Category 902

Wyoming Forest Pest Control

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CITATION
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Transition area where lodgepole pine and ponderosa pine intersect and were both attacked by mountain pine beetle.

INTRODUCTION

PREPARATION FOR YOUR EXAM

If you are preparing to take the Wyoming Commercial Pesticide Applicator Exam for category 902, review this manual several times. Please read and respond to the learning objectives in each section.

Exam questions may come from any section of this manual.

This study guide DOES NOT include the knowledge you need to pass other category certification exams.

Topics from the Wyoming Pesticide Applicator Certification CORE manual that may be included on your exam include: first aid, personal protective equipment (PPE), protecting the environment, pesticide movement, surface and groundwater protection, endangered species, application methods and equipment, equipment calibration, pesticide use, pesticide formulations, pesticide applications, and area measurements. The resource for ordering the Wyoming Pesticide Applicator Certification CORE manual can be found at the University of Wyoming Pesticide Safety Education Program website, https://uwyoextension.org/psep/commercial-applicators/training-materials.

It is important that you take note of the following:

- You may bring a basic handheld calculator with you to use during the exam (cell phones and other communication devices are prohibited—you will be failed if using your cell phone during the exam).
- Exams are closed book. You will not be allowed to refer to any notes, manuals, or other unauthorized training materials during the exam.
- You must pass each category with a 70% or better to be issued a license.
- Exams can be taken at any University of Wyoming Extension county office—please call your local extension office to make an appointment.

USING THIS TRAINING MANUAL

At the beginning of each chapter, a list of learning objectives highlights the key information you should understand and be familiar with before taking the forest pest control exam. These target learning objectives are illustrated by a target icon located next to the “Learning objectives” heading.

Example target icon

CHAPTER 1: INTEGRATED PEST MANAGEMENT

LEARNING OBJECTIVES

- Be able to define integrated pest management (IPM) and describe management strategies that may be included in a forest IPM program.
- Understand action threshold.
- Be able to explain why identification of a pest is the first step in developing an effective pest control strategy.
- Understand why evaluation is important in a forest IPM program.

PESTS AND PEST CONTROL

Forest pests are plants, **insects**, or plant diseases that interfere with management objectives. The protection of forests from pests and a reduction in timber losses cannot be accomplished without accurate detection, identification, and diagnosis of pest problems. Healthy **trees** are generally better able to withstand disturbance by insects, infestation by diseases, and competition from other plants than weakened trees.

After you have identified a pest, you must decide how to manage it. Remember that even though a pest is present, it may not be very harmful. Consider whether the environmental impact or the cost of control would be more than the economic loss from the pest's damage.

If control is necessary, decide whether you need to **prevent** the pest from becoming a problem, suppress the numbers of pests or the level of their damage, or **eradicate** the entire pest population.

Pesticides are a valuable tool, but you should use them only when and where they are needed. Consider **chemical control** when pest numbers or the damage the pests are causing are unacceptable, when other pest management methods will not provide effective control, or when your knowledge of the situation indicates that you need to use a pesticide preventively.

Remember, never try to control any pest until you know what it is. If you use a pesticide, follow the **label** directions carefully.

INTEGRATED PEST MANAGEMENT

The management of forest pests rarely relies on a single control practice; usually a variety of tactics are integrated to maintain pests at acceptable levels. **Integrated pest management** (**IPM**) is an approach in which all available control tactics are evaluated and integrated into a unified program. Forest IPM includes **silvicultural**, **mechanical**, **regulatory**, **biological**, **chemical**, and other control practices. Applying multiple control tactics minimizes the chance that pests will adapt to any one tactic. For example, pest-resistant tree varieties, regular monitoring for pests, pesticides, natural predators of the pest, and good stand management practices may be used singly or in combination to control or prevent particular pests.

Integrated Pest Management

IPM programs use current, comprehensive information on the **life cycles** of pests and their interaction with the environment and the **host** plant. This information, in combination with available pest control methods, is used to manage pest damage by the most economical means, and with the least possible **hazard** to people, property, and the environment. The goal of IPM is not to eliminate all pests; some pests are tolerable and essential so that their **natural enemies** remain on the plant. Rather, the aim is to reduce pest populations to less than economically damaging numbers.

MONITOR AND IDENTIFY PESTS

Detection of forest pests and determination of population densities during the early stages of an infestation is critical.

Detection of problems in time to prevent significant plant injury requires a well-planned inspection or monitoring system. Monitoring requires that you are able to identify the various stages or symptoms of the common pest problems, where to look, and when the different **stages** are likely to be present. Scouting and monitoring for all pests and pest problems must be done regularly to avoid surprises. When monitoring or scouting a forest area:

- Examine the center of the area as well as the edges.
- Note competition levels among trees and other plants.
- Note types, quantity, and location of weeds.
- Check a representative sample of trees for **signs** and **symptoms** of insect and disease problems.
- Inspect all parts of the tree, from top to bottom and from branch tips to trunk. You may also need to inspect the root zone.

If you find weeds, signs of insect presence or damage, and/or disease presence or damage, try to determine:

- What kind of pest is present?
- What stage of the pest is present?
- What is the size of the pest population?
- How much damage has occurred?
- How much damage is likely to occur if no control measures are taken?
- Does the pest or damage require immediate attention, or can control measures be postponed?

Certain tools are useful in carrying out an IPM program. A hand lens is essential for magnifying disease signs, insects, and weed plant characteristics. If pests are in the tops of trees, binoculars may be beneficial. Pruning shears and a pocket knife are needed when probing for insects or disease, or when collecting specimens. Field guides, extension bulletins, or other references with pictures and biological information on tree ID, weed ID, insects, and diseases will help with identification. Have plastic bags, vials, and containers available to take samples of the pest or pest damage to someone for identification.

ECONOMIC JUSTIFICATION FOR CONTROL

Before taking any pest-control action, determine the economic or **action threshold**. This is the point at which pest populations or environmental conditions indicate that pest-control action must be taken to prevent an economic loss. The term action threshold implies that when a pest population reaches this threshold, economic damage from the pest is expected unless it is controlled in some manner. The threshold level may be related to the beauty, health, or economic value of the tree crop. Some pests (i.e., **noxious weeds**) must be managed by law, not just when an action threshold is reached.

MANAGEMENT STRATEGY

Once a pest has been accurately identified, decide on management (control) strategies. This decision will be based on the size of the pest population, the kind of damage the pest is causing or may cause, and the control measures that are available. The primary goal of most pest control programs should be reduction of pest damage to an acceptable level. It is also very important to consider the cost effectiveness of potential controls. You must carefully weigh the control cost, the tree value, and the impact of the pest damage on the value of the tree. Management options may be very different for high-value **nursery** tree **species** than for other lower-value trees. The following are some examples of management strategies.

Do nothing

In situations where the pest does not damage the tree crop value or the crop value is so low it is not cost effective to apply a control measure, no action is needed.

Silvicultural control

Silvicultural management manipulates the environment to make it more favorable for the plant and less favorable for the pest. Silvicultural controls make it less likely that the pest will survive, colonize, grow, or reproduce. Silvicultural management can be very effective in preventing pests from building to unacceptable levels. Silvicultural controls include:

- Planting environment - Match plant species to the environmental conditions to which they are adapted.
- Hardiness - Select plants that can survive Wyoming's climate.
- Host plant **resistance** - Select resistant varieties to minimize plant maintenance and maximize longevity.
- Selective pruning - Remove dead, dying, and broken branches to maintain tree appearance and promote tree vigor. Thin younger **stands** of trees to reduce competition. Prune insect-infested or diseased branches.

