ORCHARD MONITORING MANUAL FOR PESTS, NATURAL ENEMIES, AND DISEASES OF APPLE, PEAR AND CHERRY

AN ILLUSTRATED GUIDE FOR WASHINGTON STATE

Compiled by **Naná Simone**

Center for Agricultural Partnerships

Funded in part by U.S. Environmental Protection Agency and United States Department of Agriculture

Funded in part by U.S. Environmental Protection
Agency and United States Department of
Agriculture.

Publication of this book was provided in part through a
USDA Risk Management Education Partnership.

REFERENCES AND ACKNOWLEDGEMENTS

Much of the text in this book is modified from the following publications:

Orchard Pest Management: A Resource Book for the Pacific Northwest. Edited by E. Beers, J. Brunner, M. Willett, and G. Warner. Good Fruit Grower. Yakima, WA. 1993.

Integrated Pest Management for Apples and Pears. Prepared by IPM Education and Publications, University of California. M.L. Flint, Director and Technical Editor. 1991.

A Pocket Guide for IPM Scouting in Michigan Apples. D. Epstein and L. J. Gut. Michigan State University Extension Bulletin E-2720. 2001.

Orchard Pest Monitoring Guide for Pears, P. VanBuskirk, R. Hilton, N. Simone, and T. Alway. Oregon State University Extension Service. 1999.

1998 IPM Almanac. Gempler's. 100 Countryside Drive, Belleville, WI 53508.

Guía ilustrada para el monitoreo de plagas y enfermedades en frutales de pepita. L. Cichón, et al. INTA Centro Regional Patagonia Norte, Argentina. 1996.

Washington State University Cooperative Extension North Central Washington website: http://www.ncw.wsu.edu/pestman.htm

Government of British Columbia Ministry of Agriculture website: http://www.agf.gov.bc.ca/cropprot/tfipm/treefruitipm.htm

Degree Day Calculator for Orchard Pests
http://entomology.tfrec.wsu.edu/entohome.html
Cougarblight (fireblight prediction) model
http://www.ncw.wsu.edu/FB2000f.htm

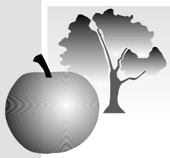
Thank you to Teresa Sáenz Gutiérrez, Pablo Palmández, Francisco Sarmiento, Leo García, Joseph Grantham, and Socorro Anaya Morales for translation into the Spanish version; Mike Doerr for original versions of tables "Critical Periods in Pest Management", editing by Hilary Sampson, Andy Kahn and Betsy Valdez; Michael Bush, Larry Elworth, David Epstein; Casimir "Kaz" Lorentz, Susan Pheasant, Sarita Simone, Lucia Varela, Laura Willett and many others for support. Thanks to Jill Morrison (Blind Renaissance Design) and Hérida Zamora for graphic design.

Photo credits: Ted Alway, Elizabeth Beers, Jay Brunner, Michael Bush, Stephen Cockfield, Brian Croft, Mike Doerr, John Dunley, David Epstien, Jack Eves, Gary Grove, Brad Higbee, Frank Howell, Stan Hoyt, Larry Hull, Christian Krupke, Peter Landolt, Eugene Miliczky, Arlo Pelegrin, Hugh Philip (Agriculture and Agri-Food Canada), Helmut Riedl, Timothy Smith, Nick Stephens and Chang Lin Xiao.

The text of this book may be downloaded from: http:/www.agcenter.org/projects_hisporch.html

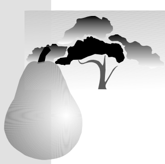
CONTENTS

INTRODUCTION


Apple

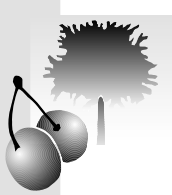
This guide is intended to provide descriptions, information on life stages, cycles, monitoring methods and treatment thresholds for common pests of apple, pear and cherry in Eastern Washington. The manual also includes the common natural enemies (predators and parasites) and information on the most common tree fruit diseases as well.

The selection of Spanish names of the insects found in the color plates and Spanish printing of the book reflect what is most similar to English, such as "áfidos" for "aphids" rather than the sometimes more common "pulgones". These choices reflect the needs of the intended audience of the Spanish version: workers in Washington State's tree fruit industry. Although common names vary between regions, scientific names are the same around the world, and so the scientific name is included with each organism's description. Each pest name is followed by a picture or icon (seen on the left border of this page) to indicate which crop it attacks. For example, the apple icon indicates that the pest attacks apple.


Pear

The descriptions of insect and mite pests include steps on how to monitor them in the orchard. Many of these protocols have been developed by entomologists, but others have been devised through the experience and practice of pest management consultants. Monitoring protocols are often expressed as "scan 500 shoots", or "scan 25 trees", etc. These suggested numbers are appropriate for orchards or blocks of up to 10 or 20 acres, generally. If the orchard management unit is larger, and particularly if it lacks uniformity, these numbers should be increased.

A discussion of Action Thresholds is included for the majority of pests in this manual. An action threshold is the density (number of insects per unit area, for example, number of mites per leaf) at which control measures should be taken to avoid economic damage to the crop. The action thresholds in this book have been determined through scientific research and/or through experience of field practitioners (pest management consultants). Some pests in the book do not have an action threshold listed because it has been impractical to establish one.


Cherry

It is not the intention of this manual to be a spray guide, yet there are some references to specific insecticides because the monitoring protocols for some insects depend on the type of insecticide used. In addition, references to pesticides in the manual will change as older products become unavailable and new products are introduced to the market.

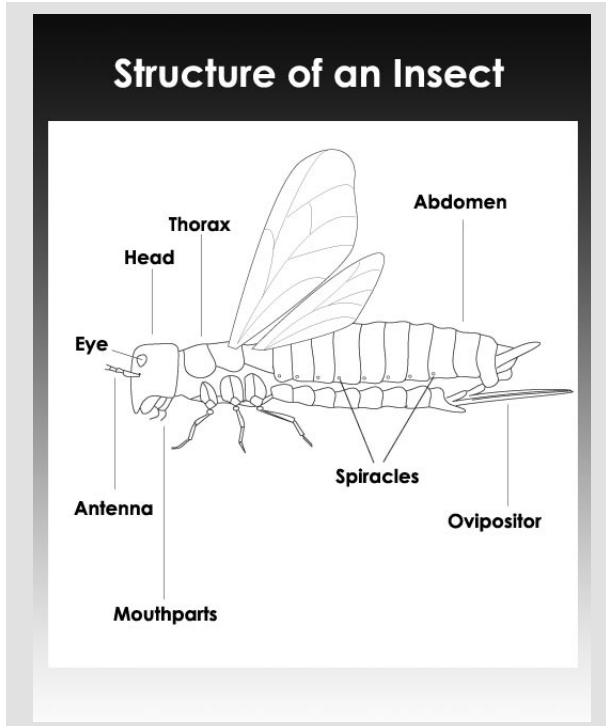
GENERAL INFORMATION

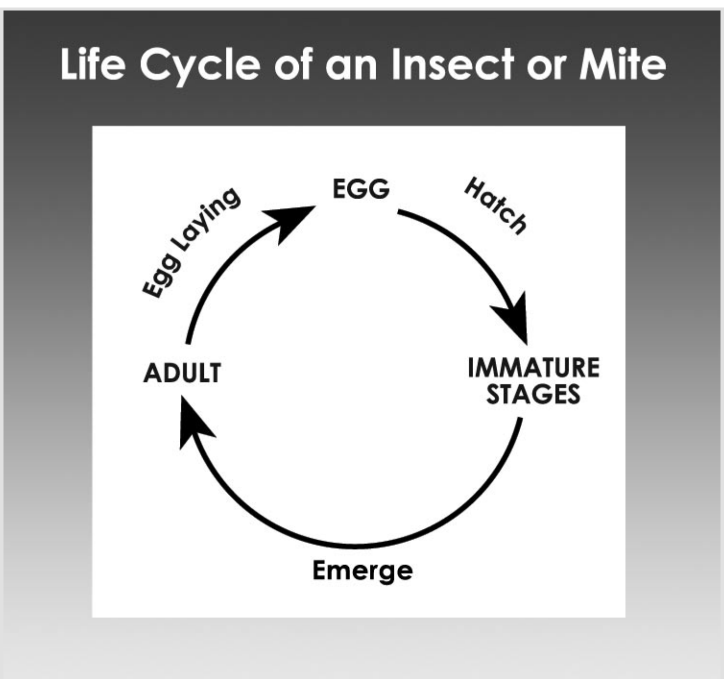
DIFERENCES BETWEEN INSECTS AND MITES

Insects:
3 pairs of legs
Body divided in three parts (head, thorax and abdomen)
One pair of antenna
Almost always two pairs of wings (in adult stage)

Mites:
4 pairs of legs (except immature forms may have 3 pairs)
Body divided in 2 parts (united head and thorax, and abdomen)
Small size
Some are pests, others beneficial

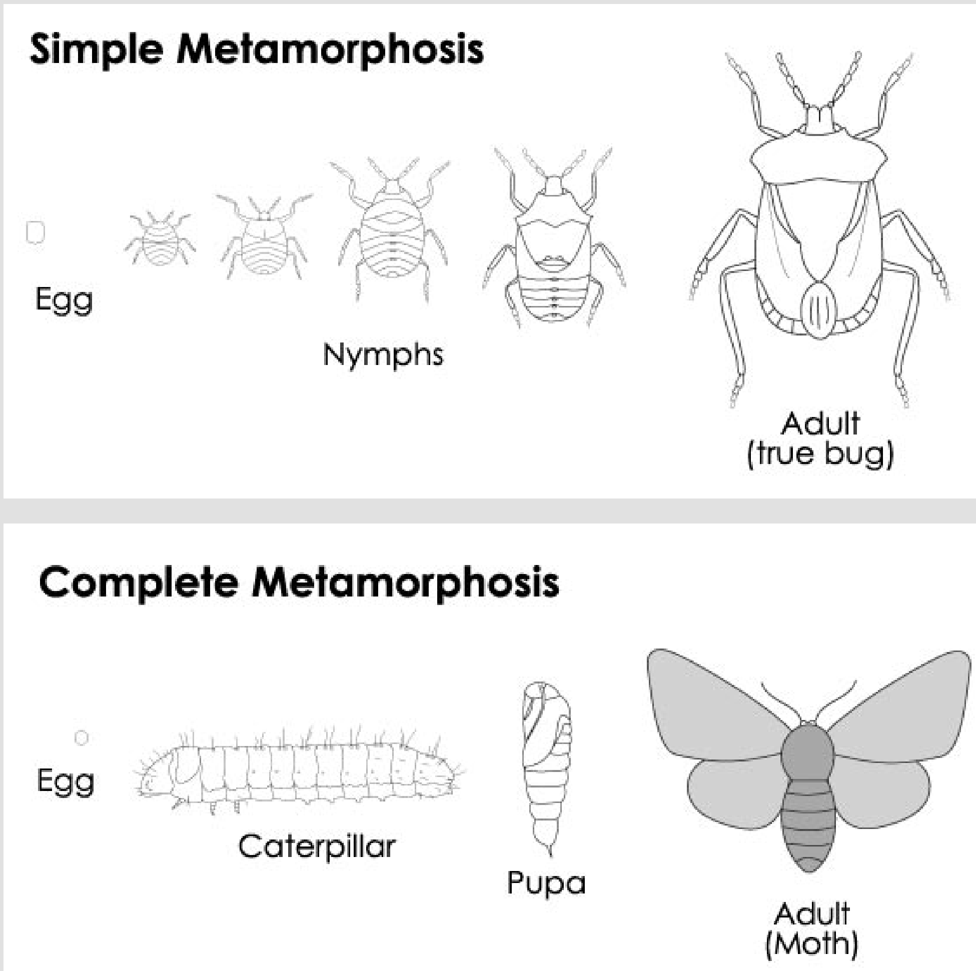
Spiders:
4 pairs of legs
Body divided in 2 parts (united head and thorax, and abdomen)
Spiders are always beneficial (they hunt insects, other spiders, etc.)





TYPES OF DEVELOPMENT

METAMORPHOSIS



Insects change their shape as they grow during the course of their life cycle, from egg to adult. These changes are known as metamorphosis, which means, "change of form". In some cases, the changes of form are not very drastic and the young, that is, immature insects are very similar to the adults, but in other cases the immature insects do not resemble their adult form. Therefore, we can classify insects by their type of metamorphosis as below:

Simple ("incomplete") metamorphosis: these insects go through the stages of egg, nymph (juvenile) and adult. Juvenile stages are similar to their parents (adults); the main difference is that the immature stages do not have wings and are not sexually mature. Examples: true bugs, aphids.

Complete metamorphosis: these insects go through the stages of egg, larva, pupa and adult. Juveniles are very different from adults. Most are worm-like larvae that transform into a pupa and then into adults. The pupa is a "resting" stage during which time the larva may wrap itself in a cocoon, or simply remain a bare exoskeleton while it's transforming internally into its adult stage. Examples: moths, butterflies, beetles, and flies.

BASIC TYPES OF MOUTHPARTS

Piercing/sucking: the insect sucks sap or juice from the plant tissue or prey. E.g. leafhopper, aphid, campylomma bug.

Chewing: the insect chews holes in leaves, fruit, trunks or roots of the tree. E.g. caterpillars such as codling moth, leafrollers, borers, leafminers, and beetles.

Siphoning: the mouthparts are modified into a coiled tube, which is unrolled for feeding on nectar or other liquids. E.g. butterfly and moth adults.

Sponging: the mouthparts are modified to be able to absorb liquids like a sponge. E.g. flies.

Note: some adult insects that are pests in their immature stage change their type of mouthpart, that is, they may have chewing or sucking mouthparts when in their immature, crop-damaging stage, but sponging or siphoning mouthparts as an adult, when they don't cause damage.

INSECT CLASSIFICATION

It's very useful to recognize the group, or "Order" in which an insect belongs, since insects that belong to the same order have similar characteristics, such as the type of metamorphosis and mouth-parts. The following orders of insects are represented in this manual.

IMPORTANT GROUPS OF INSECTS IN FRUIT TREE PRODUCTION

Order: Common Name	Order: Scientific Name	EXAMPLES of species	Type of meta-morphosis	Type of mouthpart
Aphids	Homoptera	Aphids, leafhoppers, scales, mealybug, psylla	simple	piercing-sucking
True Bugs	Heteroptera	Lygus, campylomma and stinkbugs, Deraeocoris	simple	piercing-sucking
Thrips	Thysanoptera	thrips	simple	rasping
Earwigs	Dermaptera	earwigs	simple	chewing
Moths and butterflies	Lepidoptera	codling moth, leafrollers, cutworms, leafminer	complete	chewing (larvae) siphoning (adults)
Beetles	Coleoptera	shothole borer, lady beetles	complete	chewing
Fllies	Díptera	cherry fruit fly, Syrphid fly, cecidomyid fly	complete	chewing
Wasps and bees	Hymenoptera	Pear slug, parasitic wasps	complete	chewing
Lacewings	Neuroptera	Green lacewing	complete	chewing

INSECT DEVELOPMENT

THE INFLUENCE OF TEMPERATURE IN INSECT DEVELOPMENT

Insects are cold-blooded animals which means that they don't regulate their body temperature the way mammals do, and their body temperature in general depends on the temperature of the environment they are in. This is why most insects develop or grow more rapidly in summer, when temperatures are hot, and more slowly in spring or fall when temperatures are cooler, and not at all in the cold of winter.

Each insect species has its optimal temperature range for development. The lowest temperature in this range is called the lower critical temperature threshold and the highest is the upper temperature threshold. If the average temperature approaches the lower temperature threshold, then the insect's development is slower. If the environmental temperature is below the lower temperature threshold, then the insect ceases developing and may go into an over wintering state. On the other hand, if the environment's temperature is higher than the insect's upper temperature threshold, the insect also stops developing (usually temporarily), and may die if it's extremely hot.

