in young fruit and turns to deposit an egg; she then turns again and cuts a 1/8 inch curved slit beneath the egg to leave it protected by a flap of apple tissue. This injury appears as a small crescent-shaped cut on the fruit. Egg laying and feeding damage can occur as soon as the fruits form, and continues until the apples are about 1 1/2 inches in diameter. The crescent-shaped egg-laying slits become D-shaped scars as the apples grow.

Most infested fruits drop in June. Fully grown larvae leave fruit and enter soil to a depth of 1 inch and pupate. Adults of the next generation emerge about 50 days after the eggs were laid in June, and feed on maturing apples until they seek hibernation sites.

Plum curculio damage to fruit can begin abruptly, and extensive damage can occur in a single night. If the temperature exceeds 70°F for 2 days before petal fall, females may be ready to lay eggs at petal fall. Humid, calm, warm evenings (especially if the temperature is above 70°F), pose the greatest risk. The risk of plum curculio damage increases after there have been 3–4 days of average temperature of 55–60°F, or 2 days with maximum temperatures above 75°F, after petal fall.



The plum curculio. (A) Pupa. (B) Legless larva. (C) An adult weevil.

To monitor egg laying, check fruit on border row trees (especially near woods) for fresh damage. Damage appears as small crescent-shaped egg laying cuts and small hollowed-out feeding cavities. Fresh scars show no shriveling of the skin edges, no browning of the flesh at the cut, and no crusty exudate. Search as high as is practical in the tree. Damage may be heavier in trees pruned in April or May, compared to trees pruned earlier or not at all.

Adults can be monitored on warm, humid evenings with a beating tray and a rubber mallet to jar the limb. The new adults move down to the orchard floor during the day and during cool, windy weather. Thus, limb tapping that finds no weevils does not guarantee that they are not present.

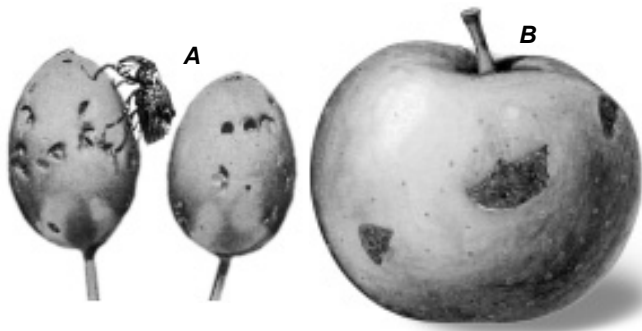
Managing plum curculio

Removing unsprayed plum, hawthorn, and native crabapple trees from near the orchard will reduce the threat of plum curculio damage, especially the threat of egg laying damage 3 weeks or more after petal fall.

Pick up damaged apples as they fall off the tree and destroy them before the adults emerge.

Insecticide applications for apples are typically applied at petal fall, first cover, and (depending on block history, scouting, and weather) second cover. For peaches and cherries, applications are made at petal-fall and shuck-split stages. The shuck split stage is the point where new fruit is just barely visible emerging from the drying floral cup.

If populations of other pests at petal fall are below threshold, and there is not a history of plum curculio damage, it may be possible to delay the first post-bloom spray. The most conservative approach is 2–3 full block applications. An intermediate approach starts with a full block insecticide application right at petal fall followed by border row treatments as needed to maintain effective residue on trees at risk of attack.



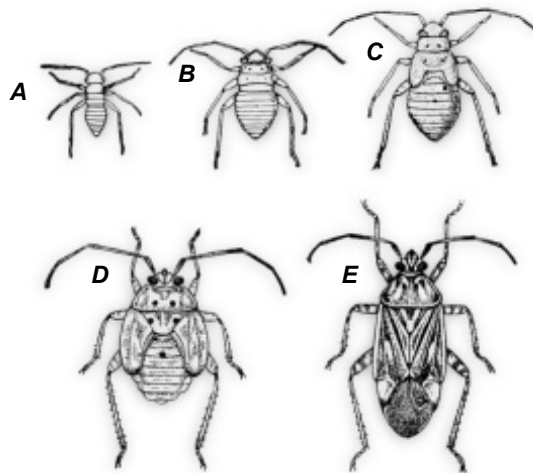
(A) Crescent-shaped scars are a sign of egg-laying (oviposition) by female plum curculios. (B) These enlarge to D-shaped scars as the fruit grows.