- Sanitation - Remove leaf debris, downed timber, or plants that may serve as reservoirs for insects or diseases.

Mechanical control

Mechanical and physical controls are practices or devices used to eradicate or exclude pests. These can be labor-intensive, but they may be applicable under certain conditions. Types of mechanical and physical control include:

- Traps, screens, fences, and nets - Remove the pest.
- Tillage and mowing - Mechanically manage weeds.
- Prescribed fire - Reduce brush and eliminate unwanted trees and shrubs.

Regulatory control

Regulatory controls are legal methods aimed at excluding, eradicating, or reducing plant pests. Inspections and quarantines are used to restrict the movement of plant material, plant products, or soil from an area with the pest to areas that do not have the pest. Generally, inspections are used to certify the absence of a pest before shipment or upon receipt of a shipment. In Wyoming, the Wyoming Department of Agriculture (WDA) Technical Services Division has the responsibility for inspections of plant material. Quarantines, sometimes called containment, are used to prevent the escape of a pest from a limited area and to prevent entrance of certain materials into an area.

Biological control

Biological control is the reduction of pest populations by natural enemies and typically involves an active human role. Biological controls include beneficial **predators**, **parasitoids**, and **pathogens** that kill pests. Insects, diseases, and weeds may be managed using biological controls.

Chemical control

Pesticides are a very important IPM tool when large pest populations threaten high-value trees. Knowledge of the pest's life cycle, selection of an appropriate pesticide, proper application timing, and use of the right application equipment will improve effectiveness. Certain pests can be controlled only by pesticides; others can be controlled equally well with non-chemical methods; and some cannot be controlled at all with pesticides.

Pesticides are a very important IPM tool.

EVALUATION

It is very important to determine how effective your management and control tactics are. This information will determine whether any follow-up treatment is needed and will improve your management strategies for next year. Sound IPM practices pay off both economically and environmentally.

CHAPTER 2: FOREST PESTICIDES

LEARNING OBJECTIVES

Be able to list and describe factors that can influence the effectiveness of insecticides and miticides.

- Know the insect growth stages during which the best control is usually achieved.
- Be able to describe how chemical methods are used to manage pests, including mode of entry, selectivity, persistence, and mode of action.
- Be able to describe how contact and stomach poisons, fumigants, and systemic and non-systemic insecticides work.
- Be able to describe the types of pesticides used to control plant diseases.
- Be able to describe how contact and translocated herbicides work.
- Know the types of pesticide formulations and adjuvants available.
- Recognize the characteristics, advantages, and disadvantages of formulations (WP, EC, etc.).
- Understand the terms compatibility and incompatibility and how they relate to tank mixing.

Pesticides are used to fight forest pests or to create growing space for recently planted young trees by eliminating competing vegetation. Most pesticides can be classified according to the pests they kill. The word ending or suffix "-cide" means to kill. **Insecticides**, **fungicides**, and **herbicides** are examples of pesticides used in forest management. Pesticides vary in the manner they affect pests (**mode of action**): some are used before a pest is present to prevent it and others must be applied while the pest is present to kill it.

CHEMICAL CONTROL OF INSECTS AND MITES

Insecticides and **miticides** (**acaricides**) are frequently the only tools available to control outbreaks of insects and **mites**. When these pesticides, collectively referred to as insecticides, are used properly, they provide effective and reliable control of most pests. Although insecticides should be used only when necessary, chemical control is an integral part of an IPM program.

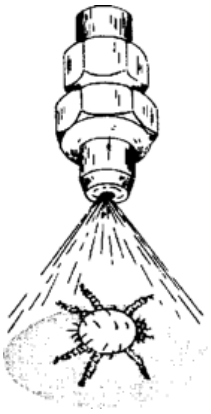
The selection of the appropriate insecticide should be based on the tree, pest species, potential impact on the environment and human safety, insecticide efficacy, and cost of material and application.

Because mites are not insects, most insecticides are not effective in controlling mite pests. Read the label to determine that the product you choose is listed as being effective against the pest mite.

Correct timing of insecticide application is important. To give its best performance, an insecticide must be applied at a time when pests are present and vulnerable. That is, application must be matched to the pest life cycle. For example, **eggs** are the life stage least **susceptible** to insecticides,

while **larvae** or **nymph** life stages are the most susceptible to insecticides. **Adult** insects are generally more resistant to pesticides.

Insecticides are classified in several ways, and it is important to be familiar with these classifications so that the choice of an insecticide is based on more than simply how well it controls the pest or the cost.



Contact poison

Mode of entry

When classified by method of application (method of activity by insect), insecticides are referred to as **contact poisons**, **stomach poisons**, or **fumigants**. Most insecticides are contact poisons. The **target** pest is killed either from direct contact during spray applications or by coming into contact with **residues** when moving around on plant surfaces. Contact insecticides generally provide quick knockdown of target pests. Stomach poisons are sprayed on the plant's leaves. These insecticides poison the pests when they eat the treated plant. Fumigants are insecticides that work in a gaseous or vapor form. The pests breathe the poisonous fumes and die.

Insecticides can also be classified as **systemic** or **non-systemic**. Systemic insecticides can be applied to one part of the plant, such as the root or the leaf, and will move throughout the plant to make the whole plant poisonous or toxic to plant-feeding pests. An insect is killed when it feeds on treated plants and consumes the insecticide. Systemic insecticides are most effective on insects with piercing-sucking mouthparts, such as aphids and soft scales, because these insects feed within the vascular plant tissues. Systemic insecticides are generally considered less harmful to natural enemies. Non-systemic insecticides do not move throughout the plant. They stay where they were applied. The insect must eat or touch a portion of the plant that was treated with the insecticide.

Selectivity

Insecticides may be either **broad spectrum** or **selective**. Broad spectrum or non-selective insecticides eliminate a wide variety of pests, usually by attacking a system common to all, such as the nervous system. Many broad spectrum insecticides are toxic to **beneficial insects**. Selective insecticides have activity against a specific, small group of pests. They generally provide control of the target pest while causing minimal disruption of their natural enemies and the environment.

Persistence

Insecticides vary in how long they last. **Persistent** pesticides remain active for a long time. These are **residual** pesticides and are very useful for recurring insect problems. **Non-persistent** pesticides break down quickly into nontoxic byproducts. **Non-residual** pesticides last only a few hours.

Mode of action

The major classes of insecticides used in forest systems include organophosphates, carbamates, and pyrethroids. Others include **microbials, horticultural oils**, **insect growth regulators**, and **fumigants**.

Organophosphates are an older family of insecticides and are becoming more restricted in their use. This group includes both contact and systemic insecticides. They are persistent and also tend to be toxic to applicators and wildlife.

Organophosphates are **cholinesterase** inhibitors and act as nerve poisons. Organophosphates have been involved in most serious human pesticide poisonings.

Neonicitinoids are also nerve poisons. They tend to be quite **soluble** in water and some are systemic in plants.

Pyrethroids are synthetic insecticides derived from chrysanthemumic acids. They are typically used at rates that are several times lower than organophosphates and carbamates. They generally exhibit low mammalian **toxicity** but are highly toxic to fish and other cold-blooded organisms. Pyrethroids may cause skin reactions in humans.

The following are additional chemical groups of insecticides and their descriptions.