For example, during typical summer temperatures, pest mites complete a generation (from egg to adult) in 8 to 11 days, but may flare up quickly in very hot summer periods, taking only 6 days to complete a generation. On the other hand, in spring, with cooler temperatures, a generation may take as long as 21 days to complete.

The degree day calculation and development tables for codling moth and other pests may be found in Orchard Pest Management and on the Internet (see the References page at the beginning of this book.)

DEGREE DAYS, INSECT DEVELOPMENT MODELS, AND BIOFIX

The concept of degree days

As previously explained, insect development is influenced by environmental temperature. An insect's life cycle may require more or fewer days depending on temperature, and this is why the duration of the biological or life cycle of insects is measured in heat units, or "degree days" rather than calendar days.

Degree days are a measurement that combines time (days) with temperature. A degree day is the heat experienced by the insect when the temperature is one degree above the lower development threshold for 24 hours. Example: the lower developmental threshold for codling moth is 50∞F; if the average hourly temperature of a given day is 51∞F then one degree day is accumulated on that day.

Models of insect development

Scientists have measured the amount of time it takes insects to go through each of their life stages at different temperatures. With this information they have created mathematical formulas or "models" to predict the amount of time it takes an insect to pass through each of its life stages. These models allow us to predict when a pest will be present in its different life stages – such as at egg hatch – when a control method can be used to prevent the insect from reaching the stage at which it can damage the crop.

Each day, using the hottest (maximum) and coldest (minimum) temperatures for that day, a certain number of degree days are accumulated. Every day we add the degree days to the previous days, for an accumulation. This accumulation will tell us where we are in the development of that insect, as a whole population at any moment in time. For example, when 500 codling moth degree-days have accumulated, the model indicates that 90% of the moths exited their pupal stage within winter cocoons to fly, and 54% of the eggs that these first generation moths will lay have been laid.

Biofix

To properly use a degree-day model, you must establish a point, and a date which initiates the accumulation of degree days. This point is called a biological fix point or biofix, for short. For most pests, it is established by when the insect begins to fly in the spring. For some others, such as cherry fruit fly, it begins on a set date, specifically March 1st, in this case. The biofix is usually set at zero, and from this point, using daily maximum and minimum temperatures, calculate degree days for each day. The degree days measured on day one are added to those of day two, and so on. The developmental tables or spreadsheets indicate the corresponding percentage of flight and egg hatch for the degree day accumulation at any point during the growing season.

For example, let's say that in 2003, the first codling moths in an orchard were caught on May 1. From that date on record the daily maximum and minimum temperature that are representative of that location. The corresponding degree days are found in the lookup table. Repeat this procedure each day, adding together the degree days. The accumulated sum corresponds to events in the development of that first generation of codling moth. For example, when 260 degree days are accumulated, 52% of the flight of adults emerging from their overwintering larval/pupal stage, and 3% of the egg hatch of their offspring, the next generation, will have occurred. This happens to correspond to the standard timing for a first cover spray.

Notes:

1) *Temperatures should be measured using approved weather stations or properly situated and housed thermometers or temperature recording devices. The housing, or "radiation shield" protects the thermometer from direct sunlight and radiation from the ground.*
2) *In order to establish a biofix, place traps and lures in the orchard before the first flight is expected to begin. Check traps frequently to detect the first capture of adults, or biofix.*

COMPONENTS OF AN IPM (Integrated Pest Management) PROGRAM

IDENTIFICATION: KNOW YOUR PESTS

Correct identification of the pest or disease is essential to pest control in an orchard. It's important to know all the stages of a pest, such as, eggs, larvae, where they pupate, and the adult's appearance, as well as the type of damage to the fruit or tree. An incorrect diagnosis can lead to unnecessary sprays. Worse yet, overlooking the presence of a damaging pest population can lead to serious crop losses. Many insects found in the orchard are not pests, but only incidental visitors, while others are beneficial (natural enemies), acting as biological controls for pests.

MONITORING: FIGURE OUT IF THERE'S ENOUGH PESTS TO HURT YOUR CROP

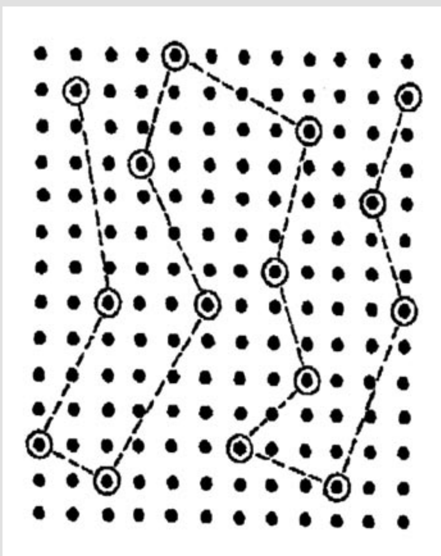
Planned, regular and systematic monitoring is the most fundamental activity in an IPM program. Both the need for control and the effectiveness of any action taken (sprays, pruning, irrigation, etc.) are determined by monitoring pest and natural enemy populations. It is not enough to simply know whether the pests are present. Since it is impossible to count all the insects, only a portion, a sample, is counted. Information obtained from the sample is used to make inferences about the level or density (quantity, level) of the pest in the orchard. To decide if a control is required, pest density must be related to the potential damage. This information is balanced against the likelihood that the pest's natural enemies will be able to keep it below damaging levels.

It is important to know how a pest develops (its life history), because different life stages may be monitored and managed in different ways. For example, foliage is sampled to look for leafroller larvae, while pheromone traps monitor adults. Common methods of monitoring include visual inspection and counts, beating tray samples, and pheromone traps.

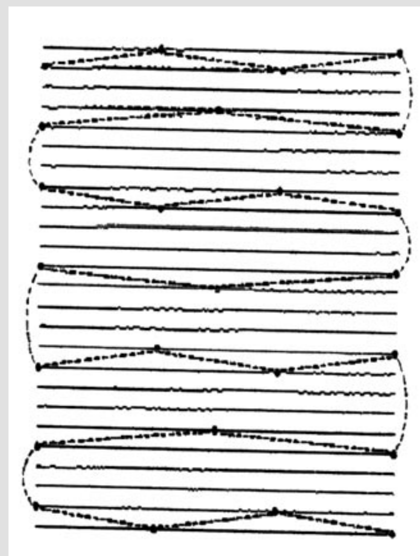
METHOD FOR SAMPLING TREES IN ORCHARDS

A good sampling session is done throughout the orchard. Orchards that are trellised require a different pattern of sampling compared to free-standing trees that allow travel across rows.

Zigzag monitoring: *as the figure indicates, enter the block from a border and walk in a zigzag manner until reaching the far edge. Generally, monitor at least 20 trees. In successive sampling sessions, begin sampling from different points, so that the same trees are not always sampled.*



Trellised blocks: *as the figure indicates, monitor along the rows of the block.*



DECISION MAKING: KNOW YOUR ACTION THRESHOLDS

To decide whether a control tactic such as a spray is necessary consider all the monitoring information, as well as factors such as the stage of the tree and age of the fruit, developmental stage of the pest, climatic factors, fruit variety, etc. The density of a pest, given all these factors, that will result in an economic loss of the crop, which outweighs the cost of the control measure, is termed the *economic injury level* (EIL). There is a lag time between when the EIL will occur and when the control measure (spray) can be applied and take effect, so an *action (or treatment) threshold* is set somewhat below the EIL. It must be said that EIL's have been scientifically determined for only some pests, thus for many pests and fruit varieties thresholds (including many in this manual) have been devised by the grower or consultant based on experience, level of aversion to perceived risk of crop loss, etc.

MANAGEMENT TACTICS: CONSIDER ALL YOUR OPTIONS

These include sprays, mating disruption, biological control, and cultural controls (such as pruning out fireblight). IPM stresses reliance on control methods that will be the least disruptive of natural enemies while still providing adequate control of pests.

IPM: WHAT'S IN IT FOR ME?

IPM is:

1) Eliminating insect, disease and weed pest problems, NOT eradicating all pests
2) Applying pesticides, fertilizers or irrigation only when the benefits outweigh the costs
3) Considering all of your management options, including natural, biological and chemical methods

.

IPM increases profits
Inputs such as chemicals are expensive. IPM techniques allow you to apply these inputs only when they are truly needed. IPM helps determine just the right time for an application, so you get the best results for the money spent.

IPM reduces risk
Fewer pesticide applications, at reduced rates, using the safest materials: this minimizes the dangers associated with pesticide applications, including accidents, drift and toxic effects on wildlife and beneficial organisms.

IPM delays pest resistance to pesticides
Applying the same pesticide over and over again results in pests that are no longer killed by the formerly fatal pesticide. By choosing from all possible control methods, including rotating among pest control methods, resistance can be delayed or prevented.

IPM preserves the environment
The more we limit pesticide applications to essential uses only, and choose the least toxic materials whenever possible, the more we help support the important web of life in the orchard and outside it.

EQUIPMENT AND TOOLS FOR MONITORING THE ORCHARD

1. **Magnifier or hand lens.** 10x – 15x.

2. **Binocular visor magnifier** (Optivisor™) 3.5x.

3. **Beating tray and limb tapper.** The limb tapper is used to dislodge insects from the limbs of the tree onto the beating tray, where they can be identified and counted. The beating tray is a rigid frame 18 inches (45 cm) by 18 inches, over which a cloth is stretched tightly. The cloth can be black on one side and white on the other, or a color that will allow one to see both pale and dark insects. The tray can be made of aluminum window screen frame with cloth replacing the screen. The limb tapper is a piece of thick hose, or a PVC pipe or wooden dowel covered with rubber or other soft material on its far end to prevent damage to the limbs

4. **Monitoring forms or notebook.** To record the counts.

5. **Telescopic pruning shears or pole pruner.** To cut shoots from the top of the tree.

6. **Counter.** To count the exact number of insects while sampling.

7. **Pheromone traps and lures.** For codling moth, leafrollers, etc.

Optivisor™

Counter

Magnifier

INSECT PESTS

Codling moth figs. 1 – 4
Cydia pomonella

DESCRIPTION
Eggs are flat, round, one to 1.3 mm in diameter and are placed singly on leaves and fruit. The larva, only 2 mm when newly hatched, grows up to 20 mm long and ranges from creamy white to pink with a black head. Pupae are brown, 8 – 12 mm long, and are protected in cocoons spun by the larvae before they metamorphose into the pupal stage. Adults are moths that are about 12 mm long with gray wings that have a distinct patch of bronze scales at the wing tips, unlike any other moths that may fly into a trap.

LIFE CYCLE
Codling moth survives the winter in the 5th instar larval stage, in a silken cocoon. These larvae spin their cocoons under the tree bark, in props, or on the ground in pieces of wood in the orchard. They will also spin cocoons in bins scattered in the orchard before harvest. Overwintering larvae do not actually pupate within their cocoons until first pink bud stage.

The first adults emerge and fly around full bloom; complete emergence may take 6 to 7 weeks. Moths begin mating immediately and females lay their eggs on leaves and fruit. Hatch takes 8 to 14 days; the hatched larvae search for and chew their way into the fruit through a small hole. In 3 to 4 weeks larvae grow to their last (5th) instar and exit the fruit, to search for a suitable pupation site. Pupation takes 2 to 3 weeks, and finally they emerge as second-generation adults, beginning in early July. In very warm years, in warmer areas of Washington, a portion of the brood will lay 3rd generation eggs, which hatch in late August or early September. The generations may partially overlap.

DAMAGE
There are two types of fruit damage: deep entries, where the larva feeds on the seeds (sometimes called “strikes”) and shallow entries (“stings”), where the young larva has usually died. Brown frass (excrement) usually exudes from the fruit.

NATURAL ENEMIES
Some parasitic wasps (e.g. *Mastrus, Trichogramma*), earwigs and predatory ground beetles.

MONITORING
Adults are monitored with pheromone traps. The large “Delta” style seems to catch the most moths. One pheromone trap for every 2 to 2.5 acres is optimal; 1 trap per 5 – 8 acres is acceptable in large, uniform blocks or once the distribution of codling moth in an orchard is known (although this too can change!) Use high load (10X) lures in mating disruption block traps; use standard (1X) in non-mating disruption block traps. If using red rubber lures, replace every 3 weeks first generation and every 2 weeks second generation. Other lure types are available; some will last for an entire generation.

Traps should be up and loaded with lures by first bloom. When traps are first placed in the orchard, they should be checked at least twice weekly to determine biofix. Sometimes a lone moth will fly into the trap, with no more activity for a week or longer. It’s best to use the first sustained moth capture for the biofix determination. It can be difficult to determine biofix in orchards with very low codling moth populations. In that case it is desirable to ask other growers or consultants for this information from a similar orchard in the area.

In addition to trapping, fruit should always be visually inspected for larval entries. Entries are most likely to be found in the upper part of the trees and at orchard borders. Also look in between fruit that are touching each other. Visual searches for fruit should begin by 600 – 700 degree days (75 – 85% egg hatch) or sooner. Ten – twenty minutes spent scanning the fruit in a block should indicate whether any significant number of codling moth have escaped control.

CODLING MOTH EVENTS AND ACTIONS

DD° (from Biofix)	Events	Action
Pink bud - first bloom (in apple)	Development of overwintering larvae	Set traps. Apply mating disruption
0 DD° = Biofix (about 200 DD° after Mar 1)	1st sustained moth captures	Set DD° = 0
50 – 100 DD°	Egg lay begins	Timing for 1st treatment if using insect growth regulators directed at eggs
250 DD°	Start of 1st generation egg hatch	Timing for 1st spray application directed at larvae if over action threshold
360 DD°	70% flight/ 20% hatch (1st generation)	Timing for single spray application directed at larvae (larvicide) where population pressure is low
1000 DD°	Expected end of 1st generation activity	
1200-1250 DD°	Start of 2nd generation egg hatch	Timing for larvicide spray if over threshold
1400 DD°	70% flight/ 20% hatch (2nd generation)	Timing for single larvicide spray where population pressure is low
2100 DD°	Expected end of 2nd generation activity	

NOTE: Respond to trap catches that exceed threshold levels even when the model indicates that codling moth should not be in a stage requiring sprays

ACTION THRESHOLDS

In apples, a cumulative catch of 3 – 5 codling moths in any one trap over a three-week period may indicate the need for a spray. In pears, first generation threshold is higher: 7 – 10 moths (5 – 7 moths in mating disruption orchards), because young pear fruits are poor hosts for codling moth. Do not total captures from more than one trap to attain the threshold.

Example for accumulating moths captured

Number of Moths Trapped				
	Week 1	Week 2	Week 3	Week 4
Trap 1	0	2	2	2
Cumulative catch		*2*	*4*	*6*
Trap 2	1	1	1	2
Cumulative catch		*2*	*3*	*5*

NOTE: Respond to trap catches that exceed threshold levels even when the model indicates that codling moth should not be in a stage requiring sprays

Leafrollers figs. 5 - 12
Pandemis and Obliquebanded Leafroller
Pandemis pyrusana and *Choristoneura rosaceana*

There are two common species, pandemis (PLR) and oblique-banded leafroller (OBLR), similar in life cycle, appearance, and feeding damage. One or the other tends to dominate a particular area.

DESCRIPTION

Pandemis larvae have green heads and wiggle vigorously backwards when disturbed. OBLR larvae have brown to black heads and wiggle too, but not as vigorously. Larvae grow up to about 25 mm. Moths of both species are 18 – 25 mm long. There are some subtle differences between the species, but since the pheromone lures used in trapping are unique for each, it is not necessary to distinguish them visually.

LIFE CYCLE

These leafroller species have 2 generations per year. Pandemis and OBLR overwinter in the tree as small 2nd or 3rd instar larvae. They emerge around 1/2” green and feed inside bud clusters prior to bloom. Larvae mature in late May and June. Pupation occurs from mid May to early June or later, with the first adults flying between late May and early June. Egg hatch of the summer generation begins in mid – late June. Keep in mind that these dates will vary with elevation (how early the site is) as well as with the year. Summer generation larvae are present from late June through August. These larvae develop through August, pupate and the adults begin to emerge in late August and September. The offspring of these adults are the overwintering larvae.