TARNISHED PLANT BUG

The tarnished plant bug, *Lygus lineolaris*, overwinters as an adult under rubbish, weeds, fallen leaves, etc. The bronzish adult is about 1/2 inch long and marked with yellow and black dashes. The young nymphs are often misidentified as aphids but, unlike aphids, they are extremely active. Adults become active as the weather warms in spring and they feed on a wide range of weeds, crops, and ornamental plants, including apple fruit buds or fruit from the time of bud swell until about petal fall. Eggs are laid on host plants and hatch in 7–10 days. The complete life cycle may be completed in 3–4 weeks. Three to four generations may occur in one year.

Both adults and nymphs feed on plant sap with piercing-sucking mouth parts. As they feed, they inject poisonous saliva that causes injury to the plant tissues. The buds and developing fruit may be either killed (blind buds), dwarfed or deformed. Fruit dimpling and scabbing is caused primarily from feeding damage at tight cluster to petal fall; feeding before tight cluster causes flower bud abscission.

Tarnished plant bug populations vary considerably between blocks. White sticky traps placed at silver tip can help determine the need for a prebloom treatment. Traps should be stapled to stakes or hung on low branches, no higher than knee height, and near the orchard perimeter. Use at least one trap per 3 acres, with at least 3 traps per monitored block. Pesticide applications may be more effective when applied on a warm, sunny, calm day when TPB are most active.



The tarnished plant bug. (A) The youngest nymphs are 1/25 inch long, yellowish green, with four round black dots on the thorax. (B–D) As nymphs mature, they develop wing buds, that become fully developed as adults. (D) Adult tarnished plant bugs are 1/2 inch long.

Managing tarnished plant bug

Destroying broad leaf weed hosts (such as mullein, pigweed, and golden rod) in and around the orchard in the fall may decrease the overwintering tarnished plant bug population. To improve control, avoid mowing or using herbicide between pink and petal fall because disturbance of alternate hosts in the groundcover may cause tarnished plant bugs to move up into apple trees. If dandelion removal before bloom is necessary, applying insecticide application at pink immediately before the dandelion removal to control tarnished plant bugs that are flushed up into the trees.

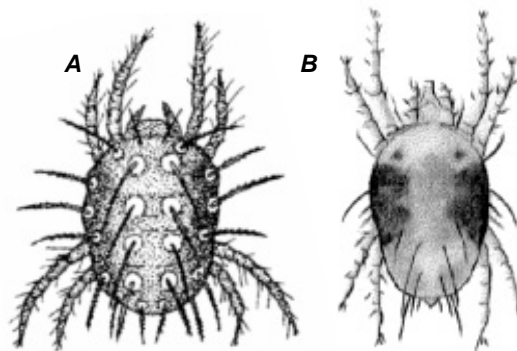
MITES

There are two significant mite pests in orchards, the **European red mite** (*Panonychus ulmi*) and the **twospotted spider mite** (*Tetranychus urticae*). Mites are arachnids related to ticks but they are tiny; adults are just a quarter to a half of a millimeter in length. The first immature stage of both mite species (known as a larva) have only 6 legs; all other immature stages (known as nymphs), as well as the adult, are 8-legged. When temperatures are cool, mites may require more than a month to complete a generation but less than two weeks if the weather is unseasonably dry and warm.

European red mites overwinter as red or orange eggs on rough bark areas of small limbs and fruit spurs. Egg hatch begins at tight cluster, is about half complete by pink, and finishes by petal fall. The twospotted spider mites overwinter as mature females on the lower portion of the tree trunks or in orchard groundcover. They become active before bloom but usually stay on weed hosts beneath the trees into June. They move into apple trees as their populations increase and weeds decline, or when they are disrupted by groundcover management.

These mites have piercing mouthparts and feed on plant juices. Because these mites are foliar feeders and do not directly damage fruit, low populations can be tolerated. However a severe infestation can cause leaf bronzing, reduced photosynthesis, fruit size reduction, preharvest drop, poor fruit coloring, and reduced crop potential for the next year.