Additional Insecticide Chemical Groups

Chemical Group	Mode/Site of Action	Active Ingredient	Mode of Entry
Botanicals	Growth and development / Metabolic processes - Prothoraciotropic hormone inhibitor and phagostimulant disruptor	azadirachtin	systemic
	Nervous system - Sodium channel modulator	pyrethrins	contact/ stomach
Soaps and Abrasives	Growth and development - Breaks cuticular surface tension, causing insect to dehydrate	potassium salts of fatty acids	contact
Spinosyns	Nervous system - Nicotinic acetylcholine receptor agonist	spinosad	contact/ stomach
Oils	Growth and development - Suffocation	petroleum	contact/ stomach
Soil Fumigants	Compounds of unknown or non-specific mode of action	chloropicrin	fumigant
		dazomet	
		dichloropropene	
Chloronicotinyls	Nervous system - Acetylcholine agonist	imidacloprid	contact/ systemic
Insect Growth Regulators	Growth and development - Juvenile hormone mimics - Chitin synthesis inhibitors	clofentezine	systemic
		diflubenzuron	
		tebufenozide	
Microbials	Metabolic processes - Insect midgut membrane disruptor	*Bacillus thuringiensis (Bt)* subspecies *aizawai*	stomach
		Bacillus thuringiensis subspecies *kurstaki*	
		Bacillus thuringiensis var. *amyloliquefaciens*	
Organosulfurs	Energy production - Inhibits AT-Pase	propargite	contact

CHEMICAL CONTROL OF PLANT DISEASES

Disease control measures and fungicide applications in most forest situations are not usually cost effective. Most fungicides are used only in forest nurseries, and on especially valuable trees where many diseases have been managed successfully. Fungicides are recommended in nursery production to protect **seedlings** from **infections**. Seeds are generally treated with fungicides prior to planting to inhibit fusiform **rust** and soil-borne damping-off **fungi**.

Fungicides are divided into those that are inorganic and those that are organic in composition.

Inorganic fungicides

Many of the first fungicides developed were inorganic compounds based on sulfur or metal ions, such as copper, tin, cadmium, and mercury, that are toxic to fungi. Copper and sulfur are still widely used.

Organic fungicides

Organic compounds contain carbon molecules. They may be derived from natural sources (botanicals and oils) or synthetic sources. Synthetic organic fungicides are subdivided into **protectants** and systemics.

Protectant fungicides form a barrier between the plant and the pathogen to prevent infection and disease. They must come into direct contact with a germinating **spore** or growing **mycelium** to prevent further spore germination and infection. They are used as seed or soil treatments, or as **foliar** sprays. Additional terms used to describe protectant fungicides are preventive, contact, and broad spectrum. Because they are not absorbed by the plant, they do not affect existing infections. To be effective, a protectant fungicide may be applied repeatedly over the season and in a way that allows for maximum spray deposition and coverage.

Systemic fungicides have been developed for the control of a limited number of fungi. Also called eradicant fungicides, they are absorbed by the plant and can eradicate existing infections. Their main advantage is that they can be applied after infection has occurred and still be effective. Because they move within the plant, coverage is less critical, and they do not need to be applied as often as other fungicides.

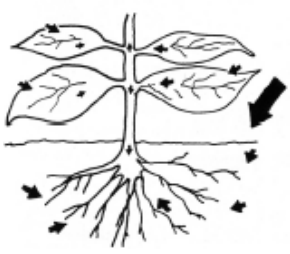
CHEMICAL CONTROL OF WEEDS

Herbicides are chemicals that affect the germination or growth of plants. To choose the appropriate herbicide for a particular situation, you need to understand some basic herbicide characteristics.

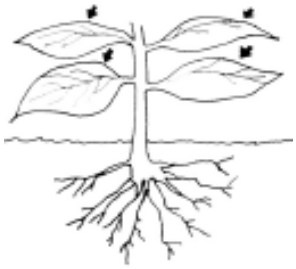
Selectivity or specificity

Herbicides are not equally effective on all types of vegetation. Selective herbicides are available that control grasses only, broadleaf plants only, or certain grasses and broadleaf plants. There are also **non-selective** herbicides that kill all vegetation that they contact.

Selectivity depends on many interrelated factors. It is influenced by the herbicide, **adjuvants**, and **rate** of application, as well as how and when applied, and under what environmental conditions.



Translocated herbicide



Contact herbicide

Mode of entry

Herbicides affect plants in different ways. **Translocated** herbicides, sometimes referred to as systemic herbicides, are absorbed through the **foliage**, stem, shoots, or roots and move throughout the plant. Contact herbicides are applied directly to plant foliage and rapidly kill plant parts they directly contact. Other herbicides are applied to or incorporated in the soil to prevent the germination of weed and grass seeds.

Residual nature

A herbicide is considered to have residual effect if it prevents the regrowth of vegetation for a period of time after application. This time period varies from a few months to more than a year. Several residual herbicides exert pre-emergent control by continuing to kill weeds as their seeds germinate. Application rate, soil texture (particularly clay content), **soil organic matter** content, soil moisture level, and herbicide solubility affect a herbicide's residual properties. Many herbicides that are absorbed through foliage (**post-emergent**) have little or no residual effect, whereas those applied to the soil before plant growth (**pre-emergent**) usually have residual effect.

Pesticide formulations

PESTICIDE FORMULATIONS

Pesticide **formulations** are the finished, ready-to-mix or **ready-to-use** (RTU) products that contain the **active ingredient** (a.i.), which controls the target pest plus various **other ingredients**. The latter are used to improve the performance of the pesticide by affecting characteristics such as handling, persistence on foliage, safety, ease of application, and ability to mix with water. The formulation of a pesticide will dictate which type of application equipment to use.

Some formulations are ready for use. Others must be further diluted with water, a petroleum-based **solvent**, or air (as in **airblast applications**) by the user before they are applied.

A single active ingredient often is sold in several formulations. If you find that more than one formulation is available for your pest control situation, you must choose the best one for the job. Remember, all formulations are not labeled for all uses.

Formulation types can be divided into solids, liquids, and gases. Abbreviations (i.e., EC, WP, S) are often used after the trade name on the pesticide label to indicate the type of formulation.

Adjuvants

Adjuvants are materials that are added to a spray mixture to enhance the activity or performance of a pesticide, or to minimize or eliminate spray application problems such as drift, by modifying the physical characteristics of a spray mixture.

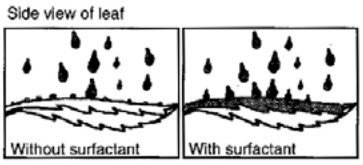
Most pesticide formulations contain at least a small percentage of adjuvants. Always read the pesticide label before adding an adjuvant to a pesticide mixture to make sure it is legal and safe.