DAMAGE

Leafrollers spin silk to tie leaves either together, or onto fruit as a protective enclosure and feed within it. The important damage is to the fruit. It is always surface feeding, not deep tunnels as with codling moth. It can cover a large area of the fruit, or appear as just a tiny pinhole. There is almost always at least a small strand of silk associated with leafroller feeding sites, and often some bits of excrement (frass).

MONITORING and ACTION THRESHOLDS

Fruit injury discovered at harvest or in the fruit warehouse is often the first indication that leafroller is in the orchard at levels capable of causing injury the following year. Indeed, time is well spent at harvest checking bins or watching fruit run at the warehouse in order to determine whether leafroller sprays will be needed in the next growing season.

MONITORING LARVAE IN SPRING:

Although larvae can be found at tight cluster or even earlier, monitoring can be done most efficiently between 315 and 495 leafroller degree days from March 1st. This period roughly begins around bloom or petal fall and lasts about 14 – 17 days.

WHERE TO MONITOR

Scan for surviving larvae in low fruit clusters (preferred by OBLR in spring) and high shoot terminals (preferred by PLR; OBLR will go to them too). A pole pruner is valuable to confirm suspected LR damage. Petals that fail to fall normally may be tied together with leafroller silk, giving an indication of leafroller presence in fruit clusters. If larvae are found in more than _ - 1% of the shoots and clusters (scan about 500 shoots), summer controls will be needed.

TRAPS

Each leafroller species has its own pheromone blend, so different lures are used in trapping. Use one pheromone trap per 15 or 20 acres to set biofix and as an indicator of leafroller activity. Lures are highly attractive and generally last a generation. Traps tend to capture a lot of moths because the male moths fly long distances, making it difficult to use trap counts for decision-making. However, a consistent catch of 20 - 30 moths for 2-3 weeks in orchards where there is a history of damage, often indicates a population within the orchard. Very low catches of less than 20 moths per week for an entire flight period generally indicates that this pest is not present at problematic levels. Due to the long flight distance of male leafrollers, some orchards cannot be reliably monitored with traps and one must depend on monitoring for larvae.

MONITORING LARVAE IN SUMMER:

Beginning about two - three weeks after traps begin catching moths, look for evidence of larvae particularly on shoot tips high in the tree. Summer generation sprays should be aimed at early egg hatch, about 450∞ days (PLR or OBLR model) after biofix. Monitor for larvae over a period of 1 – 3 weeks after spraying to make sure that control is adequate.

EFFECT OF AN INSECTICIDE:

Leafroller development into the summer generation may be delayed by at least two weeks if Bt sprays (Dipel®, Deliver®, etc.) have been applied in an orchard. In the Bt-treated orchard, reset biofix to zero when there is a distinct surge in trap catch (usually 10 or more days after the first few moths are caught), to compensate for the delay when Bt is used.

Cutworms — Figs. 17 - 18

There are various cutworms, which may attack fruit trees. Spotted cutworm (Xestia c-nigrum) is one of the most common species that crawls up from the ground into the trees in the spring and may chew cavities into the swelling buds. After the leaves expand, these larvae do little additional damage. Another species, Bertha armyworm, Mamestra configurata, can attack the fruit if its broad-leaved weed hosts are growing into the trees. Lacanobia primarily attacks apple, and although it mainly eats leaves, fruit damage can be significant.

Lacanobia — Figs. 13 - 16
Lacanobia subjuncta

DESCRIPTION

The young larval instars are green with 5 narrow white stripes along the back and sides and cannot be distinguished from many other caterpillars. The later instar larvae may be green, tan colored, or orange brown and have distinctive "V"s on their back. Cutworms typically curl into a 'C' when disturbed. The moth is large, and similar to many others of the Noctuid family. Lacanobia eggs are laid in a jumbled mass and are grayish.

LIFE CYCLE

Lacanobia overwinters as a pupa in the ground. The adults fly in May, lay their eggs in the trees or on weeds, and by June the larvae begin to show up as they feed on the foliage. A second generation of larvae hatch in August and feed through September.

DAMAGE

First and second instar larvae chew only on one surface of the leaf, causing a skeletonized. windowpane appearance. Older larvae chew large irregular areas of the leaf and will chew large, clean, circular gouges into the fruit.

NATURAL ENEMIES

There is probably some predation by earwigs and other general predators. Soil fungi kill many cutworms that spend time in the soil.

MONITORING

Leaf damage is easily seen on shoots of infested trees. Larvae can be hard to see, but limb tapping readily dislodges them and confirms their presence. Monitor by randomly scanning 30 trees per block, when leaf feeding becomes evident in June. If more than 30% of the trees show leaf feeding, fruit injury may be economic if no control is applied. Pheromone traps may be used to detect the adult moths, but they fly very long distances and may come from outside the orchard. Place traps at the same time as codling moth traps.

ACTION THRESHOLDS

Larvae: if more than 30% of the trees show leaf feeding, there may be economic damage to the fruit unless a spray is applied.

Moths: Captures of more than 100 moths per trap in a week may indicate that there will be a significant level of larvae hatching in the orchard. Economic damage has resulted where more than 150 moths in a week were caught.

Lygus bug Fig. 26
Lygus hesperus, L. elisus

DESCRIPTION
The different species vary in color from green to brown with reddish brown to black markings, but can be distinguished by a prominent triangle behind the thorax. Lygus has many hosts, such as alfalfa, wild mustards, and sagebrush. Adults will feed on apples, pears, and peaches, but do not reproduce on tree fruits.

LIFE CYCLE
Adults overwinter beneath weeds or dead plant material in the orchard or in nearby uncultivated areas. In spring they may fly to fruit trees and feed there. Mowing or cultivating orchard floor can remove food and habitat, and force Lygus bugs up into the tree.

DAMAGE
Injury is caused by feeding on developing flower buds that can occur from tight cluster to about two weeks after petal fall (or up to about 10 mm diameter fruit). Small droplets of sap may appear on the surface of injured buds, which then shrivel. As the fruit grows the damage leaves dimples or deep pits. In pear, damage can appear as corky scabs.

MONITOREO
Begin monitoring in April near borders and near patches of mustard weeds. At tight cluster scan the buds for exuding sap. Limb tapping with a beating tray confirms the bug's presence. Beating tray samples should be done in the early morning on warm days, and when the air is fairly calm, because adults fly when disturbed. Host weeds may be swept with a net.

ACTION THRESHOLDS
Since none have been developed through research, I use my own thresholds:

At tight cluster bud stage, 5% buds with injury, which shows up as sap drops on the bud.

At tight cluster through small fruit (10 mm), 0.3 Lygus bug per beating tray in a minimum 20 tray sample (or, 7 bugs in 20 trays.) Often, Lygus reaches this level, or density, only at or near orchard borders, so monitor these areas separately and spray only these areas if warranted by sampling.

Stink bugs figs. 28 - 32
***Euschistus conspersus, Acrosternum hilare* and others**

DESCRIPTION
Three to four species of plant feeding stinkbugs are found in Washington orchards. Adults are usually some shade of green, tan or gray-brown, have a shield-shaped body, and range from 12 – 18 mm long. Eggs are barrel-shaped and laid in groups. Nymphs go through 5 instars and change color patterns, which can be quite striking, as they mature. Like Lygus, stinkbugs have many plant hosts, but the stinkbug may lay its eggs in fruit trees. There is a predatory stinkbug that is dark gray with white specks (fig.97).

LIFE CYCLE
Adults overwinter beneath weeds or in brush piles. They become active in April. Some may move into orchards and deposit their eggs on trees. Although nymphs may feed on fruit this does not result in significant economic injury. Most nymphs develop on non-fruit tree hosts. Adults may migrate to orchards in late summer when uncultivated vegetation dries up, and most damage occurs near the orchard border.

DAMAGE
Shortly before harvest, stink bugs puncture fruit as they feed. The puncture may not be visible, but the surrounding area is sunken and often dark green. Beneath the skin the flesh is loose and spongy. Damage looks similar to bitter pit caused by calcium deficiency in the fruit, but bitter pit damage tends to be around the bottom of the fruit, while stink bug damage is typically around the shoulders of the fruit. Bitter pit turns the flesh brown, while stink bug injury only slightly discolors the damaged flesh.

NATURAL ENEMIES
Wasps parasitize stinkbug eggs. Tachinid flies will attack adults.

MONITORING
In August, begin searching the borders of orchards with a history of stinkbug injury for signs of excrement and fruit feeding. Because they are more active at night it is difficult to detect the bugs. Stinkbugs are easy to see because they are large, but they tend to quickly hide when disturbed. The excrement appears as small, brown drops (fig.30). Recent research has shown that stinkbugs can be monitored using an aggregation pheromone lure placed in mullein plants along the orchard border. As stinkbugs are migrating toward the orchard, they collect on the plant with the pheromone lure, especially at night. When several bugs have collected on the baited plants, more plants can be baited. This way, the stinkbugs can be concentrated on the "trap" plants: spraying these baited plants with an insecticide can significantly reduce border damage on apples and pears.

Boxelder bug fig. 27
Leptocoris rubrolineatus

Boxelder bug is usually a minor, sporadic orchard pest. Adults overwinter in sheltered places including buildings and tree crevices. They are found in low numbers in trees and in beating tray samples. Nymphs are not usually found on fruit trees. Adults cause damage just before harvest by sucking juices from fruit as they feed, producing dimples and deformations. The injured flesh is corky and white.

Campylomma bug figs. 19–22
Campylomma verbasci

Campylomma is an excellent predator of soft-bodied insects such as aphids and pear psylla, but can be a serious pest of apples in early spring.

DESCRIPTION
The nymph is pear shaped, translucent white when first hatched, and turns pale green over time. The adult (2.5 mm) has an elongated oval shape and is pale gray-brown.

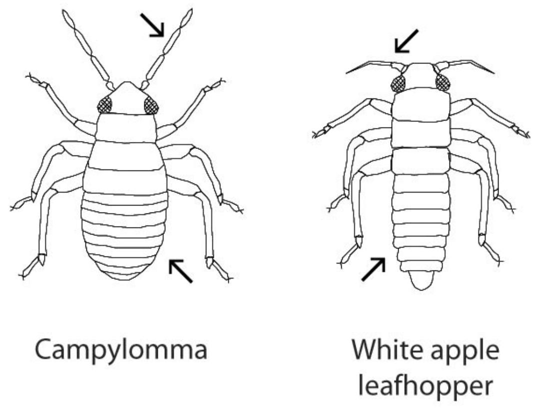
During the monitoring period for campylomma, a number of other species of insects and mites can fall into the beating tray and may be confused with Campylomma in its early instars. For this reason, it is important to use a hand lens to distinguish them.

- In contrast to leafhopper's thread-like antennae that project off to the side, campylomma have 4-segmented, thicker antennae that project forward. Campylomma are broader and more oval, while leafhoppers are narrower and more wedge-shaped. The insects move differently: campylomma move faster and in a forward direction, while leafhoppers tend to move jerkily, and may move sideways.

- The western predatory mite does not have antennae (but don't mistake its very active front legs for antennae) and its body is nearly translucent.

- Aphids at this time are generally green with a rounder body and cornicles at the rear of the abdomen. Campylomma move more quickly than aphids.

Distinguishing Campylomma and Leafhopper Nymphs



LIFE CYCLE
Campylomma overwinters as an egg, inserted into the bark of woody host plants, such as apple. Egg hatch begins as early as tight cluster or pink, but usually peaking at bloom and continuing through petal fall. The nymphs pass through 5 instars. There are 3 - 4 generations per year. After the first generation, some campylomma migrate to herbaceous hosts, such as mullein.

DAMAGE
Around the bloom period campylomma feeds on flower parts and developing apple fruits with its piercing-sucking mouthparts. The early feeding causes a dark, raised pimple or corky wart, often surrounded by a depression. Campylomma may also feed on pear shoot tips (fig. 21). By about two weeks after petal fall, or when fruit is about 10 mm in diameter, they do not cause more damage, and indeed become valuable predators.

MONITORING
In blocks where campylomma have been present the previous summer, take a minimum of 20 beating tray samples per block around bloom time, over a 2 – 3 week period. Be sure to check near borders for higher populations, or areas where damage was found the previous year. If approaching threshold, then increase to 25 or 30 trays in those blocks. A colored cloth surface makes the pale nymphs more visible.

ACTION THRESHOLDS
Average Number of Campylomma per Beating Tray at Full Bloom:

Variety	Action Threshold
Golden	0.2
Red Delicious	4
Gala	1
Granny	3 – 4
Braeburn	not susceptible
Fuji	10? (low susceptibility)

If about half this many are found at pink bud, the numbers above will probably be reached by bloom or petal fall, and sprays may be applied before bloom.

Pheromone traps placed at the end of summer are useful for providing an indication of risk for the following spring. Use 1 large Delta trap per 2.5 acres baited with a lure for the period from August 1 to November 1. Change the lure every 4 weeks and count the bugs at the same time. If a trap accumulates 125 campylomma in a Golden Delicious orchard, the orchard block is at risk of developing a damaging population the next spring. Monitor the orchard carefully as bloom begins the following year.

Western flower thrips figs. 43 - 44
Frankliniella occidentalis

DESCRIPTION
Thrips are tiny, black or yellow narrow-bodied insects. They are 1 – 1.5 mm long with two pairs of fringed wings. Males are smaller than females and always yellowish, while females are bigger and the abdomen can be dark brown. Nymphs are similar to adults, but wingless, and whitish-yellow, from 0.3 – 0.8 mm long.

LIFE CYCLE
Adult thrips overwinter in protected places on the ground. In spring, they emerge and seek out flowering plants. They enter apple blossoms from full pink bud through bloom and feed on the flower parts. The insertion of eggs in flower parts causes the injury, not feeding. Larvae hatch from the eggs and feed in the flowers. When mature, 7 - 14 days after petal fall, they drop to the ground and pass an inactive stage under dead leaves before molting into adults. Thrips have several generations each year.

DAMAGE
Egg-laying punctures on the fruit at bloom to petal fall cause a condition called pansy spot. The damage is seen on green and sometimes yellow varieties, especially on Granny Smith. Braeburn and Ginger Gold may also show visible damage by harvest. In most red varieties the damage usually colors over before harvest. Thrips occasionally attack cherry.

NATURAL ENEMIES
Pirate bug, lacewings, and predatory thrips.

MONITORING
Beating tray samples during the bloom period detect damaging levels of thrips. Thirty – fifty trays per block should be taken, the higher number if a 30-tray sample average reaches 0.8 thrips per tray. Sample once per week in cool weather; increase to twice per week if temperatures rise over 75 degrees F, since warm weather increases their activity. Blue sticky cards are also useful for monitoring, but no thresholds have been established.

ACTION THRESHOLDS
In Granny Smith, an average of 1 thrips per tray or more can cause unacceptable damage. Braeburn, 2 thrips per tray.

White apple leafhopper figs. 23 – 25
Typhlocyba pomaria

DESCRIPTION
Adults are elongated, yellowish white, 3 – 4 mm. long. The wings are held tent-like over the body. Nymphs are translucent white to yellow. Early instars have red eyes. (Note the differences mentioned in Campylomma section in antennae shape and appearance.)

LIFE CYCLE
There are 2 generations per year. This leafhopper overwinters as eggs inserted beneath thin bark on the host tree. Egg hatch peaks during or after bloom. The nymphs pass through 5 instars, ranging from 0.8 – 2.7 mm long. The adults (3 mm) begin to fly in late May. Females deposit their eggs in the leaf tissue, laying about 60 eggs over a long period. The second-generation nymphs begin to appear in mid-August, but hatch is drawn out into early September. The 2nd generation adults deposit their eggs from mid to late September. Adults are active until killed by a hard frost.

DAMAGE
Leafhoppers cause damage to leaves by removing the juice from cells. The damage appears as a whitish stippling of the leaves. There is no bronzing as seen with mite damage. The tree can sustain much of this damage without a loss in fruit size or quality. The droplets of excrement deposited on the leaves and fruit cause another type of damage. If a large amount accumulates in the stem cavity, especially in light skinned apple varieties, it may be difficult to wash out on the packing line. A third concern with leafhoppers is the annoyance caused to pickers by high populations of flying adults.