Mite injury is most likely to be significant in the weeks following petal fall. It is critical that mites are not allowed to build up during May and June, when the trees are most sensitive to even relatively low numbers of mites (2–5 per leaf). From July on, apple



The two major mite pests of orchard fruits are (A) the European red mite, and (B) the twospotted spider mite.

trees can withstand much higher levels of mite activity. Accumulations of 500–750 mite days (1 mite day = 1 mite per leaf for 1 day) have not caused any apparent damage to fruit in field experiments.

Managing mites

The many predatory insect and mite species that prey on pest mites offer naturally occurring biological control. Unsprayed apple trees rarely have mite problems because this complex of natural predators keeps mite populations low. The best long-term solution to mite management is natural biological control by conserving predatory insects and mites. This requires limiting the use of pesticides that are harmful to beneficial predators. Growers who adjust pesticide selection and application method to maximize the potential for mite predator buildup may no longer need any miticide beyond prebloom oil sprays.

- Apply oil as close to dilute as feasible. Use prebloom chemical miticide as needed but restrict pesticide applications to situations where monitoring indicates need.
- Maintain groundcover, tree, and fruit condition to reduce susceptibility to the negative effects of mite feeding on foliage.
- Monitor accurately and frequently to detect potential mite problems as they develop.
- When a pesticide is needed, select materials with low hazard to beneficial species. It is also important to pay attention to potential effects on miticide performance of other materials in the tank.
- Use spot or border treatments whenever possible.
- Use high volume/low concentrate sprays (1X–3X spray concentration) from accurately calibrated equipment, insure proper dosage, use appropriate adjuvants, apply during good weather, and drive at a tractor speed that favors good coverage.

Chapter Six

Vertebrate Pests

ORCHARD VOLES

Two species of voles (sometimes called meadow or field mice) can cause serious damage to orchards in Maine. These rodents damage orchard trees by gnawing on trunks and large roots causing lower yields and tree mortality. Symptoms of vole damage include poor shoot growth, small leaves, leaves that turn off-color early in the fall, and small, highly colored fruit. Commercial apple cultivars and rootstocks are very susceptible to vole feeding. Young trees (1–15 years old), and dwarfing rootstock are the most likely to be damaged. Because of the numerous risk factors and high cost of establishment of high-density apple orchards on dwarf rootstocks, considerable effort should be made to eliminate voles from the orchard. Good ground cover management equals effective vole management.

Meadow voles, *Microtus pennsylvanicus*, are found throughout the state. They inhabit the orchard floor by developing a network of surface trails through the groundcover. They burrow in some soils, and can cause damage several inches below the ground surface. An individual meadow vole's activity is usually restricted to an area of about 2,000 square feet. They produce 5–6 litters per year, averaging about 8 young per litter. Because of their prolific breeding, a few overwintering voles in the spring can lead to a damaging population in the fall. Meadow voles primarily feed on grasses, herbs, and sedges, although they will also eat seeds and occasionally tubers and bulbs, they also chew away areas of bark and cambium near the ground line or from higher positions on the trunk reachable from the top of snow cover. Tree damage is possible any time of the year, but is most common from late fall to early spring when other food sources are scarce. Feeding damage leaves 1 millimeter-wide tooth marks at various angles, these are narrower and less varied than marks left by rabbits.

Pine voles (*Microtus pinetorum*, also known as woodland voles) are present in the southern part of the state. They travel in burrows within the drip line at depths up to 3 feet or more, depending on soil conditions. In solid grass sods they may be almost totally subterranean, but where the groundcover contains a high percentage of broadleaf herbs, pine



Voles, sometimes called meadow mice, are small, compact rodents with short tails that burrow underground.

vole surface trails may be numerous. Most of an individual pine vole's activity is within a small area of about 400 square feet. During the cold months, their activity is largely limited to the underground burrows. On apple trees, pine voles feed upon bark and cambium primarily below the soil line, and chew off small roots up to about pencil diameter.

Monitoring and identification

It is important to determine if pine voles are present, because some of the management practices used for meadow vole are not effective against pine vole. Trapping is too time consuming to use as a control measure in large plantings, but it is the best way to identify which species are present.