Some common types of adjuvants are:

- Acidifier - used to lower the **pH**
- Activator - increases the biological **efficacy** of pesticides

Summary of Formulation Types for all Pesticides			
Name	**Description**	**Advantages**	**Disadvantages**
Solids			
Dry Flowable (DF) / Water Dispersible Granule (WDG)	-Formulated into small pellets or granules -Forms a suspension in water	-Require less agitation than WP -Easier to measure and mix than WP -Less inhalation hazard than WP	-Spray mix requires constant agitation -Abrasive*
Dust (D)	-Finely ground dry material of a low concentration of a.i.	-Ready to use -No mixing	-Drifts -Easily inhaled
Granular (G)	-Mix of dry, large free-flowing particles usually with a low concentration of a.i.	-Ready to use -No mixing -Minimal drift	-Some dust -May need incorporation
Soluble Powder (SP or S)	-Dry material that goes into true solution when mixed with water	-Agitation not needed after mixing	-Dust can be inhaled
Wettable Powder (WP or W)	-a.i. added to a powder -Contains a wetting and dispersing agent -Forms a suspension in water	-Less skin absorption than EC	-Hazardous if inhaled -Needs premixing and constant agitation -Abrasive* -May clog screens and filters
Liquids			
Emulsifiable Concentrate (EC or E)	-Clear solution with emulsifiers to be diluted in water -Final spray solution has a milky look	-High concentration of a.i. so less product to store, purchase, or transport -Easily mixed -Non-abrasive	-Amount of a.i. increases mixing hazard -May cause leaf burn -Flammable -Easily absorbed through skin
Concentrated Emulsion (EW)	-Consist of thick water- based emulsion and an a.i. paste -Diluted in spray tank for application	-Minimize level of solvent needed to dissolve pesticide and emuslify the solution in water	-Hazardous if ingested
Flowable (F)	-Finely ground particles suspended in a liquid carrier -Forms suspension in spray mix	-No dust -Premix not needed	-Needs agitation before mixing as a.i. may settle out -Spray mix needs constant agitation -Abrasive*
Gel	-Semi-liquid, emulsifiable concentrate	-Used with WSP	-Cannot measure amounts smaller than package size
Micro-encapsulated suspension	-Suspension with a.i. impregnated into tiny, slow-release plastic beads	-Easy to mix and apply -Reduces hazard to operator	-Agitation needed -Can be very hazardous to bees
True Liquid/ Solution (L)	-a.i. is in solution, usually water -When mixed with water remains clear	-Easily mixed	-Possible corrosive
Gases			
Fumigant	-Volatile liquids or solids packaged for release as a gas	-Toxic to many forms of the pest at one time	-Area to be fumigated must be well sealed -Highly toxic
Packaging			
Water Soluble Packets (WSP)	-Pre-weighed amount of WP, SP, or gel formulation in a special plastic bag that dissolves in spray tank and releases contents	-Low applicator **exposure** during mixing and loading -Convenient for measuring -No container to dispose	-All quantities are pre-measured and may not be the correct amount for the site
*increases wear on **nozzles** and **pumps**			

- Anti-foaming agent - eliminates or suppresses foam in the spray tank
- Buffer - causes the solution to resist change in pH. Each buffer has a limited range of pH over which it is effective
- Colorant - a material used to alter the color of the **tank mix** for ease of application
- Drift control agent - used in liquid spray mixtures to reduce **spray drift**
- Penetrant - enhances a pesticide's ability to enter a substrate or penetrate a surface
- Spreader/wetting agent - increases the area that a spray droplet will cover on a target, e.g., a leaf
- Spreader/sticker - increases the area that a spray droplet will cover and the ability of a pesticide to stick to treated plant surfaces
- Sticker/deposition aid - assists the spray deposit to adhere or stick to targeted surfaces
- Surfactants (surface active ingredients) - a class of adjuvants that include spreaders and stickers that change the surface tension of the spray solution



A surfactant reduces the surface tension of spray droplets

TANK MIXING

Mixing two or more chemicals together in the tank can save time, save money, increase the number of pests controlled, and delay resistance. Fertilizers also are added with some pesticides. It is legal to tank mix chemicals if all products are labeled for the application **site**, but not if the label prohibits mixing specific pesticides.

Tank mixing allows the applicator to determine the exact amount of a.i. needed for each chemical in the application. Many premixed or RTU products may not have the combination needed for a particular application.

Not all pesticides are compatible or can be mixed together. **Incompatible** mixtures can increase the toxicity of the mixture to the applicator or the environment. They may also greatly reduce the effectiveness of the spray mixture or may cause plant injury.

Incompatibility can involve undesirable physical changes in the mixture. For example, a mixture may cause material to precipitate out as a solid and settle on the bottom of the spray tank. Physical incompatibility may also cause the components to form separate layers following agitation. Large aggregates may form or the mixture may curdle. These types of changes may result in an unsprayable mixture or may cause variability in the amount of pesticide applied.

Chemical changes may also occur when mixtures of pesticides or pesticide-fertilizer combinations are made. This is particularly common when acidic or alkaline materials are used. Reactions in the tank may form compounds that increase environmental hazards, reduce the amounts of a.i., or cause plant injury.

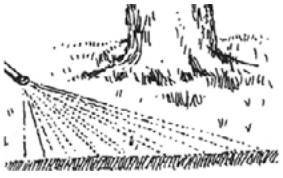
Increasingly, tank mixes of two or more compounds are specified on pesticide labels. **Compatibility** problems should be minimal with these previously tested and registered combinations. If a combination is not specifically labeled, an applicator may make a tank mix unless the label instructions prohibit it. Remember to follow the label limitations for each product used in a tank mix and use caution when mixing.

Conduct a jar test for physical compatibility if the label does not specifically recommend the combination. Many labels give directions for compatibility testing. If not, mix the products with their **carrier** in a small jar at proper **concentrations**. Watch for changes and feel for heat, which indicates a reaction. If products do not mix properly, compatibility agents may solve the problem. Repeat the jar test with the compatibility agent. If everything looks fine, test the tank mix on a small portion of the site to make sure the combination is still effective and safe to the desirable vegetation before mixing hundreds of dollars' worth of solution.

CHAPTER 3: PESTICIDE APPLICATION

LEARNING OBJECTIVES

- Know the main application types used in forestry (i.e., broadcast, soil application, stem injection, etc.).
- Know when pesticides should be applied to be the most effective.
- Be able to describe pre-plant, pre-emergence, and post-emergence herbicides.
- Understand application methods used in forestry (i.e., aerial, chemigation, ground application, etc.).



Soil application

APPLICATION TYPES

Terms that describe how to apply a pesticide include:

- Application rate - The specific amount of pesticide applied to a treated area or target stem
- Broadcast - Uniform application over an entire area or the application of a granular product with a rotary spreader
- Band - Application to a strip or band over or along each tree row
- Basal - Application to the lower portion of stems or trunks
- Cut surface - Application to a cut or incision in a tree or stump
- Directed - Aiming the pesticide at a specific portion of a plant
- Foliar - Application to the leaves of plants
- Over-the-top - Application over the top of trees
- Soil application - Application directly on or in the soil rather than on a growing plant
- Soil incorporation - Use of tillage equipment to mix the pesticide with the soil
- Soil injection - Application beneath the soil surface
- Spot treatment - Application to a small, discrete area
- Stem injection - Application into holes made in a tree stem
- Stump treatment - Application to the top or edges of a tree stump

APPLICATION TIMING

Pesticides work best if applied when the target pests are most susceptible, or when trees are most resistant to injury. Applying them too early or too late may reduce or even eliminate their effectiveness and may damage the tree crop. Terms that describe when to apply pesticides include:

- Pre-plant - Applied before the crop trees are planted
- Pre-emergent - Applied before weed seedlings begin to grow (emerge) in the spring and usually after the trees have been planted
- Post-emergent - Used after the weeds begin to grow

APPLICATION METHODS

The application method for a pesticide is usually specified on the label. You often have a choice between several application methods. Several factors may influence your application choice. These include the characteristics of the pest or site, available application equipment, environmental conditions, and the relative cost and effectiveness of alternative methods. The principal objective with any pesticide application is to effectively bring the chemical into contact with the targeted pest(s).

Chemigation

Applying pesticides through irrigation systems like center pivots, handline, or drip irrigation systems is an application method used in nurseries and in **windbreaks**. Most labels specify whether a product can be chemigated or not. For information on calibrating chemigation equipment, please refer to Category 901F of The Wyoming Agricultural Pest Control manual. If you plan on using chemigation in these settings, you will also need this endorsement.