NATURAL ENEMIES
Anagrus is a tiny wasp that may attack as many as 90% of the leafhopper eggs in an orchard. Predators such as damsel bug and spiders also attack leafhoppers.

MONITORING
Begin monitoring around petal fall in apples, when most eggs will have hatched into nymphs, but before too many have become adults (making them uncountable). Leafhopper nymphs may be counted by picking 100 - 200 spur leaves from a total of 20 trees per block. Turn the leaf over and count the leafhoppers, which generally prefer the underside of the leaf. Divide the total number of nymphs counted by the number of leaves checked for the average number of nymphs per leaf. Second generation nymphs are counted around mid-August, on leaves from the mid-shoot area.

ACTION THRESHOLDS
Generally 1 - 3 leafhoppers per leaf will bleach around the midrib only, while 6 - 8 per leaf will stipple and nearly whiten the entire leaf. Thresholds for trees with sparse canopy and heavy crop load should be lower than for trees with luxurious canopies. For very long-season varieties such as Fuji an average of >2 per leaf in August may be a problem, due to the very long time during which they will feed.

San José scale figs. 45 – 47

Quadraspidiotus perniciosus

DESCRIPTION

The majority of the stages are protected under a scale that the insect produces to protect itself. The female doesn't have wings, feet, or eyes. The body underneath the scale is soft, white, and rounded. Its scale is circular and gray, with a nipple-like bulge in the center. The male is small (1 mm), winged, dark yellow, with a reddish band that crosses the thorax. The first instar nymph is oval, yellow, with six legs and a pair of stubby antennae. This is the only mobile instar of the nymphal period, and is called a "crawler". The scale stages range from 0.3 – 1 mm.

LIFE CYCLE

San José scales overwinter predominantly in the black cap nymph stage. They complete their development in early June and female scales give birth to the crawlers that emerge from under the edge of her scale covering. These tiny yellow crawlers wander on the tree until they find a suitable place to settle: on bark, leaves or fruit. They insert their mouthparts into the host to feed. They begin to secrete a white waxy material and lose their legs, forming the first scale stage. Eventually the covering turns black and then gray. They may be carried to other trees on the feet of birds or by the wind. A second generation of crawlers is produced in August. The two generations may overlap.

DAMAGE

A red spot appears around the scales as they feed on the fruit. Besides making fruit unmarketable, scale kills twigs and limbs if not controlled. Scale tends to build up in old trees where spray coverage is difficult.

NATURAL ENEMIES

Several parasites and small predators attack San José scale.

MONITORING

- Scale is usually first detected when it has infested a few trees in the orchard, showing up on the fruit at harvest. This is the best opportunity to mark the infested trees that can then be treated in the following spring.
- Prunings may be examined from the treetops in the dormant period for scale. Scrape the caps off and examine the undersides for live scale bodies
- In early June, search for scale that have begun to settle on the fruit; the red halo around the scale helps make them visible.
- Crawlers may also be monitored by wrapping double-sided sticky tape around infested limbs, in mid May. Examine with magnification to find yellow crawlers on the tape.

Grape mealybug figs. 49 - 50

Pseudococcus maritimus

DESCRIPTION

Nymphs are pink to salmon colored. Those just hatched measure 0.5 mm and grow to 2.5 mm. As the nymph matures it becomes covered in white waxy filaments that give it a floury appearance. Adult females resemble nymphs but are bigger: up to 5 mm. Nymphs and adults produce honeydew.

LIFE CYCLE

Mealybug overwinters as eggs or crawlers (young nymphs) within a cottony egg sac under bark scales on the tree. Crawlers begin to emerge at bud swell and feed at the base of buds. When buds open crawlers go to the clusters and shoots. Emergence continues until about petal fall. The nymphs mature in late June and July, at which time they can produce copious amounts of honeydew. The mated females migrate to sheltered areas, lay eggs, and die in the egg sac. Second generation summer nymphs emerge in July and quickly crawl to either the fruit calyx or onto actively growing suckers. They mature by early August and again seek shelter to lay the overwintering egg sacs.

DAMAGE
Honeydew causes russeting of the fruit, similar to but usually darker than pear psylla. They may also infest the calyx end, which can lead to storage decay, especially in fruit stored beyond short term.

NATURAL ENEMIES
Many predators such as lacewings, syrphids, lady beetles and predatory bugs attack mealybug.

MONITORING
WINTER: During the dormant season look for eggs and crawlers (1st instar nymphs) in the white cottony egg sacs found under bark scales on scaffold limbs and protected sites on trees. Pay particular attention to hard to spray areas, such as suckers at the top of scaffold limbs.
SPRING: From cluster bud through petal fall (stage 4 and beyond) look for crawlers and nymphs by examining the developing flower clusters arising from large diameter wood in the centers of trees. Beginning several weeks after bloom, when developing shoots are 8 to 10 inches long, examine shoots from fruit clusters high in the tree centers; look closely at the base of these shoots where mealybugs may be concentrated.
AUGUST: Second generation nymphs and adults are found on shoots in the tree centers, often near the shoot tips.
LATE SUMMER: Late summer counts, and fruit examination during harvest for mealybug infestation can help in determining the need for and location of control measures the next spring. Infestations often begin in limited parts of the orchard, and by marking infested trees or areas the control measures can be limited to those spots. Monitoring programs help time pesticide applications for the most susceptible mealybug life stages, the 1st to 3rd instar nymphs.

Apple grain aphid fig. 33
Rhopalosiphum fitchii

DESCRIPTION
Nymphs and adults are green. Antennae are short, reaching only about 1/3 back of the aphid body length. The legs and cornicles (paired tubular structures located dorsally near the end of abdomen) are also short and very dark. As the aphid grows, a dark green stripe on its abdomen helps distinguish it from other apple aphids.

LIFE CYCLE
This aphid is the first one to hatch on apples, and is the most commonly seen species in early spring. Apple grain aphids do not develop wings until the 3rd generation, and in late May will begin to leave the orchard to colonize summer host grasses. By June, they all leave and do not return to the apple trees to lay eggs until late fall.

DAMAGE
In general, it does not cause injury, unless there are high numbers infesting nursery trees, or a high population is sustained over time where the aphids are feeding directly on fruit. In most situations, these aphids should be tolerated because they provide food that attracts aphid predators.

NATURAL ENEMIES
Common aphid predators include lady beetles, syrphid fly larvae, lacewings, cecidomyiid midge (fly) larvae, and predatory bugs (Deraeocoris and pirate bug).

Green apple aphid figs. 34 - 36
Aphis pomi

DESCRIPTION
Eggs are black, narrow, and shiny, as are those of other aphids. Also like other tree fruit aphids, they are only found in winter. Nymphs are bright green in color with intermediate size antennae (compared to apple grain and rosy aphid.) Antennal tips, cornicles and legs are black. There are two forms of adults (3 mm), winged and wingless. They have a black head and thorax, and a yellow-green abdomen. The winged form is better equipped to colonize new sites.

LIFE CYCLE
Green apple aphid overwinters as eggs on dormant spurs and shoots. The nymph hatches out from silver tip to green tip. As with all aphids described in this manual, after the spring hatch, all other generation females give birth to live young rather than eggs during spring and summer. The eggs are not laid until August at the earliest, and these are the overwintering form of the insect. Green aphid may have more than 9 generations per year, on average one every two weeks, from April through September. Since each female may have many offspring, and with so many generations in a short period, they may easily cover the terminal growth of apple trees with their colonies.

DAMAGE
Feeding does not generally cause damage to the tree itself, except for young trees if the infestation is dense and prolonged over many weeks. The most important damage is caused by the honeydew excreted by the aphids. This bothersome honeydew is often obvious to workers during thinning and harvesting . When the honeydew is colonized by the sooty mold fungus to the extent that it coats the stem cavity, sometimes the mechanical washing in the packing shed does not remove it, resulting in downgrading.

NATURAL ENEMIES
Common aphid predators include lady beetles, syrphid fly larvae, lacewings, cecidomyiid midge (fly) larvae, and predatory bugs (Deraeocoris and pirate bug). A parasitic wasp may attack the green aphid, causing it to swell and darken, but the wasp cannot complete its life cycle in this aphid species, so makes no exit hole in this species.

MONITORING
Monitor by visually scanning a minimum of 30 trees and record populations as a percentage of shoots with "X" number of terminal leaves infested." For example: "50% of shoots with 2-3 leaf colonies", or "80% shoots with 4+ leaf colonies". Score shoots as 0-1 infested leaves, 2-3 infested, and 4 or more.

ACTION THRESHOLDS
Thresholds will vary depending on the variety and tree structure. For example, old Delicious can tolerate 50 – 80% shoot infestation with 4 or more leaves per shoot infested. Young trees have the lowest threshold at 25 – 50% infested shoots with 2 – 3 leaves/shoot colonized. Some additional considerations: light skinned varieties such as Goldens and Grannies have low tolerance for sooty mold in the stem bowl. Tree structure is a factor to consider if there is a heavy or sparse canopy, and whether the fruit hang underneath the aphid infestations. Note whether the fruit are getting sticky and the strength of the predator populations.

Rosy apple aphid figs. 39 - 41
Dysaphis plantaginea

DESCRIPTION
Young aphids have long cornicles and antennae that are almost half as long as the body. They are dark green when they first hatch, then become rosy brown or purple. Winged adults are brownish-green to black (about 2mm long).

LIFE CYCLE
In spring, the hatched nymphs feed on expanding buds, then move to the leaves of developing fruit clusters. As soon as the blossom cluster begins to separate the aphids work their way down among the clusters and are hard to see until petal fall. Young leaves are colonized as they unfold, and the saliva of the aphid stunts and curls the leaves as they grow. Rosy aphid goes through several generations before they migrate to weeds by late June or July as winged adults.

DAMAGE
Rosy aphid is one of the most damaging aphid species, feeding on apple leaves and fruits. The deformed shoots are undesirable in young trees. Fruit feeding causes small, misshapen apples. Honeydew from feeding aphids drips on fruit and leaves below and dark sooty mold grows in the honeydew.

NATURAL ENEMIES
Same predators as for green apple aphid. In addition, parasitic wasps can be important.

MONITORING and ACTION THRESHOLDS
Visually scan for infested clusters and shoots from bloom through June. In a scan of 30 trees during May, if about 5% or more of the trees have aphid infestations, treatment may be warranted.

Woolly apple aphid figs. 37 – 38
Eriosoma lanigerum

DESCRIPTION
These aphids are covered with white waxy filaments. Their bodies are purplish-brown and 3 mm long. Woolly apple aphid colonizes both the roots and above-ground portions of apple trees. They are found on old pruning wounds and scars and in leaf axils, and when populations are high, all along actively growing terminals and vegetative growth.

LIFE CYCLE
Woolly aphids overwinter as nymphs on the apple roots, or even on the trunk or limbs. This aphid does not form eggs in our region. As temperatures warm in spring, the overwintering females produce live young that migrate up and down the tree. The populations are largest and most obvious in mid to late summer.

DAMAGE
Aphid feeding causes swellings, or galls, on twigs and roots. Over time this damage can kill roots and twigs. Most rootstocks are susceptible to damage, although MM.106 and MM.111 were developed to be resistant to woolly apple aphid. They produce honeydew that can drip onto fruit, as with other aphids. Infestations are sticky and unpleasant for pickers. Wooly aphid may facilitate the spread of perennial canker.

NATURAL ENEMIES
Aphelinus mali, a wasp parasite can often completely control woolly aphid. Unfortunately, most insecticides are toxic to the wasp. Lady beetles, syrphid fly larvae, lacewings and *Deraeocoris* are also good predators.

MONITORING
During the delayed dormant period, look for whitened areas indicating past or present infestations. Pay special attention to pruning scars and cracks around the base of the tree. Examine these areas for live aphids. In mid-June, inspect one side of 25 trees in blocks with a history of infestation. Look for small colonies beginning to form in leaf axils of 100 water sprouts, suckers and shoots. Where infestations are found, continue monitoring over the following weeks for *Aphelinus* and predators.

ACTION THRESHOLDS
No threshold has been established for Washington State. In New Zealand, a threshold used is 10% of water sprouts or shoots infested with aphids.

Black cherry aphid fig. 42
Myzus cerasi

DESCRIPTION
Aphid nymphs range from amber to dark brown or black and are the only aphids of this color on cherry. Both winged and wingless adults are shiny dark brown to black and have a large round abdomen. They are about 3 mm. long.

LIFE CYCLE
Females lay eggs on the cherry tree in the fall, which hatch before buds open. Two, three or more generations are produced on cherry. By midsummer all migrate to mustard family plants.

DAMAGE
Black cherry aphids deform the leaves on which they feed. Colonies on terminal growth are especially damaging in nursery trees. Large populations can excrete honeydew on leaves and fruit and can be a nuisance to pickers. Low populations generally are harmless and will disappear before harvest.

NATURAL ENEMIES
Same as for other aphids, such as green apple aphid.

MONITORING
Cherry blocks should be checked weekly after bud break. Infestations usually start in the lower interior of the tree.

ACTION THRESHOLDS
None have been set, and therefore treatment may be based on the tolerance of the grower to the infestation.

Western tentiform leafminer figs. 51 – 56
Phyllonorycter elmaella

DESCRIPTION
Eggs are very small, yellow, flat and round and are laid on the undersides of leaves. Larvae in the first three instars are called sap feeders. They are white, legless, wedge-shaped, and deeply segmented (about 1.5 mm). Their mines initially appear as a thin line, or small blotch on the leaf underside. The fourth and fifth instars are called tissue feeders and their mines can be seen from the upper leaf surfaces. They are more cylindrical, white to yellowish, have legs and a typical caterpillar head capsule, and are about 5 mm long. These larvae "tent" the mine by spinning silken threads inside the mine. Adults are small moths with pretty bronze and white markings; they measure about 3 – 5 mm long.

LIFE CYCLE
Adults emerge in spring from pupae that overwinter in fallen leaves. Egg laying usually starts at pink and peaks around bloom. The larvae pupate inside the mine. There is one generation in spring and usually three in summer.

DAMAGE
Leafminers can attack apple, pear and cherry, but are usually only of economic importance in apple. High populations can remove a significant amount of green pigment from foliage, which can reduce fruit size and quality. Excessive numbers of mines (10 or more per leaf) can cause curling and actually increase sunburn.

NATURAL ENEMIES
Pnigalio flavipes, a small parasitic wasp, is the principal enemy of leafminer. It can kill more than 90% of the leafminers in a generation and often provides enough biological control that chemical controls are not required. If more than 35 - 50% of the mines are parasitized, the potential for biological control is good. Earwigs and spiders tear open the mines and eat the larvae.

MONITORING

Leafminer populations should only be quantified in apple blocks where they tend to build up to high levels.

PINK BUD: first generation egg sample. This sample is difficult to do given the small size of the eggs, requiring the use of a magnifier such as the Optivisor, but it is useful in some situations:

1 leafminer was a problem the previous summer.
2 the grower isn't planning on using an insecticide at bloom to petal fall that is also effective on leafminer for another pest such as leafroller or codling moth.
3 then, pick 50 spur leaves (5 leaves from each of 10 trees from throughout the block) and examine the lower surface for eggs with magnification. Count the total number of eggs seen and divide by the number of leaves inspected to determine eggs per leaf.

MID-MAY: First generation sap mines sample. Collect 50 – 100 leaves from fruit spurs: from the 2nd to the 4th oldest leaves in the cluster. Count the number of mines on all the leaves and note the data in a sampling form such as the following example:

DATE:			
BLOCK NAME	# of leaves sampled	Total # of mines	% of mines/leaf

$$\text{\% of mines/leaf} = \frac{\text{total \# of mines}}{\text{\# of leaves inspected}} \times \mathbf{100}$$

MID-JUNE: Parasitism sample. Collect 30 - 50 leaves that contain tissue mines when the 1st adult moths begin to emerge. Open 33 - 50 mines and determine if the leafminer larva or pupa is alive. If the leafminer is dead, look for a parasite egg, larva or pupa. Count these as parasitized. If the leafminer larva seems normal but is not moving, it has probably been stung by a parasite but no egg was laid, so include these in the count of parasitized leafminers. Parasitism samples may be repeated for the 2nd or 3rd leafminer generation.