Traps placed on the surface most likely will not capture pine voles. Find subsurface burrows by probing with your fingers 2–3 inches deep at the drip line, deeper near the trunk. Then, carefully excavate an area of sod or soil just large enough to allow a standard wooden mouse trap to sit flush with the bottom of the underground runway. Place the trap lengthwise across the trail with the trip pan in the center. Use small chunks of apple, rolled oats, peanut butter, or a combination as bait. Cover each trap site with a shingle to prevent other animals from tripping it and to help relocate it 24 hours later. Trap for 3 or 4 nights, then repeat a week or two later. Record the number of each species caught at each trap.

Tail length is useful for identification. The pine vole tail is very short; about the same length as the hind foot (not leg!), measuring $\frac{3}{4}$ inch or less. The meadow vole tail is about twice the length of its hind

foot, reaching 1½–1¾ inches on adults. Pine voles have chunky bodies, small beady eyes and small ears almost concealed in smooth brown fur. Meadow voles have more prominent eyes, larger bodies, and longer tails than pine voles. Their fur is coarser, more gray than brown.

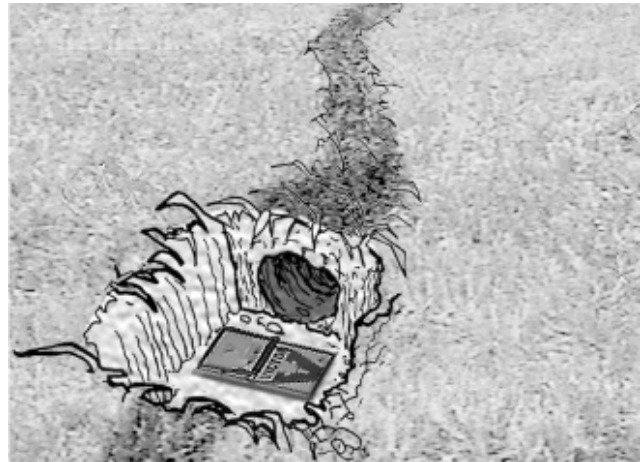
A long-tailed specimen caught in a trap is likely to be a white-footed mouse (*Peromyscus*). The tail of this species is well over 2 inches long, and all of its under parts are covered with white fur. It has very large ears and large eyes. It is reported to eat bark of young trees occasionally, but is generally considered a non-pest in orchards.

Your traps may also catch a shrew, which is a beneficial small mammal; or a mole. Shrews can be identified by their long pointed snout and needle-sharp front teeth, which are white at the base and dark brown at the tips. (Voles have chisel-shaped front teeth). Moles can be distinguished from the other groups by their large front feet with outward facing palms and prominent digging claws.

Estimating vole activity

A general estimate of vole activity is made by looking for meadow vole surface runways and pine vole tunnels. Pine vole tunneling and feeding may be indicated by spongy soil, burrow entrances with piles of soil (usually near the base of a tree trunk), and numerous shoots arising from surface roots. In addition, look for injured trees, girdled trunks, chewed prunings, runways in the grass and around trees, or dropped fruit bearing gnaw marks. Note that vole population density varies even across small areas.

Bait stations are useful to identify areas with vole activity, as well as to assess the overall vole threat in the orchard, and to check 2–3 weeks after a



To determine the species of voles present in an orchard, monitor using snap traps placed in excavated burrows. Cover each trap site with a shingle to exclude sunlight and prevent other animals from tripping it.

treatment to see if a follow-up treatment is needed. Bait stations can be made from shingles, split tires, or boards, placed in the grass at the edge of the herbicide strip or drip line. Establish the stations in the spring or summer to give the rodents time to find and tunnel under the board. Tree flagging helps to find the stations later. A full block survey requires a station at least every fourth tree in a center row, and also along a diagonal row across the block.

After harvest, check under each station for tunneling. In each station with a run or tunnel, place a 1-inch thick apple slice in the runway or next to the hole, and then recover it. Check the stations after 24 hours. If the percentage of apple slices that have tooth marks (or are entirely missing) exceeds 20%, this indicates potential for serious vole damage. A record of repeated assessments over a period of months or years gives a more accurate indication of

| Characteristic | Meadow Vole | Pine Vole |
|-------------------------------|--|---|
| Length (head and body) | 3.5–5 inches | 2.8–4.2 inches |
| Tail Length | 1.4–2.6 inches (at least twice the length of the hind foot) | 0.6–1.0 inches (less than or equal to the length of the hind foot) |
| Adult Fur | Coarse, dark brown mixed with black | Soft auburn, lacking guard hairs |
| Eye Size | Large | Small |
| Nest Placement | Usually aboveground, but occasionally in shallow burrows | In burrows, usually less than 1 foot deep |
| Food | Grasses, sedges, seeds, grain, bark, some insects | Bulbs, tubers, seeds, and bark |
| Damage | Usually aboveground, but occasionally in shallow burrows | Girdle crown and roots |