Mechanical ground application

Ground application by vehicle-mounted sprayers and spreaders has several advantages. They can treat small areas or large ones, provide banded or broadcast applications, and are less limited by weather conditions. However, due to terrain and stand conditions, ground vehicle applications have definite limitations. Rough or rocky terrain can cause damage to ground equipment or rollover accidents.

Crawlers, skidders, farm tractors, and ATVs can be used for pesticide application. The vehicle used depends on the job to be done, site conditions, and equipment availability.

The pesticide application equipment mounted on the vehicle must be suitable to do the job.

Broadcast-type sprayers are most commonly used. The application equipment must be able to cover a sizable area efficiently and must be durable. Each component of a properly working sprayer is important for efficient and effective application. The main limit of broadcast-type ground equipment is usually the presence of brush tall enough to mask a major portion of the spray pattern.

For boom-type sprayers, flat fan-type nozzles should be used to apply broadcast pesticides. When it becomes necessary to apply pesticides in bands, use an even fan or flood nozzle. An alternative to broadcast foliar application would be to broadcast a soil-active pesticide. This may be in a granular form that can be applied before full plant growth masks the distribution. Several liquid formulations also have soil activity.

Foliar and soil-active materials are often broadcast over the entire area to be treated. They can be applied to the foliage or soil by either aerial or ground mechanical equipment. Broadcast applications are common for **site preparation**.

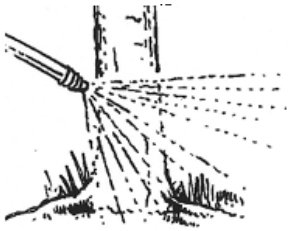
Manual ground application

Manual applications are usually applied using **backpack sprayers**, mist blowers, hand-cranked broadcast spreaders, or one of various injection devices. The commonly applied manual treatments used in forestry are directed foliar sprays, basal sprays, cut-stump treatments, tree injections, soil injections, and granule/pellet applications.

All sizes of trees and shrubs can be controlled by using the right treatment and the proper pesticide at the correct time. Following are the sizes of **woody plants** that can be treated most effectively by hand methods.

Directed foliar sprays are best used to **release** 1- and 2-year-old pine stands when brush competition is less than 6 feet tall. Apply the pesticide spray on the target foliage. Direct the spray away from pine foliage and growing tips. The benefits of release can be lost when pesticides are misapplied to needles and shoots, and pines are damaged. Directed foliar sprays are usually applied with a backpack sprayer and a spray wand equipped with a full cone, flat fan, or adjustable cone spray tip.

Basal sprays are directed at the lower 18 inches of stems and trunks that are less than 6 inches in diameter. Thoroughly wet the **basal area** until **runoff** at the ground line is noticeable. A few pesticides are applied in a single, narrow band or stream to the basal region of brush. Applications to control brush can be made any time, including the winter months, except when freezing temperatures, snow, or water prevent spraying to the ground line. Basal treatments can be more labor intensive than foliar sprays but are useful in selectively removing undesirable species from stands of desirable trees.



Basal bark

Treating stumps with pesticide can prevent resprouting of many species. This can be an effective, low-cost treatment following harvest for site preparation and after partial cuts for timber stand improvement. **Thinning** trees using saws or axes for pine release can be enhanced by treating freshly cut stumps with pesticide to prevent regrowth.

A backpack sprayer that has a wand or spray gun equipped with a straight stream, fan, or hollow-cone nozzle can be used. Alternatively, pesticide can be carried in a utility spray bottle for treating stumps after cutting; a **wick applicator** can be used for small-diameter stumps.

Microinjection allows the introduction of systemic chemicals such as fungicides and insecticides

Woody sprout control

Method	Effective size of target stems controlled
Directed foliar sprays	up to 6 ft tall
Full basal sprays	up to 6 inches dbh*
Streamline basal sprays	up to 2 inches dbh
Soil spots by grid	up to 10 inches dbh
Basal soil spots	all sizes
Cut-stump sprays	all sizes
Injection	sizes greater than 1 inch dbh

* dbh is **diameter at breast height**, which is the stem diameter measured at 4.5 ft above the ground.

directly into a tree without any contact with the environment. Microinjection, macroinjection, and implants are the most commonly used methods to introduce systemic chemicals directly into the vascular system of trees. Trunk injections and implants are efficient delivery systems that can be performed under most weather conditions. Systemic materials placed into the tree are rapidly available within the tree and there is no environmental contact with pesticides.

Injections and implants require holes to be drilled into the trunk, causing some wounding to the tree. This wounding should be taken into account and weighed against the possible benefits of the injection or implant.

Tree injection can be used alone or in combination with other individual stem treatments for site preparation, pine and hardwood release, **timber stand improvement**, and stand conversion. Commonly used tree injection methods are: hack-and-squirt, hypo-hatchets, and tubular tree injectors.

- The hack-and-squirt, also known as **frill**, is an effective and economical means of selectively controlling undesirable hardwood stems. A lightweight hatchet is used to cut into the tree stem through the **cambium** and a herbicide is sprayed on the cut from a trigger squeeze bottle.

Frill treatment

- The hypo-hatchet is a hatchet with an internal delivery system connected by a hose to an external herbicide container. When the hatchet strikes a tree, the blade must penetrate into the **sapwood**. The impact of the striking action drives a piston forward that delivers herbicide into the cut.

- Tubular tree injectors have a long metal tube fitted with a chisel-type blade that is used to cut through the tree bark into the sapwood near the base of the tree. The unit is equipped with a lever, handle, or wire, which is pulled to deliver the herbicide from the cylinder into the cut. The delivery rate can be adjusted for accurate calibration.

Soil injections are used to inject systemic pesticides into the root zones of trees by either using a deep root fertilizer gun attached to a high-pressure spray system or by using a manually operated, handheld low-volume injector. Increasing concerns about **groundwater** contamination have limited the use of soil injections in many areas.

Granules and pellets can be applied by hand-cranked spreaders, air-blown backpack spreaders, and hand-broadcast. Hand-cranked broadcast spreaders can distribute granular or pelletized pesticides on small tracts and areas with steep slopes or rough terrain. They can be used where machine spreaders are not suitable. Hand-operated spreaders are small, simple, inexpensive, and generally reliable hand tools. Uniform application is often difficult to obtain, and treatment is slow and laborious.

CHAPTER 4: EQUIPMENT AND CALIBRATION

LEARNING OBJECTIVES

Know what to consider when selecting a sprayer.

- Understand the variables that affect application rate.
- Be able to define calibration; know why it is important to calibrate equipment; and understand how to prepare equipment for calibration.
- Be able to describe hydraulic sprayers, low-pressure sprayers, high-pressure sprayers, backpack sprayers, tree injectors, soil injectors, wiper- type applicators, airblast sprayers, mist blowers, injection spraying systems, soil fumigation, chemigation, and granular applicators and describe their operation and use.
- Know how to calculate the amount of product to add to a spray tank, determine percent concentration, and to calculate the size of the target site
- Be able to describe how to properly maintain equipment before, during, and after application
- Know how to prepare a sprayer for storage.

The primary function of any application equipment is to deliver the proper rate of chemical uniformly over the target area. When selecting a sprayer, be certain that its components will withstand the deteriorating effects, if any, of the chemical formulations you use. Also consider durability, cost, and convenience in filling, operating, and cleaning.