Calculate the percentage of parasitized leafminers as follows:

$$\text{\% parasitized mines} = \frac{\text{\# of parasitized mines}}{\text{\# of mines inspected}} \times \mathbf{100}$$

MID- TO LATE JULY: 2nd generation leafminer mine sample. Sample as for the 1st generation, except leaves should come from the middle portion of the shoot. The third generation, should monitoring be necessary, occurs in mid-August.

ACTION THRESHOLDS

Generation	Average # mines per leaf
1st (at pink bud)	Egg sample: 3 per leaf.
1st (in mid-May)	1 mine per leaf
2nd (in mid-June)	2 – 3 mines per leaf (unless 1st generation parasitism was 35% or more: then raise the threshold; some orchards appear to require 50% or more)
3rd (in mid-August)	5 – 8 mines per leaf (unless parasitism is as above)

Shothole borers and ambrosia beetles fig. 65 - 67

Scolytus rugulosa, Xyleborus dispar, Xyleborus saxeseni

DESCRIPTION
These small beetles are attracted to injured or stressed trees. If there is a population buildup in a wood pile, they can attack nearby healthy trees as well. The adult beetles (2 – 3 mm) are dark brown to black, with a shiny and elongated thorax. Larvae are white, legless, and hidden under the bark of the tree.

LIFE CYCLE
Shothole borers overwinter as larvae in burrows beneath bark. The peak emergence of shothole borer adults occurs from mid-May through mid-June. They continue to be present in low numbers until the peak of second generation adult activity from late July into August. The beetles often feed at the base of leaves or small twigs and deposit eggs under the bark in galleries. These hatch into white grubs that feed under the bark.

Ambrosia beetles overwinter as adults and become active in spring when temperatures warm above 65∞F. The peak of adult activity occurs from April through May. A second generation of the Ambrosia beetle, *X. saxesini*, appears from July into August. These adults also lay eggs, but stay with their young in galleries under the tree bark until the next generation of adults develops.

DAMAGE
Shothole borers are attracted to damaged or stressed trees. Borers weaken and can eventually kill the tree. Ambrosia beetles usually kill branches first.

NATURAL ENEMIES
Birds, especially woodpeckers, wasps, and some insect diseases.

MONITORING
Examine trunks and branches in late May or early June for the round 1 – 2 mm holes. Cherries will exude gum from the holes. Chemical controls are directed at the adults when they are visible outside the tree. One may also see the shothole borer beetles in spring. Pay special attention to areas where there is a history of attacks or that have freeze injury. There is a method for monitoring ambrosia beetle with a alcohol bait trap described in Orchard Pest Management. Yellow sticky traps will catch shothole borer or ambrosia if placed in the infested source, such as on an infested wood pile.

Pear psylla figs. 57 - 62
Cacopsylla pyricola

DESCRIPTION
Pear psylla is a small sucking insect that feeds primarily on the foliage of pear trees. It resembles a cicada, but much smaller. The overwintering or “winterform” adults are dark gray and 2.5 mm. long. The summerform adults are smaller, 2 mm, and paler. Their wings are transparent and held roof-like over the body. Eggs are yellow, oblong, and very small: 0.3 mm. Nymphs go through 5 instars, as seen in the figure below. The 1st to 3rd instar nymphs are yellow; the 4th is light brown or green and the 5th is dark brown, with an armored appearance, also called the “hardshell”. The recently hatched nymphs are 0.5 mm long and the fully developed, 5th instar measures up to 2.2 mm. Wing pads begin to develop in the 3rd instar nymph.

LIFE CYCLE
Psylla overwinters as an adult both inside and outside pear blocks. When temperature exceeds 50° F in February or early March, psylla begin to lay on pear trees. Eggs are laid on spurs and later on all live tissues. There are usually four generations a year.

DAMAGE
Feeding on foliage causes browning and defoliation. If damage is extensive enough, reductions in tree vigor, fruit size, and return bloom can occur in the next season. Psylla honeydew, which drips onto the fruit and produces a gray to black stain, causes cosmetic fruit damage. Varieties vary in sensitivity to psylla damage. Susceptibility is rated as high for Anjou and Bartlett, moderate for red pears, and low for Bosc early in the season, but Bosc becomes more susceptible late in the season.

NATURAL ENEMIES
Deraeocoris, campylomma, other true bugs, lacewings, ladybeetles, and earwigs all feed on eggs and nymphs. A parasitic wasp, *Trechnites insidiosus*, attacks the nymphs.

MONITORING
Psylla generally must be monitored during the entire growth period of pear.

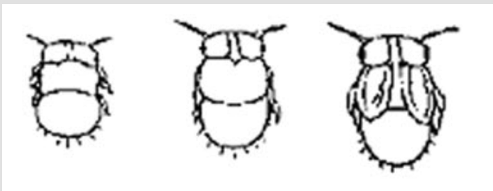
1) **Delayed dormant through pink bud (or “popcorn”) stages.** To assess adult populations use limb tapping with a beating tray. Take 10 - 20 trays per 20 acre block. If psylla adults are present in large numbers, stop at 10 trays.
2) **Delayed dormant (stages 1 – 2) through bloom.** Collect spurs and flower clusters from the interior of the tree, preferably from those attached to scaffold limbs at around 4 – 7 foot height. Collect 2 clusters each from 20 trees. Examine for eggs and nymphs (mites may be counted simultaneously).
3) **From petal fall until harvest.** Collect leaves for egg and nymph counts. Take separate samples from the lower and upper (treetop) portions of the trees. From the lower tree, collect 40 leaves from fruiting spurs located as described in 2). Monitoring of the upper portion of the tree should begin when vegetative or “top” shoots are about 8 – 12” long, and generally coincides with the appearance of the first summerform adults. Collect at least 15 top shoots and examine 3 to 5 leaves per shoot (for a total of 45 or 75 leaves), distributed between the tip, middle and lower portions of the shoot.

> The 3.5X binocular magnifier (such as Optivisor,) is very useful for examining leaves and flower clusters: it is much faster than using only a hand lens because the range of view is wider and the binocular magnifier allows hands-free operation. Use a 10X hand lens to assist viewing greater detail.

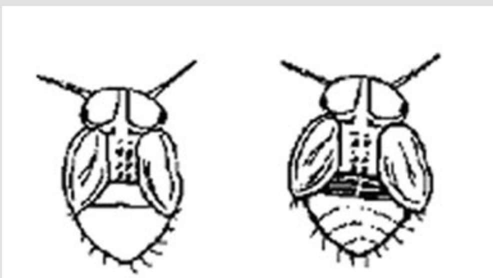
It’s not necessary to count every egg: simply estimate the numbers as low, moderate or high. Evaluating the eggs in this way will give an indication of whether many nymphs are likely to hatch soon.

When counting nymphs, divide counts into instars (stages) 1-3 and 4-5 to better time the application of insecticides. Instars 1-3 are generally more susceptible to chemical sprays than instars 4 and 5, hence the reason for counting separately.

PEAR PSYLLA NYMPH DEVELOPMENT



INSTARS 1-3



INSTARS 4-5

ACTION THRESHOLDS
(for the most susceptible Varieties)

	Pear Psylla	**Spider Mites**
Delayed dormant	0.1 adults/tray*	4-5 mites/spur or cluster
Pink (popcorn)	30% of the clusters infested	Over 20% of the clusters infested
Post-bloom Spur leaves	0.2 - 0.3 nymphs/leaf	0.5-1.0 mites/ leaf
Top shoots	0.5 – 0.75 ninfas/hoja	

*this is a very conservative threshold. Many consultants are content with control measures that result in 1 – 2 per tray.

Pear slug, pear sawfly fig. 68
Caliroa cerasi

DESCRIPTION
The pear sawfly adult is a shiny black wasp, about 5 mm long. The larvae resemble small, black slugs. They are covered with green slime. The front end of the body is wider than the rest of the body. When they have just molted, larvae are yellow.\

LIFE CYCLE
Pear slug overwinters as a pupa in the soil. Adults emerge in spring and insert their eggs into the leaf. In 3 – 4 weeks the larvae pupate. Second generation larvae appear in August and September.

DAMAGE
The larvae feed on the upper surface of the leaves, leaving a skeletonized appearance. When infestations are severe, significant defoliation can occur.

MONITORING
Look for larvae of the second and more destructive generation in August and September. Infestations usually only can be found in unsprayed or organic orchards.

Western cherry fruit fly figs. 63 - 64
Rhagoletis indifferens

DESCRIPTION
The adult (5 mm) is slightly smaller than house fly; its body is black with yellow markings near base of wings and white stripes across the abdomen. Wings have black markings, with a “crab claw” towards the tip that helps distinguish this pest from related fruit flies. The larva is a white, legless maggot, up to 8 mm long, without a distinct head.

LIFE CYCLE
It overwinters as pupae in soil under the host tree. This fly has a single generation per season, emerging from the soil under the host tree for about eight weeks, with emergence peaking around sweet cherry harvest time. Flies will usually travel no further than the first cherry tree they find, although they can fly several hundred meters. They may only disperse across long distances if adults are carried on strong winds from an infested site. Five to 10 days after emerging, female flies lay eggs singly in cherries. Each female can lay 100 – 300 eggs over a 30 day period. The eggs hatch in 5 to 8 days and larvae feed for 1-2 weeks before cutting exit holes and dropping to the ground to pupate.

DAMAGE
Maggots feed in the flesh of the cherry, rendering it unmarketable. This pest is under quarantine status, resulting in a zero tolerance for injury. If State inspectors find infested fruit in the packing house, fruit shipments can be prohibited.

NATURAL ENEMIES
Parasitic wasps, but control is not significant.

MODEL
In Washington, the cherry fruit fly model is an excellent tool to time the first spray. It is more accurate than timing the first spray when the cherries begin to turn “straw color”. The degree day accumulation is initiated on March 1 (“biofix”). The model predicts first fly emergence from heavily infested sites at 950 degree days. In orchards where control has been good historically, the first spray can be applied at 1060 – 1100 degree days.

MONITOREO
Traps are not an effective control or monitoring device in commercial orchards. In infested trees (such as in backyard sites), the presence of cherry fruit flies can be determined using commercially available sticky yellow traps baited with ammonium carbonate. At the beginning of June, hang the traps preferable around 10 feet high in exposed sunny parts of the trees. Use a minimum of 4 traps with an average of 1 trap per acre in large solid blocks. Inspect traps daily until the first fly is caught, then at weekly intervals.

MITE PESTS

Pear rust mite figs. 69 – 70, 75 - 76
Epitrimerus pyri

DESCRIPTION
This is an extremely small pest (0.015 mm!), only marginally visible with a standard 10X hand lens. The mites are tan colored and wedge-shaped (wider at the head end).

LIFE CYCLE
Pear rust mite overwinters in bark crevices or under bud scales. Overwintering females emerge as buds expand and infest the clusters to feed and lay eggs. There are many generations, especially in summer. They can go through a generation in a week, so the potential for population explosions is high.

DAMAGE
Their plant feeding habits cause a russeting of the underside of the leaf and fruit surfaces. Damage to fruit is typically concentrated at the calyx end but can cover the whole fruit.

NATURAL ENEMIES
Typhlodromus, a predatory mite, as well as lacewings, ladybeetles, predatory thrips, and other predators feed on pear rust mite, but natural controls are rarely sufficient to keep rust mite below damaging levels.

MONITORING
Because of their small size, rust mites can multiply without detection by even the most careful scout. Use a hand lens with minimum 14X magnification in order to see the mites. Rust mites concentrate at the base of and under bud scales starting in the dormant period. Later they can be found on leaves beginning shortly before bloom and on the fruit. Examine small pear fruits weekly, beginning no later than fruit turndown, unless or until a post-bloom miticide has eliminated them. Rust mite distribution tends to be clumped; take a sample of no fewer than 25 fruits per 10 acre block. In mixed D'Anjou and Bartlett blocks, examine the D'Anjou fruit, as these will be infested and harmed first. Examine the calyx area of each fruit, looking closely under and around the sepals.

Sample weekly until a miticide has been applied and rust mites have been reduced to very low levels or eliminated. Sampling fruit at harvest and cull fruit from the packing house is of great value for identifying areas where pear rust mite may be a problem in the next season.

Apple rust mite
Aculus schlechtendali

DESCRIPTION
This tiny mite (0.015 mm!) is usually considered beneficial because it provides an alternate food source for the predatory *Typhlodromus* mite. Like pear rust mite, it is wedge-shaped and tan-colored. When populations are very high, their feeding bronzes the apple foliage but this is not injurious to growth. Although very rare, apple rust mite in extremely high populations early in the season can cause a tan russeting on light colored varieties such as Golden Delicious.

MONITORING
The presence of large numbers of rust mites can be detected by the bronzed color of the leaves. Detection is confirmed by using a hand lens. ARM can be a problem on very young trees, and can stunt growth. Control may be required during the first years of orchard establishment until beneficial mite populations build up.

European red mite Figs. 71, 72, 77 - 79
Panonychus ulmi

DESCRIPTION
Eggs are red, spherical and microscopic in size. After the egg hatches, the empty shell is transparent. There are three immature larval stages, light orange to red with a greenish cast. The adult female mite (0.4 mm) is bigger than the male; she is brick red, oval-shaped, and has bristles. The male is more slender, reddish-yellow and with a tapered abdomen.

LIFE CYCLE
Red mite overwinters as eggs on rough bark near buds and on fruit spurs. Egg hatch begins at bud stages tight cluster to pink. They prefer the underside of the leaves in pear, but adult mites inhabit both surfaces. Mites prefer mature foliage when available. During the growing season the female lays eggs on the leaves. Red mites can complete their life cycle in 10 to 25 days; the warmer the weather, the shorter their generation time. Dusty conditions (often near borders and roads) also stimulate mite outbreaks, perhaps by increasing leaf temperature. There are six to eight generations per year.

DAMAGE
Plant-feeding mites insert their mouth parts into leaf cells to suck out the contents. The feeding damage initially is pale, giving the leaves a stippled appearance. As damage progresses, the infested leaves take on a brown hue, called bronzing. When this damage is severe, it may affect tree growth in young trees, and fruit size and quality. In pears, injury appears as dead, burnt-looking patches on the leaves that then fall off.

NATURAL ENEMIES
The Western predatory mite usually keeps plant feeding mites under control in apple and cherry orchards, unless certain pesticides have been used which are toxic to the predator, or if they have not been able to build up sufficiently in an orchard for other reasons. This may occur when their alternate food source, the rust mite, is in short supply, due to being killed by sulfur sprays or very hot weather.

MONITORING and ACTION THRESHOLDS
Pear:

Dormant period: spurs may be examined for eggs
Pink bud: collect 40 flower clusters from throughout the block. Examine entire cluster thoroughly with magnification. Rate each cluster as Low (1-2 mites), Moderate (3 – 4) or High (5+).
After bloom: collect 40 leaves per block from 20 trees, spur and shoot leaves.

ACTION THRESHOLDS FOR PEAR

Variety	Average # of mites per leaf
Green Anjou	0.5 to 1
Bosc	0.5 to 1
Bartlett	1 to 2
Comice	1 to 2
Red Anjou	20 to 25

Also refer to the table of action thresholds on page 28. If you detect mite predators, consider increasing the action thresholds.

Apple and Cherry:

Dormant period: Collect 50 fruit spurs per block from the interior of the tree. Sample borders separately. Examine with magnification. If the grower is considering skipping the ½" green – tight cluster oil spray, then a red mite egg sample should be taken to assist with that decision.

Suggested action threshold: average of 50 eggs per 2" spur in conventional orchards, and 75 per spur in organic blocks. This may be varied depending on history and grower tolerance.