From Tobin and Richmond. 1993. *Vole Management in Fruit Orchards*. U.S. Department of the Interior, Fish and Wildlife Service.

vole activity. These vole monitoring stations can be used later as bait stations for control. The combination of a trail/tunnel survey and apple slice feeding tests gives a better assessment than either method used alone.

Managing voles

A successful vole management program requires a comprehensive approach that includes individual tree protection and groundcover management. Poison baits provide short term population reduction, and are a necessary tool in emergency situations. However, rodenticides are a supplement, not a foundation for vole management.

Tree guards. Properly installed tree guards made of heavy gauge wire or plastic, are very effective in preventing most meadow vole damage unless snow depth exceeds guard height. Trunk guards do not prevent underground damage by pine voles. Embed guards at least 2 inches below the surface. Avoid close-fitting plastic spiral trunk wraps; they are less effective for voles and provide favorable habitat for trunk-boring insect larvae.

Mowing. Keep orchard floor vegetation below 10 inches (below 4 inches is best) with regular mowing. This discourages vole activity above ground because it leaves them visible to predators. Flail and rotary mowers do a much better job than sickle bar mowers at making orchard ground cover less suitable for voles.

Herbicides. There is little vole activity on ground with less than 40% vegetative cover. While hay-straw or fabric mulch can exacerbate vole

problems, a NY trial found that wood chip and bark mulch did not. Removing sucker growth, which attracts voles, also helps suppress meadow voles. To a lesser degree these practices can reduce pine voles which live primarily underground. An effective method for reducing or even eliminating meadow voles from the orchard is to combine an herbicide strip that kills vegetation in the tree row, remove brush and weedy areas around the orchard, and promptly remove or mow dropped apples.

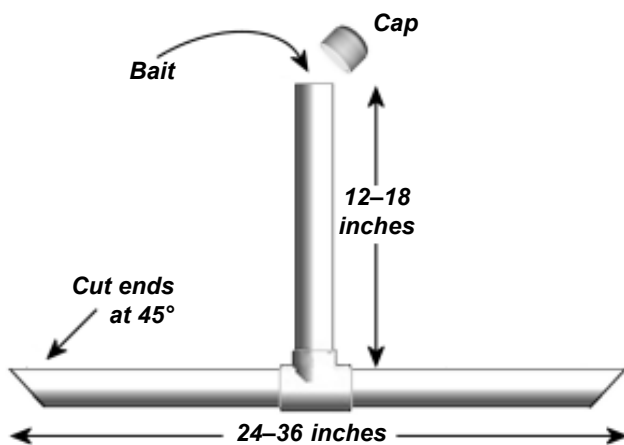
Rodenticides. There are two types of rodenticide baits for vole control: zinc phosphide and anticoagulants. Zinc phosphide baits have been more effective than anticoagulant baits against meadow voles. Just 1 or 2 fresh grains or pellets of zinc phosphide baits can quickly kill a vole that eats them, but it may take several days of feeding on anticoagulant baits for the same effect.

Nontarget hazard. Rodenticide baits may be attractive to domestic pets, birds and other nontarget wildlife. Exposed bait, particularly waxed corn or grain-based pelletized bait on bare ground, increases the chances of nontarget injury. As with all pesticides, follow label requirements, use good judgment and take reasonable precautions to avoid problems.

Rodenticide application

Broadcast bait application is fast, particularly if applied with a fertilizer spreader, and can be effective against meadow voles. It is usually not effective against pine voles. Placing the baits within a weed-free herbicide strip is probably not effective because voles avoid open ground. The presence of dropped apples may also make baiting ineffective, as firm apples are a preferred food for voles. Therefore, all sound drops should be removed before broadcasting bait. Wet weather and dark days discourage vole activity, and wet bait loses potency and palatability. So if the weather is wet and dark during the first few days after a broadcast application, the effort is wasted. The best timing for bait application is soon after a postharvest mowing, and before a 3-day period of sunny, dry weather. Most product labels limit treatments to the postharvest dormant period. The goal is to reduce the vole population just before winter.