You must be thoroughly familiar with a sprayer's components to properly select, maintain, and operate the sprayer. The major components of a sprayer are the tank, pump, flow control, and nozzles. Other important components include **strainers**, **pressure gauges** and **regulators**, hoses, and fittings.

VARIABLES AFFECTING APPLICATION RATE

It is easy to adjust sprayer delivery rates. If your sprayer is delivering too much or too little spray, change the rate using one of these methods:

- Change the nozzle. Larger nozzle orifices mean more spray is delivered; smaller nozzle orifices mean less spray is delivered. Changing nozzles is usually the preferred method when making substantial changes in sprayer output.
- Change the sprayer speed. Slower speed means more spray is delivered over the area; faster speed means less spray is delivered over the area. Doubling the ground speed of the sprayer reduces the sprayer delivery rate by one-half, except for wheel-driven sprayers.
- Change the pump pressure. Lower pressure means less spray is delivered; higher pressure means more spray is delivered. To double output, you must increase the pressure fourfold. Remember, spray pressure affects both nozzle patterns and drift.

CALIBRATION

Calibrate your equipment

Calibration is simply determining the delivery rate, or the amount of material delivered over a known area (application rate). Regular calibration ensures that your equipment applies the correct amount of pesticide over a given area. If your equipment is not calibrated properly, you could make costly or even dangerous mistakes in the application rate of a chemical.

You will need to calibrate your own equipment on a regular basis, even if your equipment supplier provides charts and tables to help you determine equipment setup and delivery rates. Charts and tables cannot account for equipment wear or for inaccurate gauges and speedometers.

Preparing equipment for calibration

Your equipment should be in good working order before you try to calibrate it. Use the following guidelines to prepare your equipment for calibration.

1. Be sure your sprayer nozzle tips are the same across the boom and the right kind for the spray application you want to make. Consult the nozzle manufacturer's recommendations and the pesticide label.

2. Thoroughly clean all nozzles, nozzle tips, and screens to ensure proper operation. Use a soft brush, not wire or any hard material. Add water only to the spray tank and visually check nozzle output during sprayer operation. Also look for leaks along lines and at fittings. Discard and replace nozzle tips that produce distorted spray patterns.

3. Check all the pressure gauges. If a gauge is rusty or of questionable accuracy, replace it.

4. Check the spray volume output of all nozzles and replace any nozzle tip that differs by more than 5% of the average output of all nozzles or replace all the nozzles if more than one is off.

Many types of equipment are available to apply pesticides, and different methods of calibration can be used effectively. Check with your equipment dealer, chemical dealer, or county extension office.

HYDRAULIC SPRAYERS

Water is most often used as the means of carrying pesticide to the target area with hydraulic spraying equipment. The pesticide is mixed with enough water to obtain the desired application rate at a specific pressure and travel speed. The spray mixture flows through the spraying system under pressure and is released through a nozzle onto the target area.

Hydraulic (liquid) **sprayers** make spot, band, or broadcast treatments. The sprayer may have one or several nozzles on a boom or in a cluster. The nozzles may be permanently mounted or handheld. Hydraulic sprayers are usually motorized and can be towed, self-propelled, or mounted on other equipment, including aircraft. However, for small jobs, a hand-carried compressed-air or backpack sprayer often is most effective.

LOW-PRESSURE SPRAYERS

Low-pressure sprayers are commonly used in forest nurseries to deliver low to moderate volumes at 15–100 **pounds of pressure per square inch** (**psi**). The spray mixture is applied through a boom equipped with nozzles. The boom usually

is mounted on a tractor, truck, or trailer, or the nozzle(s) can be attached to a handheld boom.

Roller-type pumps are often used on small tank sprayers (50–200 gal), but sprayers with large tanks (200–1,000 gal) usually have centrifugal pumps. Low-pressure sprayers do not deliver sufficient volume to penetrate dense foliage. They are most useful in distributing dilute pesticide over large areas.

HIGH-PRESSURE SPRAYERS

High-pressure sprayers are used in forest nurseries and seed production areas to deliver large spray volumes. Boom sprayers deliver 200–600 gallons per acre (**GPA**). Choosing the right handheld spray guns will depend on application type and tree size.

High-pressure sprayers provide thorough coverage and can penetrate dense foliage; however, these sprayers produce large numbers of small spray droplets, which can drift. These sprayers can provide low-pressure flow when the proper pressure regulators are used.

BACKPACK SPRAYERS

Backpack sprayers are useful in situations where small areas or widely dispersed trees require treatment. They are well suited for treating individual brush plants and for basal and cut-surface applications. Tanks usually hold 3–5 gal. The sprayers can be fitted with a single nozzle or with a boom with three or more nozzles. Some are filled to about ¾ of the tank capacity with liquid and then air is pumped into the remaining space. Initial pressure is 30–60 psi, but it drops continuously as the spray is applied unless a special pressure regulator is used.

Other backpack sprayers have a lever that is pumped during the spraying operation to activate a plunger or diaphragm pump. They have a small air chamber to reduce the surging of the spray mixture as the lever is pumped. The boom can be equipped with a pressure gauge so that a nearly constant pressure can be maintained while spraying.

TREE INJECTORS

Tree injectors are used for timber stand improvement (TSI) to precisely inject a pesticide (usually a herbicide) into the trunks of larger brush or trees. The number of cuts and the amount of chemical solution delivered in each blow will depend on the species, trunk diameter, and product being used. Cuts are made at a 60-degree angle with the ground around the circumference of the tree. The cuts must penetrate the bark and reach the sapwood or inconsistent control will result. Tree injectors are feasible in areas where fewer than 500 trees per acre need to be removed or treated.

SOIL INJECTORS

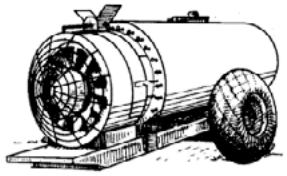
Soil injectors are used in forests and seed production areas to inject systemic pesticides into the root zone of trees and shrubs. The number of injection sites is determined by the size of the plant, with two injections per inch of trunk diameter at breast height (dbh) a common recommendation. The diameter at breast height is defined as the diameter of the tree 4.5 feet aboveground on the uphill side of the tree.

WIPER-TYPE APPLICATORS

Roller or rope-wick applicators apply pesticides at a set height, usually targeting weeds taller than the desirable plants. Wick applicators have a pesticide-

soaked rope, wick, or sponge. The pesticide is applied by dabbing or rubbing the wick across the target area, transferring the chemical from the wick to the plant foliage.

AIRBLAST SPRAYERS



Airblast sprayer

Airblast sprayers are used in seed production areas, nurseries, orchards, etc. They blow spray into trees with a blast of air and are equipped with powerful fans to generate the required air current. Nozzles dispense the spray droplets in the high-velocity air stream. Various combinations of air volume, air velocity, liquid volume, and liquid pressure are used in air sprayers to obtain uniform spray distribution.

MIST BLOWERS

Mist blowers are a type of airblast sprayer. Powered mist blowers have lightweight engines and fans that deliver a fine mist that is usually 3–10 times more concentrated with pesticide than sprays used in other types of sprayers. This arrangement enables the applicator to use much less water and cover a larger area without refilling.

INJECTION SPRAYING SYSTEM

An injection system attached to a sprayer precisely meters and injects pesticides into the water line just before the water reaches the spray outlet (boom, head). This eliminates the need to premix a tank solution and to deal with extra spray remaining at the end of an application.

It allows a variety of pesticides to be injected into the water line, depending on the pest species present.