Summer: Generally, mite populations will not begin to build up until temperatures get into the upper 80's or 90's. At this time, begin looking for leaf stippling and bronzing, starting usually with interior spur leaves. One can learn to estimate the numbers by initially counting mites on several leaves to train the eye. While examining leaves, search for predators as well.

Action threshold: in apples, even 30 mites per leaf is a conservative threshold; higher numbers may be tolerated for one to three weeks. If 0.5 - 1 predatory mite per leaf is present, they will effectively control the spider mite population within a week or two.

Twospotted spider mite and McDaniel mite figs. 73, 74, 77 - 80
Tetranychus urticae y *T. mcdanieli*

DESCRIPTION

These two mite species are similar in appearance and habit. The eggs are spherical and translucent to opaque. The mites produce webbing in which they live and lay eggs. The larva is round and has only 3 pairs of legs. The later larval stages are more oval. Adult males are smaller than the females and have a pointed abdomen. The McDaniel mite has multiple pairs of spots on its back while the twospotted mite usually has one pair of spots, but this characteristic is not always obvious. McDaniel mites are often greenish, while the twospotted mites are clear/white. Twospotted mites are more resistant to Pyramite™, so it can be important to tell the difference.

LIFE CYCLE

Both species overwinter as orange-colored adult females in the debris below trees or under bark scales. They move onto green tissue at about ½" green bud stage. As they feed, they lose their orange color and gain their normal pale or greenish hue and spots. After 2 to 5 days, egg laying begins, primarily on the underside of newly expanded leaves. Overwintering females lay about 40 eggs in 23 days when they become active in the spring, much less than the summer forms, which can lay 100 eggs in an average of 30 days. In summer, the generation time may be as short as 10 days. Depending on temperature, they take up to 21 days to hatch in the spring to as little as 1 to 2 days in the summer heat.

DAMAGE, NATURAL ENEMIES, and MONITORING

See the section on European red mite.

NATURAL ENEMIES: PREDATORS AND PARASITES

Beneficial insects, or "natural enemies" of pests include two groups: predators and parasites. Predators are capable of consuming large populations of many pest insects and mites, but they usually need high populations of their prey to survive. Many natural enemies are predators in both their larval (immature) and adult stages, but not all. For example, the syrphid fly larva feeds on aphids but the adult fly feeds on nectar, insect honeydew and pollen.

Parasites live on or inside another organism, slowly killing their host. For example, the wasp *Pnigalio flavipes*, which parasitizes the Western tentiform leafminer, lives on its host larva, while the wasp *Aphelinus mali*, lives inside its host, the woolly apple aphid. Unlike predators, most parasites attack only one individual host.

PREDATORS

Lacewings - green and brown figs. 81 – 84 *Chrysopa and Chrysoperla* (Green lacewings), *Hemerobius* and others (Brown lacewings)

Lacewing larvae are important and common natural enemies of a variety of insects such as aphids, psylla, leafhoppers, scales and thrips. The larvae are active earlier in the season than many other predators and can provide good control of early season pests. Most lacewing adults feed on aphid honeydew and plant fluids.

Green lacewing eggs are oval and suspended on a long hair-like stalk, while brown lacewing eggs do not have a stalk; both are laid on leaves. The larva (up to 15 mm long) is alligator-shaped with sickle-shaped mouthparts. Pupae are in an opaque white or yellow, tightly woven spherical cocoon. The adult green lacewing (15 - 20 mm) is green with large net-veined wings and golden eyes, brown lacewing (10 – 12mm) is brown or beige with lacy, hairy wings and is half the size of the green lacewing. Most lacewing adults feed on nectar, pollen, and aphid honeydew. Some lacewings overwinter as adults while others survive as pupae inside cocoons. Most lacewings complete 3 or 4 generations per year.

Lady beetles figs. 88 - 91

There are many species of lady beetles or "coccinelids". Lady beetles overwinter as adults and are one of the first predators to move in during the spring time (April, May). Adults (5 – 8 mm) are generally oval shaped, and are red to orange with varying numbers of black spots. They have, on average, two generations per year. Some species migrate out of orchards to mountainous areas in late summer, then migrate back in spring to mate. Eggs (1.5 mm)are torpedo shaped, yellow, and laid in groups. The adult female won't lay eggs until she has fed on prey, and will lay between 200 and 500 eggs, depending on the availability of prey. Usually eggs are laid in close proximity to prey. Eggs hatch in 5-7 days. Lady beetle larva are similar in shape to lacewing larvae, black with orange markings. Larvae prey on aphids primarily, but will feed on any soft bodied insect (mealybug, psylla, mites, and scale).

Black lady beetle fig. 92
Stethorus picipes

Adults (1mm) and larvae prey on mites and insect eggs. These beetles are usually associated with mite infestations. Stethorus is black with silvery hairs (about 1 mm). The larva is brown or black with short spines. Stethorus overwinters within the orchard in leaf litter around the base of trees.

Syrphid or flower flies figs. 86 - 87

There are several species of these predatory flies. Adults resemble honey bees, but have one pair of wings and are sometimes called hover flies due to their flight habit. The adults are not predators but feed on nectar and pollen. Eggs are shaped like a grain of rice. The larva is a blind and legless maggot, rounded at the rear, and tapering to a point at the head (5 – 10 mm). It has a mouth part that is actually a three pronged dart that it uses to seize, kill and consume its prey. Syrphid larvae are voracious aphid predators. Shiny black stains in or near aphid colonies are usually larval droppings and indicate that a Syrphid larva has been in the colony. Syrphids pupate in the ground. The adult flies move into the orchard in early spring, depositing their eggs in or near aphid colonies. There are 3 or 4 generations per year. The flies stay in the orchard through October.

Predatory midge or Cecidomyiid fly fig. 85
Aphidoletes aphidimyza

Adults are a very small, nocturnal fly; rarely seen. Eggs are orange, oval and tiny (about 0.3 mm long) and are laid in aphid colonies. Larvae are orange or pink, small (3 mm), and legless They occasionally are very important aphid predators, often with several larvae feeding in an aphid colony on a single leaf. There are several generations per year.

PREDATORY BUGS

All of the predatory bug species listed below are predators both as adults and nymphs. All the true bugs have piercing-sucking mouthparts.

Deraeocoris fig.65
Deraeocoris brevis piceatus (most common species)

Deraeocoris preys on pear psylla, mites, aphids, leafhoppers and scale insects. Deraeocoris bugs overwinter as adults, in and outside of the orchard, so these predators can be in the orchard throughout the growing season. The overwintering females lay their eggs in April or May. Nymphs of the first generation are found two to three weeks later. The adult (3-6 mm) is shiny and black. Occasionally, large numbers are caught in codling moth pheromone traps. The nymph is mottled whitish-gray with gray hairs. A single Deraeocoris nymph can eat as many as 400 pear psylla eggs or nymphs throughout its development.

Campylomma bug figs. 19 - 22
(see under insect pests)

Pirate bug fig. 95
Orius tristicolor

Pirate bug preys on mites, thrips, aphids, and young scales, and pear psylla. They overwinter as adults in sheltered places (under boards, trash, or bark) and move into the orchard in the spring when temperatures rise above 50∞F. There are 3-4 generations per year. The adult pirate bug (1.5 mm) with sets of black and white triangles on the wings forming a "pirate's mask". The nymph (1 – 1.5 mm) is yellowish to orange with red eyes, and pear shaped. As it passes through its instars the wing pads develop and the abdomen darkens.

Damsel bug or Nabid fig. 96
Nabis spp.

This bug is a general predator of aphids, leafhoppers, scale, mites, the eggs and larvae of moths, and even of other natural enemies. Adults (10 – 12 mm) are tan or gray with enlarged front legs for grasping prey and a slender body that tapers the rear. Nymphs are similar to the adults but smaller and lack wings. Often found in large numbers on the cover crop and will climb or fly to trees. They overwinter as adults in weeds, grain or alfalfa fields. There are 3-4 generations per year. Eggs are laid in soft plant tissue.

Predatory stink bug fig. 97
Brochymena spp.

Brochymena feeds on caterpillars, beetles, psylla, aphids, and other insects. Nymphs and adults (12 – 15 mm) are steel gray with white specks. The body is flattened and shield-shaped, like other stinkbugs, but the color and rough-textured appearance are distinctive in this predatory species. Also, the only similar pest stinkbug, the consperse stinkbug, is pale brown with small black specks. Brochymena overwinters as an adult and has one generation per year.

European earwig fig. 93
Auricula forficularia

Earwigs are nocturnal insects that feed on psylla, codling moth in cocoons, leafroller larvae, mites, aphids, and insect eggs but will also feed on apple or pear fruit where the skin has been broken or is overripe, and on undamaged apricots and nectarines. They overwinter as adults in earthen cells, where they lay their eggs in spring. One monitoring method is to place crumpled newspaper or cardboard bands in the tree crotch, where they hide during the day. Nymphs are similar in appearance to adults. The adult female has straight pincers, while those of the male are curved.

PREDATORY MITES

Among other characteristics, predatory mites can be distinguished from pest species by observing the speed of their movement. When disturbed, predators generally move more quickly than pest mites. Predator abundance is strongly affected by certain pesticides, especially organophosphates and some miticides.

Western predatory mite or Typhlodromus fig. 98
Galendromus occidentalis

Western predatory mite is sometimes referred to as "Typhlodromus" (their former genus), or simply "Typhs". Adults (0.3 mm long) are opaque white or nearly transparent until they feed, then they may take on the color of their prey as they feed. They are easily distinguished from spider mites (red mite, twospotted and McDaniel spider mites) by their shape. Typhs are pear shaped, smaller at the head and broader at the rear. Conversely, spider mites are larger at the front and smaller in the rear. Typhs also have the habit of hiding alongside the central vein of the underside of leaf.

Typhs feed on spider mites, rust mites, and pollen. Typhs overwinter as adult mated females in debris or under bark. They begin to emerge at about 1/2" green stage. Females begin to lay eggs at about tight cluster on the underside of leaves, and in opening buds and flowers. Eggs resemble a spider mite egg but are slightly larger and oval, and transparent to translucent white. Eggs hatch in 1-4 days; there are 8 – 10 generations per year.

Zetzelia predatory mite fig. 99
Zetzellia mali

The *Zetzellia* predatory mite is bright yellow with a tapered posterior, but develops orange markings when feeding on European red mite eggs. It will also feed on Typhlodromus eggs. Zetzellia females emerge in April and move into unfolding leaves. They pass through several generations in summer and begin to look for overwintering sites in September, but they can be found on leaves as late as November. Zetzellia overwinter in cracks, crevices, and even under the empty scales of San Jose scale.

PARASITES

Tachinid flies figs. 100 - 101
Nilia spp., *Nemorilla* spp.

Tachinids are natural enemies of stinkbugs, and leafroller, cutworms and other moth larvae that feed on foliage. The adult looks much like a housefly, but has thick hairs or bristles on its abdomen. The egg is oval and flattened, it is not unusual to see a caterpillar with several eggs attached to its body. The larva develops inside the leafroller host body after it pupates. When the fly larva completes its development, it pupates next to the shell of its host pupa, as seen in figure 101; the pupa is shaped like a grain of wheat.

Pnigalio flavipes wasp figs. 102 – 103

Pnigalio (the "p" is not pronounced) is the most common parasite of the Western tentiform leafminer. *Pnigalio* overwinters as a pupa in leafminer mines in leaves that fall to the ground. It emerges in spring about the same time as leafminers. The female wasp stings the leafminer larva and paralyses it. The eggs are deposited inside the leafminer mine. The eggs are white and cylindrical and are laid on the host larva or elsewhere in the mine. The larva searches out the paralyzed leafminer larva and begins to feed. It pupates within the mine. The wasp pupa is shiny black and most of its body segments are easily distinguished. Its life cycle follows that of the leafminer.

Colpoclypeus florus wasp figs. 104 - 105

Colpoclypeus attacks many species of leafrollers, both the common orchard species as well as others such as a leafroller that infests wild roses. The potential benefit of wild roses growing near the orchard is that *Colpoclypeus* can overwinter on the leafroller in the roses, while it cannot in the orchard species. The adult wasp is black with a golden abdomen and only 3 mm long. The female lays many eggs on a single host larva. The parasite larvae (1 – 3 mm) are bright to dark green legless maggots that lie beside the host larva and feed on it. Pupae are light brown and darker at the head. *Colpoclypeus* has two generations per year.

Trechnites insidiosus wasp figs. 106 - 107

Trechnites is a parasite of pear psylla nymphs. The adult (1 mm) is dark with a metallic blue patch on its domed thorax and antennae are elbow shaped. The adult inserts one egg in a psylla nymph, which becomes a swollen immobile mummy. Mature larvae overwinter within psylla nymphs. *Trechnites* are detected on leaves in mummified psylla, and as adult wasps when tapped onto a beating tray. There are 3 – 4 generations per year.

Aphelinus mali wasp figs. 108 - 109

Aphelinus parasitizes woolly apple aphid. Adults are black with short antennae and measure 2.5 mm long. They tend to jump rather than fly and prefer to hide under leaves, but when parasitizing aphids they can be seen in the colonies. The wasp inserts its egg in the aphid, in which the larva completes its development. Parasitized aphids are black, stick to the tree and have an exit hole when the parasite adult has emerged. The adult wasp is sensitive to most insecticides including carbaryl.

Spiders figs. 110 - 111

All spiders are predators, and some are very effective in searching out insect pests. For example, one type, a sac spider, will tear open a folded leaf to extract and eat leafroller larvae.

DISEASES

Introduction

Organisms that cause diseases are called pathogens. Pathogens are very small microorganisms invisible to the naked eye, including fungi, bacteria, mycoplasmas, and viruses. Because the actual pathogen that causes a disease cannot always be seen, we may detect their infections by the symptoms they produce in the host – that is, the plant or animal that the pathogen infects. For example, fireblight is caused by a bacteria, *Erwinia*, which can be seen under a microscope, but we detect it in the field by the symptoms such as a blackening and wilting of the shoots. In the case of humans, for example, we cannot see the virus that causes the common cold, but its symptoms are readily apparent such as a red, runny nose, sneezing, sore throat, and so forth. In the following section are descriptions of the most economically important diseases in tree fruit production in eastern Washington.

Powdery mildews

The various species of powdery mildew are caused by fungi that tend to be host specific: apple powdery mildew is not the same pathogen that attacks cherries, etc. This is important to know because control measures can be different with the various species of mildew. Powdery mildew, particularly that of apple, does not need wetting to disperse and cause infections, unlike many other diseases caused by fungi, such as apple scab and fireblight. The temperature range that is most favorable for development of powdery mildew is between 70° and 80°F.

Powdery mildew of apple and pear

figs. 112 - 117

Podosphaera leucotricha

This disease affects young shoot terminals and immature fruit. Most apple varieties except Red Delicious are very susceptible to the disease. Rome, Jonagold and Ginger Gold are among the most susceptible. Infected apple fruit develop a netlike russet. Infected shoots and fruit spurs are stunted. In pears, mainly the fruit of d'Anjou is susceptible to the russetting injury, in Bartlett this is rare in Washington. The fruit injury usually appears as a crusty russet concentrated at the calyx end. Powdery mildew does not overwinter in pear and for this reason is usually only a problem where mildew susceptible apple varieties are growing nearby. In apple, powdery mildew overwinters as mycelium, tiny white strands of cells, in leaf and flower buds infected the previous summer. The old infected buds begin to produce spores in the spring, which are carried by the air to new, young leaves. There, the spores germinate and may penetrate the outer layer of plant tissues. Chains of spores are produced on the surface of the leaves, giving them a powdery appearance. When monitoring for new mildew colonies, look at the underside of young leaves to search for the small fuzzy white colonies that are just beginning to develop.