Brushy overgrown areas adjacent to a vole-infested orchard are likely to have a population of the same species present in the orchard. If these border areas are not baited, they will be a source of reinfestation to the treated orchard.



A T-tube bait station made from 1½ inch PVC pipe. Place traps upright, held by a stake or tied to a tree trunk. A cap or can placed over the vertical feed pipe keeps out sunlight and rain, and allows baiting after snow has fallen.

Baiting in artificial trails. Although this method is more expensive than the alternatives, when used properly, a tractor-drawn mechanical trail builder allows for more efficient bait application that is effective against both pine and meadow voles. A trail is made along each side of the tree rows, beyond the wheel tracks, and beneath the drip-line in sod. A proper depth setting of 2–4 inches, proper timing, and suitable soil conditions are critical for success. If there is vehicle and foot traffic in the orchard after the trails are built, or if the soil is too dry, the tunnels will collapse and bury the poison. If the soil is too wet the poison degrades quickly.

Hand-baiting. Hand-baiting involves the selective placement of baits under established bait stations, or where active trails or burrows are located. This method makes the most efficient use of baits, but requires the greatest time for distribution. When done properly it is likely to be the most effective method, particularly for pine voles. Place teaspoon size, or larger, quantities of bait at each location, at the rate of 2–3 lbs. per acre. Some anticoagulant bait labels specify certain minimum amounts for each placement. To speed bait placement, bait stations, such as asphalt roofing shingles or split tires should be distributed beneath the trees in sodded areas well in advance of baiting time. Over a period of weeks or months, voles develop trails under these bait stations, and trails can be quickly baited after harvest.

Split tires are available in some areas from landfill operators. Split tires have the advantage of bait placement in shallow cups, and protected beneath the tire so that bait does not readily deteriorate. T-tube bait stations can be made from 1½ inch diameter PVC pipe. They are placed upright, held by a stake or tied to a tree trunk. A can placed over the upright top keeps out light and rain, and allows baiting after snow has fallen. Be sure to check the rodenticide label, to be sure this application is allowed; some labels have a very specific definition of bait stations.

Retreatment with baits. If voles have become sick yet survived a rodenticide treatment, bait acceptance during a retreatment within a few weeks will be poor. This seems to be a problem more with zinc phosphide baits than with anticoagulants. To minimize this problem do everything possible to favor complete control with the first treatment. If a second treatment is needed, and another type of rodenticide is legal, use the different type for the second application.

WHITE TAILED DEER

White tailed deer, *Odocoileus virginianus*, can cause serious economic losses in orchards. Beyond immediate yield reduction, deer feeding interferes with scaffold and leader training, delays growth and yield on young trees, and even kills small trees. The potential for damage increases in orchards with smaller trees where more fruit buds are within reach.

Deer browsing is characterized by ragged broken ends on branches. A systematic survey of 10% of the trees in an orchard provides a quick, accurate assessment of deer damage. If browsing pressure is severe, a long-term plan is needed. The plan should consider methods of exclusion, habitat modifications, and reducing the local deer population. Where there is potential for significant economic damage, herd reduction alone is probably inadequate. Exclusion and habitat modification require more initial effort and expense, but provide more complete and long-term management.

Managing deer

Fencing is the most common exclusion technique. In general, all newly planted orchards should be protected by a deer fence. Deer can be successfully excluded from large areas with an 8 foot high woven-wire fence with one or more smooth, high-tensile wires added above to increase fence height to 10 feet. This design requires relatively low maintenance although the initial cost is high and repairing damaged sections may be difficult.



The white-tailed deer section is adapted from Wildlife Damage Management in Fruit Orchards. Cornell Cooperative Extension Information Bulletin 236, 1994. Curtis, Fargione, and Richmond.

A variety of electric fence designs are also available. Electric high-tensile fences are usually designed as behavioral deterrents. Deer can be excluded with a 5–6 foot electric fence even though they can easily jump over this height. When properly installed, high-tensile electric fences are easily repaired, and the initial cost is only half as much as an 8 or 10 foot woven-wire design. However, fence voltage for electric designs needs frequent monitoring, and vegetation control along the fence line is required to maintain shocking power. Electric fencing is also susceptible to lightning strikes; adequate lightning protection is an important component.