The calibration of injection sprayers is done in a few steps:

- Calibrate, or correct, the speed sensor on each unit until the console is measuring the actual distance traveled. A measured distance of 1,000–4,000 feet is suggested.
- Drive over this distance at the normal operating speed. The ratio of the actual distance to the recorded distance is the correction factor to enter in the console.
- In a similar fashion, compare the actual output from each pump with indicated output. The amount caught from each nozzle should be as much as practical; 2 gal is suggested. The larger the volume, the less the effect of measurement errors.
- Check the sprayer periodically to adjust for wear.
- Follow the manufacturer's operation manual carefully.

SOIL FUMIGATION

Soil injection equipment is used to apply soil fumigants in forest nurseries to control soil-borne pathogens or insects.

CHEMIGATION

Chemigation equipment is used in forest nurseries to apply one or more pesticides through center pivot irrigation systems, handline, or drip irrigation systems. Many labels specifically prohibit such use. Backflow prevention devices are highly

recommended, and can be required by local or municipal regulations, for any irrigation system used for chemigation and is connected to well water or municipal water systems."

GRANULAR APPLICATORS

Granular applicators are designed primarily for soil applications and are available in various styles and sizes. Drop-through spreaders and rotary spreaders are the most common. Shaker cans and hand distribution of pellet formulations may also be used.

Granular applicators normally consist of a hopper for the pesticide, a mechanical-type agitator at the base of the hopper to provide efficient and continuous output, and some type of metering device, usually a slit-type gate, to regulate the flow of the granules.

Drop-through spreaders

Drop-through spreaders are available in widths from 1.5–3 feet or more. An adjustable sliding gate opens holes in the bottom of the hopper and the granules flow out by gravity feed. Normally, a revolving **agitator** is activated when the spreader is in motion to assure uniform dispensing.

Rotary spreaders

Rotary spreaders distribute the granules to the front and sides of the spreader, usually by means of a spinning disc or fan. Heavy granules are thrown farther than lighter ones. A 6- to 8-foot swath width is common. Both power and hand driven rotary spreaders are available, but power rotary spreaders are generally best suited for use in forests.

SPRAYING TO THE POINT OF RUNOFF

A major requirement for good application is to apply liquid pesticides uniformly to all appropriate surfaces of the tree, thoroughly covering all foliage and/or stems as needed to control the pest in question. Often called spraying-to-wet, spraying to runoff does not call for excessive pesticide use but rather efficient application technique so that each leaf or stem is thoroughly wetted throughout the tree without spraying any area more than once. This type of application often is done with handguns and backpack sprayers.

MIXING AND LOADING PESTICIDES

To determine the amount of pesticide to add to the spray tank, you need to know the recommended application rate of pesticide, the capacity of the spray tank, and the calibrated output of the sprayer. The units of application rate vary among labels and written recommendations. Most labels give the application rate in the amount of product per acre. Many recommendations state the application rate in amount of active ingredient (a.i.) or acid equivalent (a.e.) per acre. Always convert rates to the amount of product when calculating how much pesticide you need.

Some recommendations state the application in amount of active ingredient (a.i.) or acid equivalent (a.e.) per acre. A.I. or a.e. must be converted to the actual amount of product need for application. The recommended application rate of the pesticide is given on the label, typically in the directions of use section. Usually when an insecticide brand name is followed by a number and letter designation (4L, 75DF, 7EC, etc.), the number indicates how many lbs of a.i. are in a pt, qt, or gal (for liquid formulations) or lb (for dry formulations) of the formulated product, but check the label to be sure. For example, "Bugoff 4L" contains 4 lbs of a.i. per gal of formulated product, "Growl 90DF" contains 0.90 lb of a.i. per lb of formulated product, and "Nomite 3.3EC" contains 3.3 lbs of a.i. per gal of formulated product. The a.i. must be converted to actual product.

Mixing pesticides

Formulations such as WP, SP, EC, and F are typically sold as concentrates and must be diluted in the spray tank. Water is the most common **diluent**, but oil and other liquids are sometimes used. The label will tell you how much to dilute the formulation and how much of the dilute pesticide to apply per unit of area.

Common Abbreviations	
A	acre
a.i.	active ingredient
ft	foot or feet
gal	gallon(s)
GPA	gallons per acre
GPM	gallons per minute
min	minutes
oz	ounce(s)
psi	pounds per square inch
sec	seconds

DRY FORMULATIONS

Example: A carbaryl recommendation calls for 2 lbs a.i./A. You have purchased an 80% WP. Your sprayer has a 200-gal tank and is calibrated to apply 20 GPA. How much product should be added to the spray tank?

1. Determine the number of acres that you can spray with each tankful.

$$\frac{\text{tank size in gal}}{\text{GPA}} = \frac{200 \text{ gal tank}}{20 \text{ GPA}} = 10 \text{ A sprayed per tankful}$$

2. Determine the lbs of pesticide product needed per A. Because not all of the product in the bag is the a.i., you will have to add more than 2 lbs of product to each "acre's worth" of water in your tank. How much more? Divide the percentage of a.i. (80) into the total (100).

$$\frac{2 \text{ lb a.i.}}{1 \text{ A}} \times \frac{100\%}{80\%} = 2 \times 1.25 = 2.5 \text{ lb of product/A}$$

You will need 2.5 lbs of product for each "acre's worth" of water in the tank to apply 2 lbs of a.i./A.

3. Determine the amount of pesticide to add to each tankful. With each tankful, you will cover 10 A, and you want 2.5 lbs of product per A. Add 25 lbs (10 A x 2.5 lbs/A = 25 lbs of product to each tankful).

Example: An insecticide recommendation calls for 4 lbs/A. Your 5 gal air compression sprayer applies 1.25 gal per 1,000 sq ft. How many oz should you add to the spray tank?

1. Convert the recommended rate to oz/1,000 sq ft

$$\frac{4\text{ lb}}{\text{A}} \times \frac{1\text{A}}{43{,}560\text{ sq ft}} \times \frac{16\text{oz}}{1\text{ lb}} = \frac{64\text{ oz}}{43{,}560\text{ sq ft}}$$

$$\frac{64\text{ oz}}{43{,}560\text{ sq ft}} = \frac{X\text{ oz}}{1{,}000\text{ sq ft}}$$

2. Determine the amount of pesticide to add to each tankful

$$\text{oz pesticide / tankful} = \frac{\text{gal / tank} \times \text{oz pesticide / 1,000 sq ft}}{\text{gal applied / 1,000 sq ft}}$$

$$\frac{5\text{ gal / tank} \times 1.5\text{ oz pesticide / 1,000 sq ft}}{1.25\text{ gal applied / 1,000 sq ft}} = 6\text{ oz pesticide / tankful}$$

LIQUID FORMULATIONS

Example: An insecticide recommendation calls for 1 lb a.i./A. You have purchased a 4 lb/gal formulation. Your sprayer has a 150-gal tank, and it is calibrated at 15 GPA. How much product should you add to the spray tank?

1. Determine the number of A that you can spray with each tankful. Your sprayer has a 150 gal tank, and is calibrated for 15 GPA.

$$\frac{\text{tank size in gal}}{\text{GPA}} = \frac{150\text{ gal tank}}{15\text{ GPA}} = 10\text{ A sprayed per tankful}$$

2. Determine the amount of product needed per A by dividing the recommended a.i./A by the concentration of the formulation.

$$\frac{1\text{ lb a.i. / A}}{4\text{ lb a.i. / gal formulation}} = 0.25\text{ gal of formulation / A}$$

0.25 gal or 1 qt of product is needed for each “acre’s worth” of water in the tank to apply 1 lb of a.i./A.