Powdery mildew of cherry

figs. 118 - 121

Podosphaera clandestina

This mildew overwinters as spore-containing bodies, or "cleistothecia", on dead cherry leaves on the ground, in tree crotches, and bark crevices. In spring as buds break, irrigation or rain releases spores and wind spreads them to young, expanding leaves. Given the right combination of favorable temperature and leaf wetness duration, these spores germinate on young cherry leaves and start the first mildew colonies of the season. It takes 7 – 14 days for the first symptoms to appear after the first infection period. The first few infected leaves are often found on suckers in tree crotches and scaffold interiors with dense vegetative growth. These colonies produce a new generation of spores called conidia, generally around shuck fall, and continue the disease cycle. These secondary spores are favored by warm temperatures, high humidity, and dry leaves, but infection does require some moisture. The fungus reproduce in as little as 4 to 5 days under favorable conditions. Young green Bing fruit has been found to be more susceptible to infection than fruit near maturity. The most susceptible varieties are those with dense fruit clusters, late harvest, and vigorous trees. Rainier, Bing, Lapin and Sweetheart are very susceptible. Chelan is immune.

The first leaf symptom may appear as a light green, circular lesion on either leaf surface, but this is very difficult to detect. The first sign of fungal colonies encountered when monitoring is a white cotton-like growth developing on the leaf underside. Advanced leaf infection can result in curling and/or blistering. Fruit symptoms appear as circular, slightly depressed areas developing on the surface. The white, cotton like growth may or may not develop but can cover the entire fruit surface and the fruit stem. Fruit in dense, shaded portions of the tree will be infected first. As infected leaves age, the small (0.1 mm), dark cleistothecia, the overwintering spore containers, are formed over a 1 to 3 week period in July.

Apple scab figs. 122 - 123
Venturia inaequalis

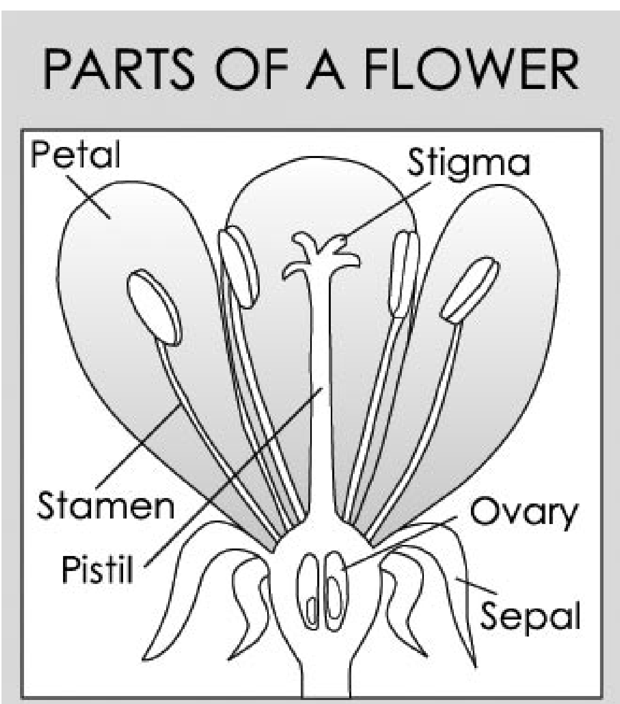
The fungus that causes apple scab overwinters in infected fallen leaves. Spores are discharged during rainy periods in spring, as early as green tip. Infection occurs if the proper combination of temperature and moisture is present (see the Mills Chart in Crop Protection Guide for Tree Fruits in Washington.) Scab first appears on the undersides of new leaves as olive-green spots. These spots become progressively olive to brown-colored and velvety in appearance. Fruit may become infected at any time in its development, although as the wax builds up on the surface a longer wet period is required to cause the infection. Typical fruit lesions are distinct, almost circular, olive-green spots that later become brown or black. The skin ruptures around the lesions revealing a dark velvety layer of spores. Older lesions become corky in appearance.

The primary scab season lasts until all the ascospores from last year's leaves have been released. This varies from year to year but typically ends in mid June. It is critical to spray properly during this primary phase to avoid further secondary infections. If the secondary infection cycle is allowed to develop, fungicide sprays will need to be applied throughout the growing season. A thorough discussion on apple scab may be found in the Canadian website http://www.agf.gov.bc.ca/cropprot/tfipm/applescb.htm

Fireblight figs. 124 - 129
Erwinia amylovora

Fireblight is caused by a bacteria, and is an extremely serious disease of apples and pears. All pears are susceptible, but Bosc are often the most devastated by the disease. Among the most susceptible apple varieties are Fuji, Gala, Braeburn, Cameo, and Pink Lady. Also, some dwarfing apple rootstocks such as M26 and M9 are extremely susceptible.

Fireblight bacteria overwinter in cankers or invisible infections on twigs, branches or trunks of host trees. In spring, when the weather is sufficiently warm and moist and trees become active, bacteria multiply in diseased tissues. A brownish liquid, containing bacteria, may ooze from the cankers. These bacterial cells can be transmitted to blossoms or succulent shoots by splashing rain, hail, insects, or wind. The bacteria colonize the flower's stigmas and under warm conditions the colony grows rapidly. Rain washes the bacteria down into the blossoms where they can invade the tissue. Within a week or two, infected flowers, shoots, or fruit wilt and turn black.



When fireblight spreads into wood, the infected wood may be detected by cutting away the bark. Newly infected wood has pink to orange red streaks. As the canker expands, the infected wood dies. In orchards on susceptible rootstock, sometimes the infection is not detected until the following year, when the tree declines and dies. It is sometimes mistaken for collar rot (*Phytophthora*).

Detection of fireblight infections in the orchard is very important because one of the primary means of controlling this potentially devastating disease is through sanitation, that is, the proper removal and destruction of infected wood. Sprays to control fireblight must be applied before the infection occurs, and even then control is rarely complete. An essential tool for timing sprays is the WSU Cougarblight model, a four day running total of degree days based on high-low temperatures, orchard history, and rain events. The website address is found in the References section of this manual.

Bacterial Canker of Stone Fruits or Bacterial Gummosis

Fig.130 - 134

Pseudomonas syringae pv. syringae; P. syringae pv. morsprunorum

Cherries are very susceptible to this bacterial disease, but *Pseudomonas* also infects other stone fruit, pears, apple rootstocks and many species of ornamental trees. Young cherry trees are more susceptible than established cherry trees, and trees under stress are much more susceptible than healthy trees with optimal growing conditions. Outbreaks are often associated with prolonged periods of cold, wet weather with late spring frosts.

Symptoms on young cherry trees are typically elongated cankers that are soft or spongy to the touch and gum copiously. When bark is stripped off the active cankers, the ooze has a putrescent odor. Cankers may expand rapidly in the spring causing girdling of the main trunk or branches. Bacterial canker is similar in appearance to *Cytospora canker* (**Fig. 135**), but this disease is caused by a fungus. Cytospora cankers sometimes tend to have a more defined edge when the wood underneath the bark is examined.

Bacterial canker infections take place mainly in the fall and winter during cool, wet weather. Trees are particularly susceptible during autumn leaf fall, when fresh leaf scars may become infected. Cankers may not be obvious until the spring, when they start to expand rapidly. Frost damage in the spring may promote additional infections. The bacteria overwinter in canker margins, in healthy buds and within the conductive tissues of the tree.

GLOSSARY

This glossary contains terms used to describe insects and mites and pathogens, their damage, and how to scout or monitor them.

Abdomen. The posterior (back end) of the three main body divisions of an insect, spider or mite. It has neither legs nor wings. It bears the majority of the internal organs of the animal.

Adult. A fully mature or sexually developed animal.

Antenna, antennae (plural.) Feeler-like appendages located on the head of most insects that serve as sense organs.

Beating tray. A square 45 by 45 cm frame with white cloth (or colored cloth to view light-colored insects) to catch insects as they drop from a tree limb. The tray is held under a limb that is about 25-40 mm in diameter while the limb is struck with three sharp blows by a length of stiff rubber hose. Insects jarred from the limb are caught on the beating tray where they can be identified and counted.

Biofix. An identifiable event that signals when to begin degree day accumulation (such as first moth capture, bud break, bloom, etc).

Bloom. A plant growth stage characterized by the presence of flower blossoms

Block. As in orchard block: refers to a planting unit

Bronzing. Damage to a leaf or to the entire tree canopy often caused by mite feeding that causes the leaves to develop an unhealthy brown hue. Initially under a hand lens, leaves may have dotted white appearance that fades to brown.

Bt. *Bacillus thuringiensis*, a microbial insecticide.

Calyx. The cuplike cavity at the end of the apple or pear opposite to the stem.

Canker. A dead, discolored and often sunken area (lesion) on a root, trunk, stem, or branch.

Caterpillar. An elongated wormlike larva of a moth

Chlorophyll. The green pigment of plant cells necessary for photosynthesis, or the capture of light energy.

Crawler. The mobile first instar of a scale or mealybug. It is the only nymphal instar that has legs and moves.

Cocoon. The silky or fibrous case that an insect larva spins to provide cover during the pupal stage.

Cornicles. A pair of protruding appendages or “tailpipes” on the posterior part of an aphid’s abdomen that secretes a waxy substance or defensive fluids.

Degree day. A measurement unit that combines temperature and time; used in calculating growth rates in an insect’s biological cycle (Example: from egg to larval stage).

Disease. Any disturbance of a plant that interferes with its normal structure, function, or economic value

Dormancy. A state of inactivity or prolonged rest.

Dorsal. On, of, or near the upper surface or back of an insect.

Emerge/emergence. To come out (from an egg, from a pupation site, etc.)

Excrement. Solid or liquid waste product voided through the anus of a living organism.

Frass. Granular feces, excrement or waste product voided by insect larvae.

Generation. The complete lifecycle of an organism, from any given stage to the same stage in the offspring.

Grub. A bow-shaped beetle larva with a well-defined head capsule.

Hand lens. A magnifying (10 to 20-fold magnification) glass or loupe used to search for and view small (less than 0.3 mm) insects in the field.

Head. The first of the three body divisions, which bears the eyes, antennae, and mouth parts of an insect, spider or mite.

Honeydew. The liquid excrement of certain sap-feeding insects, such as aphids, mealybugs and per psylla. It is composed of water, plant sugars and amino acids.

Host. A plant, insect or other living organism that serves as a food source or shelter for another organism.

Immature. A young insect or mite that has not yet completed its growth and development to the adult stage.

Infection. The entry of a pathogen into a host and establishment of the pathogen as a parasite in the host.

Instar. A growth stage of an insect between successive molts.

Larva (plural = larvae). The immature stage, between egg and pupa, of an insect with complete metamorphosis (e.g. flies, beetles, moths, wasps).

Lesion. A well-defined area of diseased tissue, such as a canker or leaf spot.

Lure. A device filled with an attractive odor (usually a pheromone) to an insect.

Maggot. A legless, headless larva- often an immature fly.

Mating Disruption (pheromone confusion). The process of controlling or eliminating an insect by saturating the air with insect sex pheromone during the mating time of the insect. The males are then unable to locate the females and viable eggs are not produced.

Metamorphosis. A change in form during the development of an insect.

> **Complete metamorphosis.** Complete changes in form that occur during growth and development. These insects pass through forms including egg, larva ("worm", caterpillar, grub, or maggot), pupa (the stage in which the insect appears to be inactive and may be in a cocoon), and adult.
>
> **Incomplete or simple metamorphosis.** Gradual changes occurring during growth and development, including egg, nymph and adult stages. The nymphs are generally similar to the adults although their wings are only partially developed and they lack reproductive organs.

Microorganism. Microscopic organisms (fungi, bacteria, viruses, nematodes), some of which are pathogens that infect other organisms like plants and animals.

Miticide. A pesticide that kills mites.

Mm. Millimeter, a metric system measurement that approximately equals 1/32 inch.

Molt. In insects, (and mites, spiders, crabs, etc.) the shedding of skin before entering another stage of growth.

Moth. An insect in the order Lepidoptera, generally active at night, and usually duller in color than a butterfly and with larvae that eat plants.

Mouthparts. Any of various structures, or organs around an insect's mouth used for biting, piercing, sucking, chewing, grasping, etc.

Natural enemies. Animals (insects or mites) that prey on or parasitize another animal (prey or host), thereby limiting the population of that prey or host.

Nocturnal. Describing an insect active primarily at night.

Nymph. The immature stages of insects with incomplete metamorphosis such as aphids and leafhoppers that gradually develop their adult form through a series of molts without passing through a pupal stage.

Oviposition. Egg-laying by insects or mites.

Overwinter. To survive the winter, or occurring during the winter period.

Parasite. An organism that lives on or in another species (the host) and derives sustenance or protection at the host's expense. In insects, this relationship leads to the death of the host.

Pathogen. Any disease-producing organism.

Pheromone. Any chemical substance secreted externally by insects, which conveys information to and produces specific responses in, other individuals of the same species.

Pheromone trap. A device to monitor many insects, especially moth species in the field. Insect pheromones are used to attract insects to a sticky trap where they are captured.

Population. The group of organisms of a single species inhabiting a particular locality that have the possibility of interbreeding.

Posterior. At or toward the rear of an insect.

Predaceous. Describing an organism that lives by capturing and feeding upon another. Unlike parasitoids, predators consume many hosts during their development.

Predator. Any animal (including insects and mites) that kills other animals (prey) and feeds on them.

Prey. An insect hunted or killed for food by another insect.

Pupa (plural = pupae). An insect in the non-feeding stage of development between larva and adult characterized by many anatomical changes and, often is enclosed in a cell or cocoon.

Pupal. Pertaining to the pupa.

Resistant. Able to tolerate conditions harmful to other individuals of the same species.

Rootstock. The lower portion of a grafted tree that makes up the crown and root system.

Russet. A rough, scaly brown coloration on the surface of a pear that may be caused by insect or mite feeding damage.

Scale. A small flattened rigid plate forming an external cover of certain insects.

Segment. Subdivision of the body or of an appendage.

Species. The basic unit of classification of living organisms. Defined as a group of organisms that naturally mate and produce fertile offspring.

Sooty mold. A dark growth of fungus living in insect honeydew on plants.

Spore. A reproductive body produced by fungi and other organisms capable of growing into a new individual under proper conditions.

Spur. A short woody shoot that is the primary fruiting structure for most fruit trees.

Stage. A visually distinguishable period of growth and development of a plant or animal.

Sticky traps (or tape). Wax-coated cardboard, plastic sheets or other objects covered with a sticky substance that captures insects that are drawn to a visual, pheromone, light, or bait attractant, walk across, or land on the trap or tape.

Stippling. Small dots or points rather than lines or solid areas.