Guard dogs contained by an “invisible” fence is another way to exclude deer. This system uses a buried perimeter wire that broadcasts signals to specialized dog collars. As dogs approach the perimeter, the collars begin to beep, a few more steps produces both beeps and mild electric shocks that form a conditioned response in the dogs to remain behind the boundary. With the proper facilities and maintenance, certain breeds of dogs can stay in the orchard year round to repel deer. During periods of heavy snow it may be necessary to break trails so that the dogs can get around to patrol the orchard. Invisible fence installation and collars cost considerably less than a woven-wire or electric wire fence. However, acquiring suitable dogs and training them is necessary for this approach, and maintenance costs (food, veterinarian bills, etc.) should be considered in comparison with other methods of deer exclusion.

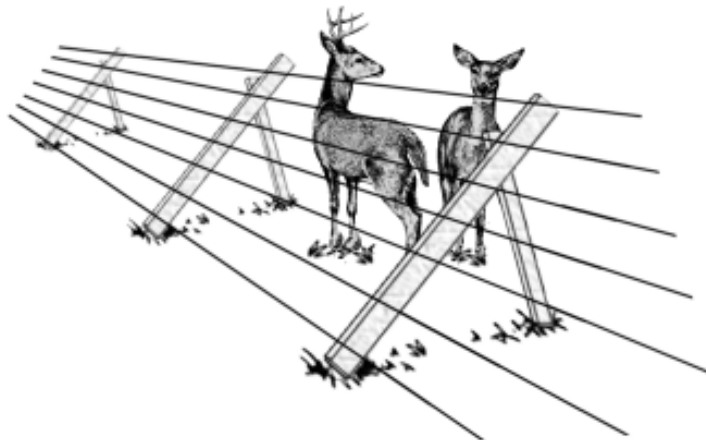
Deer can be repelled from orchards by various means but these methods are usually temporary. Sound generating “scare” devices provide protection for only a few days to weeks at best. Several chemical repellents are commercially available. These materials are usually taste or odor repellants, includ-

ing pungent chemicals (capsaicin, egg putrescence, predator urine), and bittering agents (denatonium). Odor repellents work better in warm weather; taste repellents are better during the colder months. For best effect, repellants should be applied before deer establish a feeding pattern. Because repellants do not provide complete control, some damage must be tolerated even if the browsing pressure is low.

Many growers experiment with noncommercial deer repellents. These materials currently have no EPA registration, and their effectiveness is inconsistent. To use small deodorant soap bars, drill a ¼ inch hole through the center of the bar. Leave the wrapper attached to reduce weathering; with the wrapper in place bars may last several years. Use string or wire to attach the soap to outer branches about 30 inches above the ground. There should be no more than 3 feet between bars within the tree. Caution is advised as bar soap sometimes increases vole damage when soap residues run down or drip onto the trunk. Some birds, such as crows, occasionally cause damage to new growth while feeding on soap bars.

Human hair can be applied in mesh bags (1/8 inch mesh or less) hung in mid-fall and early spring in the same distribution pattern described for soap bars. Additional applications may be necessary in wet seasons. Light cloth bags filled with ½ to 1 cup animal waste can be used in the same way.

None of the existing repellents provide reliable protection when deer density is high but they may be cost-effective where the expected degree of damage is not far above a tolerable level, or where just a small acreage is threatened, and if only 2–3 annual applications are needed for adequate control. In other situations, exclusion combined with herd reduction is the most economical long term choice.



A slanted 7-wire high-tensile electric deer fence, used where high deer pressures threaten moderate-to-large sized orchards. Deer attempt to go under or through fences that slant toward them but rarely will they jump over.

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**Maine Board of Pesticides Control — 207-287-2731
University of Maine Cooperative Extension
Pest Management Office — 1-800-287-0279**

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For chemical emergencies only, 24 hours a day:

Transportation Emergency Center (CHEMTREC) 1-800-424-9300

For information on pesticide products, health and environmental effects, safety, and clean-up and disposal procedures, 9:30am-7:30pm EST, except holidays:

National Pesticide Information Center 1-800-858-7378