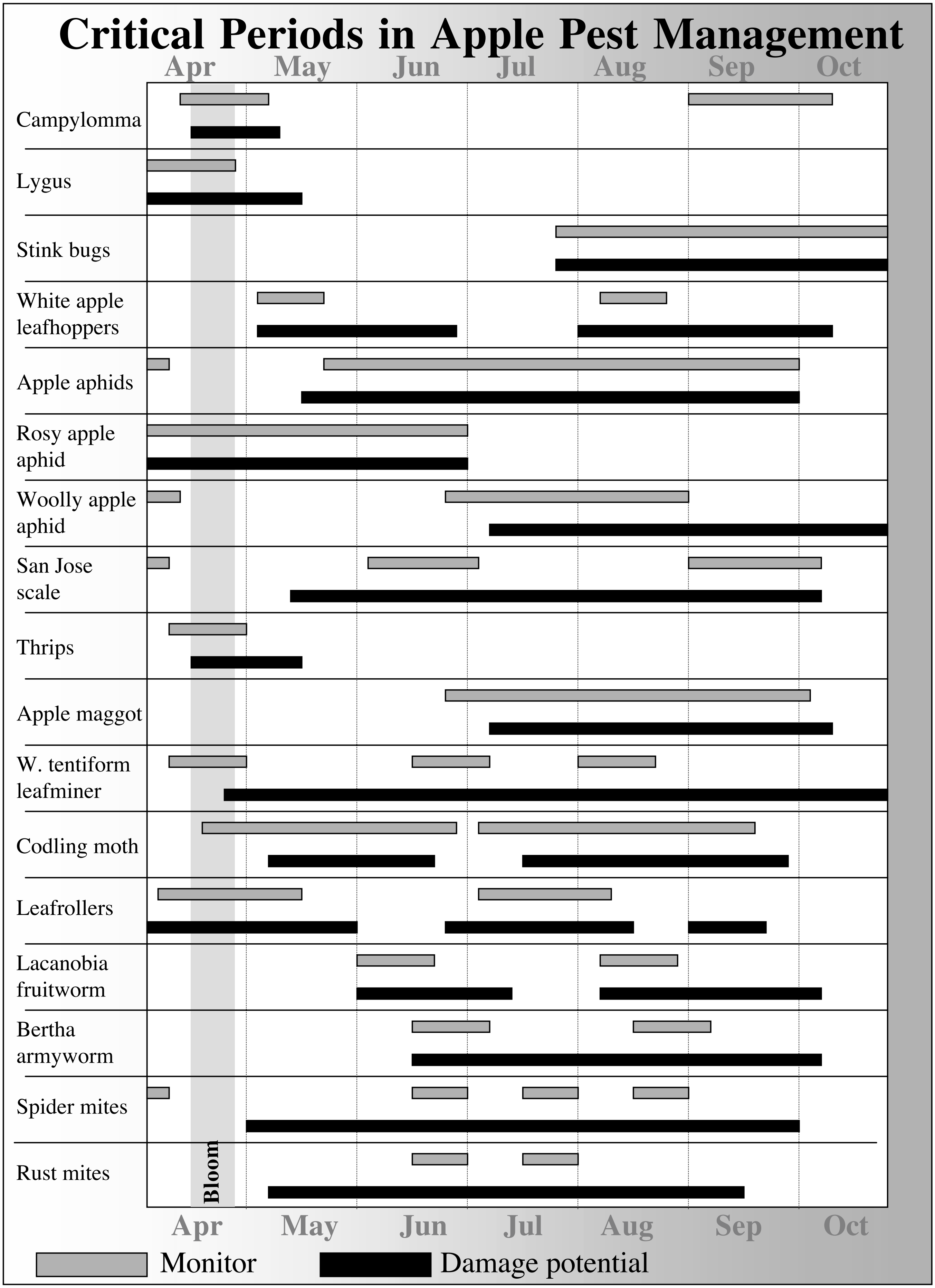
Sucker. Shoot arising from the rootstock, trunk, or main limbs than does not bear fruit. Also called a "vegetative shoot".

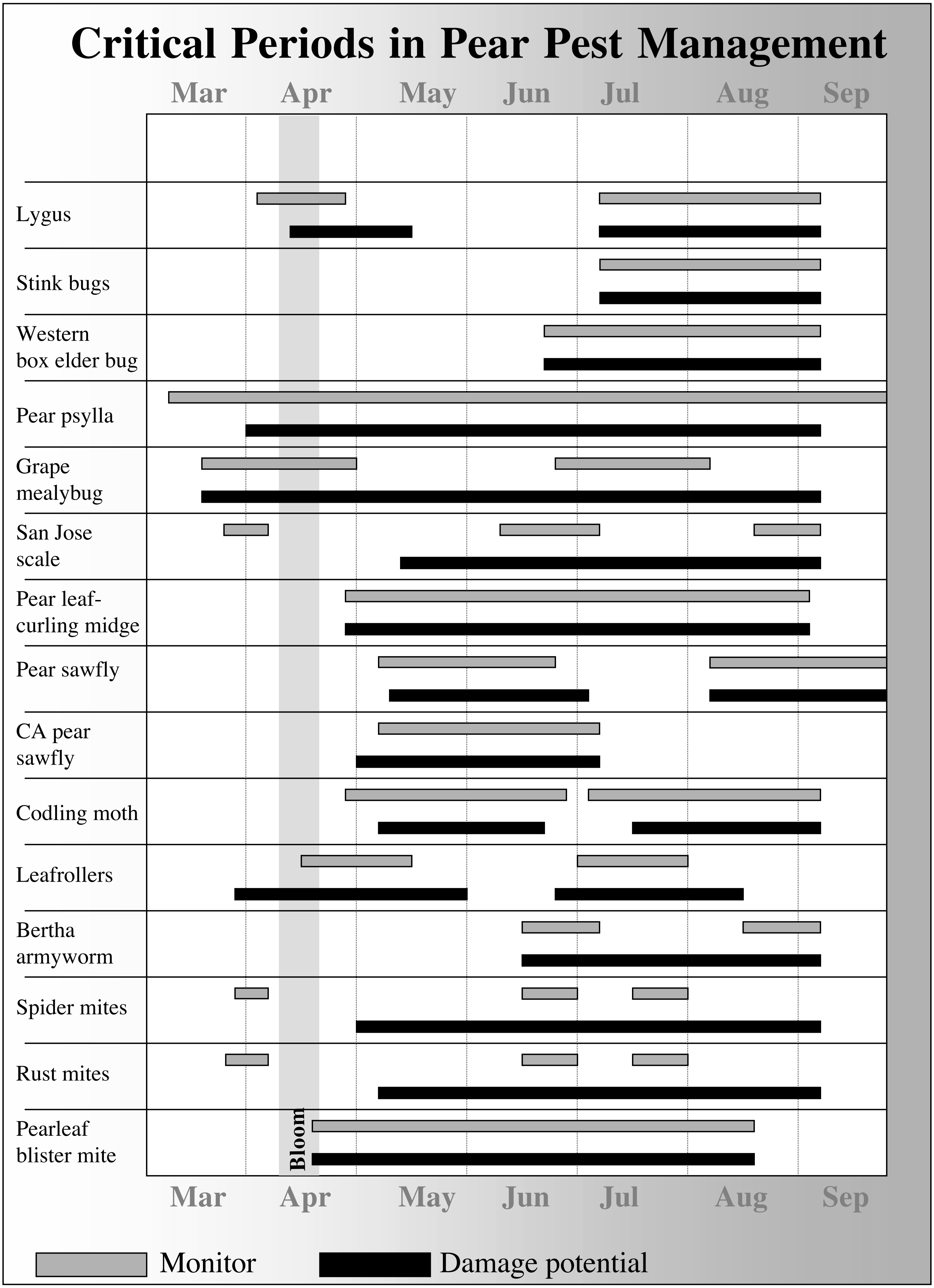
Spur. A short branch which can bear flowers and fruits.

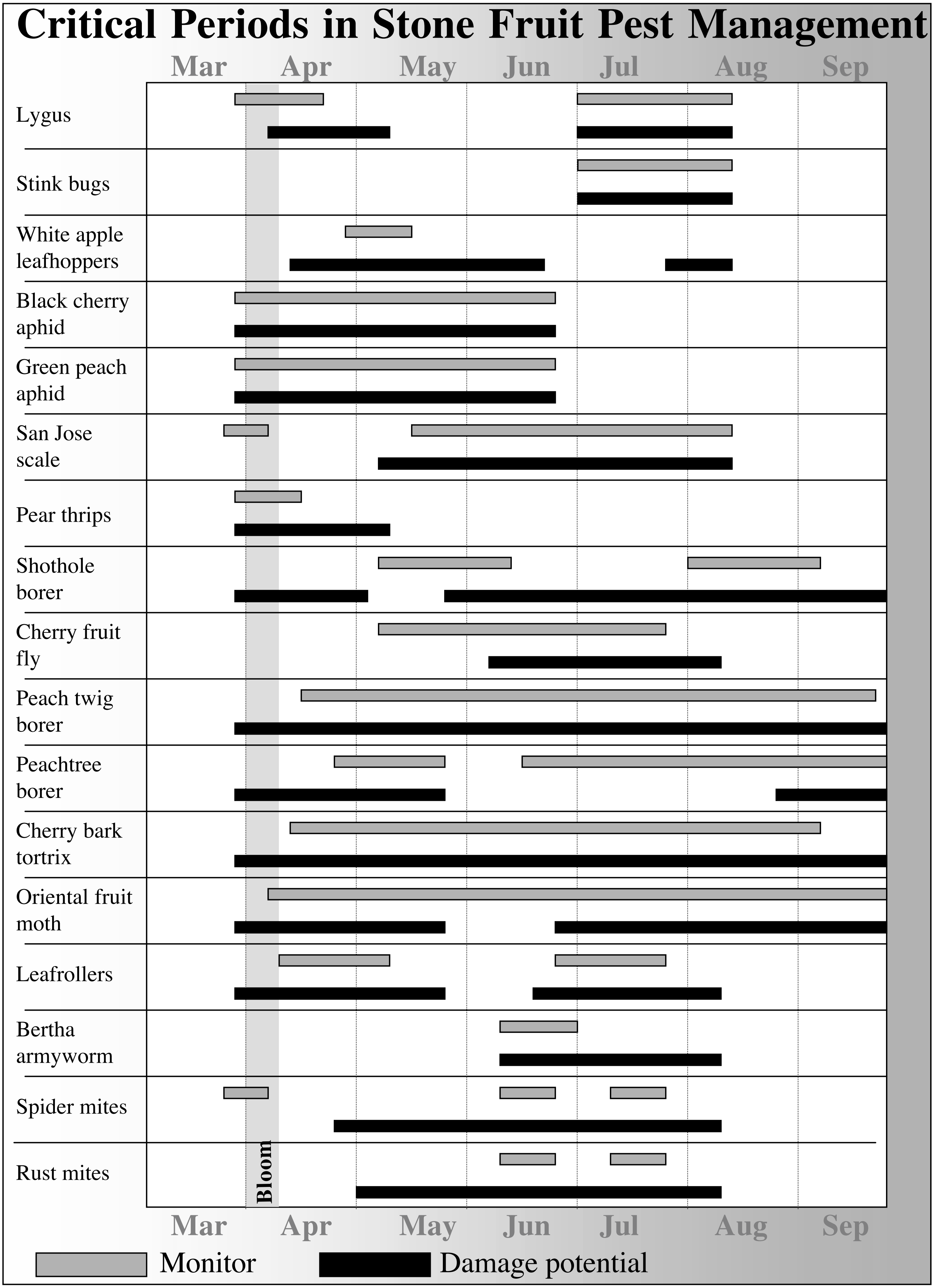
Thorax. The second of three main body divisions of an insect that bears the legs and wings.

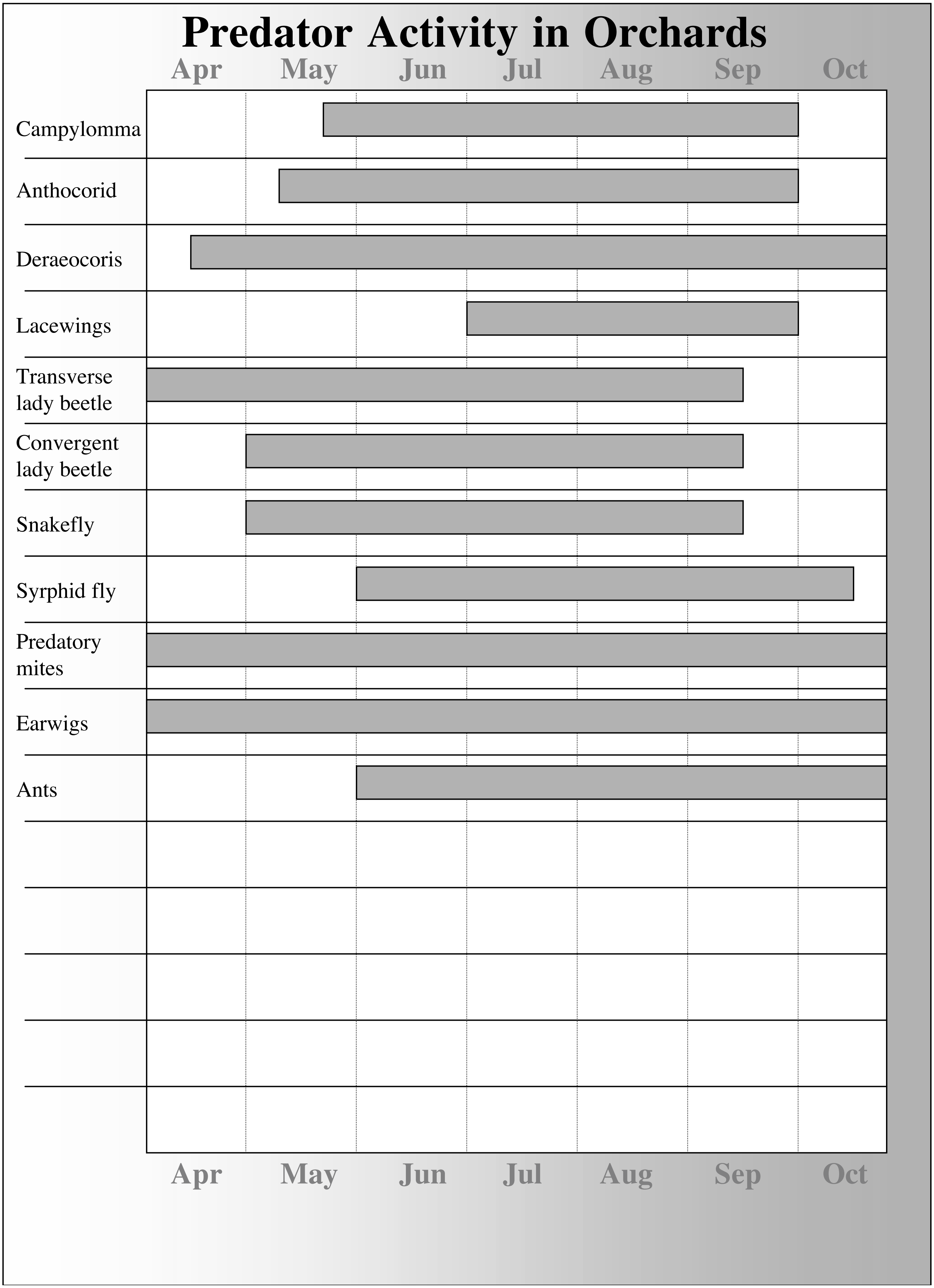
Tissue. Cells of similar structure that are organized and perform a collective function. Tissues of various types combine to form plant organs such as leaves, flowers, fruits, branches, and roots.

Wing pads. The appendage or bumps located on the back of certain nymphal instars of insects preliminary to the development of wings, such as fifth instar psylla nymphs.


Critical Periods in Apple Pest Management
Apr
May
Jun
Jul
Aug
Sep
Oct
Campylomma
Lygus
Stink bugs
White apple leafhoppers
Apple aphids
Rosy apple aphid
Woolly apple aphid
San Jose scale
Thrips
Apple maggot
W. tentiform leafminer
Codling moth
Leafrollers
Lacanobia fruitworm
Bertha armyworm
Spider mites
Rust mites
Bloom
Apr
May
Jun
Jul
Aug
Sep
Oct
Monitor
Damage potential


Critical Periods in Pear Pest Management
Mar
Apr
May
Jun
Jul
Aug
Sep
Lygus
Stink bugs
Western box elder bug
Pear psylla
Grape mealybug
San Jose scale
Pear leaf-curling midge
Pear sawfly
CA pear sawfly
Codling moth
Leafrollers
Bertha armyworm
Spider mites
Rust mites
Pearleaf blister mite
Bloom
Monitor
Damage potential


Critical Periods in Stone Fruit Pest Management
Mar
Apr
May
Jun
Jul
Aug
Sep
Lygus
Stink bugs
White apple leafhoppers
Black cherry aphid
Green peach aphid
San Jose scale
Pear thrips
Shothole borer
Cherry fruit fly
Peach twig borer
Peachtree borer
Cherry bark tortrix
Oriental fruit moth
Leafrollers
Bertha armyworm
Spider mites
Rust mites
Bloom
Monitor
Damage potential


Predator Activity in Orchards
Apr
May
Jun
Jul
Aug
Sep
Oct
Campylomma
Anthocorid
Deraeocoris
Lacewings
Transverse lady beetle
Convergent lady beetle
Snakefly
Syrphid fly
Predatory mites
Earwigs
Ants

INDEX OF SCIENTIFIC AND COMMON NAMES

Pg.