3. Determine the amount of pesticide to add to each tankful. With each tankful, you will cover 10 A, and you want 0.25 gal (1 qt) of product per A. Add 10 qts (10 A x 1 qt/A = 10) of insecticide to each tankful.

Example: An insecticide recommendation calls for 1 GPA of product. You have a 4-gal backpack sprayer that has been calibrated to apply 0.5 gal per 1,000 sq ft. How many oz should you add to the spray tank?

1. Convert the recommended rate to oz/1,000 sq ft

$$\frac{\text{gal}}{\text{A}} \times \frac{\text{128 oz}}{\text{1 gal}} \times \frac{\text{1 A}}{\text{43,560 sq ft}} = \frac{\text{128 oz}}{\text{43,560 sq ft}}$$

$$\frac{\text{128 oz}}{\text{43,560 sq ft}} = \frac{\text{X oz}}{\text{1,000 sq ft}}$$

X = 3 oz/1,000 sq ft

2. Determine the amount of pesticide to add to each tankful

$$\text{oz pesticide / tankful} = \frac{\text{gal / tank} \times \text{oz pesticide / 1,000 sq ft}}{\text{gal applied / 1,000 sq ft}}$$

$$\frac{\text{4 gal / tank} \times \text{3 oz pesticide / 1,000 sq ft}}{\text{0.5 gal applied / 1,000 sq ft}} = \text{24 oz pesticide / tankful}$$

ADJUVANTS

The manufacturer may recommend that you add a small amount of an adjuvant in addition to the regular chemical. This recommendation is often given as "percent concentration."

Example: If you use an adjuvant at a 0.5% concentration by volume, how much should you add to a 300-gal tank?

Solution 1:

1% of 100 gal = 1 gal (0.01 x 100 = 1)
0.5% of 100 gal = 0.5 gal
You will need 0.5 gal per 100 gal, or 1.5 gal for 300 gal (0.5 x 3 = 1.5).

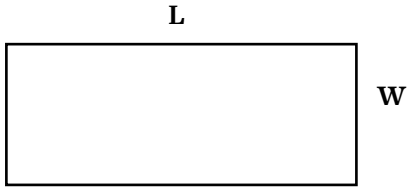
Solution 2:

0.5% = 0.005
0.005 x 300 gal = 1.5 gal

CALCULATING SIZE OF TARGET SITES

To determine how much pesticide you need for a job, you must measure and calculate the size of the site to be treated.

The area of a rectangle is found by multiplying the length (L) by the width (W).



Measuring tree diameter

Tree trunks are measured at the diameter at breast Height, or DBH, which is defined as the diameter of the tree 4.5 feet aboveground on the uphill side of the tree.

If a tree forks below breast height, each trunk is treated as a separate tree. Diameter at breast height can be measured with a tree caliper, a Biltmore stick, a tree-diameter tape, or a flexible cloth or steel measuring tape. To calculate the diameter at breast height, measure the tree's circumference and divide the circumference by 3.14. Tree calipers, Biltmore sticks, and tree-diameter tapes can be purchased through forestry equipment supply companies.

SAFETY AND MAINTENANCE OF EQUIPMENT

There are two important reasons for maintaining and cleaning equipment:

1. **To save money.** Proper equipment maintenance reduces the need for replacement parts and repairs, making it easier to control the application of pesticides. Before any sprayer can be reliably calibrated, it must be in good mechanical condition.

2. **To prevent pesticide exposure.** Pesticide application equipment will normally have some residual pesticide left in the tank, hoses, and on the surface of the equipment. This residue can harm people, animals, and plants. If someone comes into contact with this residue, it can result in serious poisoning. If you mix a pesticide in equipment that has a residue of a different pesticide, you may damage plants or injure animals. Always wear **personal protective equipment** (PPE), especially gloves, when working with equipment. Refer to the pesticide label for a list of the PPE required to handle each particular pesticide.

Before spraying

- At the beginning of each spray season, thoroughly wash the sprayer with clean water, inside and out.
- Make sure nozzle tips are the same across the boom and the right kind for the spray application. Consult the nozzle manufacturer's recommendations and the pesticide label.
- If you use nozzles with check valves, make sure they are working properly.
- Check the spray volume output of all nozzles and replace any nozzle tip that differs by more than 5% of the average output of all nozzles or replace all the nozzles if more than one is off.
- Clean residue from strainers. Replace those that are damaged or deteriorated.
- Replace hoses at the first sign of surface deterioration.
- Check the nozzle height by measuring the distance between the nozzle tip and target. Check the nozzle manufacturer's recommendations for nozzle spacing, alignment, and boom height, and adjust the boom accordingly. Boom height is very important in broadcast application because it affects the uniformity of the spray pattern.
- Make sure the tank is level during filling so that the amount in the tank is correctly indicated. Know the true volume levels of your equipment. Factory sight gauges and volume markers are often incorrect, resulting in miscalibration and misapplication.

During spraying

- Check the pressure gauge and speedometer frequently while spraying. The sprayer should always operate at the same pressure and speed used during calibration. Speeds should be reasonable so that spray booms are not bouncing or swaying excessively.
- Periodically check hoses and fittings for leaks. Keep hoses from being kinked or worn.
- Check nozzles for unusual patterns.
- Check pressure gauges frequently for accuracy. If the gauge does not zero properly, replace it.
- Always wear adequate PPE, particularly rubber gloves, if emergency repairs or adjustments are necessary in the field.
- Never use metal wire to unclog a nozzle—it may distort the nozzle opening and change the spray pattern and output. Use an old toothbrush instead.
- Never operate a sprayer pump at speeds or pressures above those recommended by the manufacturer.
- Never allow the pump to run dry. Pumps depend on the spray liquid for lubrication and removal of friction heat. Pumps will be damaged if run dry or if they have a restricted inlet or outlet.

After spraying

Use a brush to unclog nozzles

All equipment and parts exposed to a pesticide, including sprayer pumps, tank, hoses, and the boom, normally have some residue. Wear rubber gloves and a long-sleeved shirt to prevent skin contact with these residues. Some labels may require more PPE.

- Always flush the spray system, inside and out, with water after each use to prevent chemical buildup. Make the initial tank rinse at the application site. Apply the **rinsate** on the site to reduce the generation and concentration of wastes at the clean-up area. You will need extra water onsite (saddle or truck tank).

- Clean the inside and outside of the sprayer thoroughly before switching to another pesticide and before doing any maintenance or repair work. To avoid almost certain plant injury, sprayers used for herbicides should never be used for insecticides or fungicides.

- Rinse hoses often, inside and out, to prolong life. Store them out of the sun.

- Clean strainers after each use.

When cleaning granular spreaders:

- Remove all granules and store in the original container.

- Remove rust on the feeder plates or agitator with a wire brush, a file, or sandpaper.

- Tighten all nuts and bolts.

- Oil the equipment following the manufacturer's directions.

Storage of sprayer

Clean the sprayer thoroughly

- Clean the sprayer thoroughly before storing for the season. Add 1–5 gallons of lightweight emulsifiable oil (depending on the size of the tank) to an equal volume of clean water. Flush the entire system with the oil-and-water mixture. As the mixture is pumped from the sprayer, the oil will leave a protective coating on the inside of the tank, pump, and plumbing.

- Remove, clean, and place all nozzles and screens in a dry place to prevent **corrosion**.

- Cover the nozzle openings on the sprayer boom with tape to keep dirt out.

- When storing for the winter, drain water from pumps to keep them from freezing and cracking (if not stored in a heated building). As an added precaution, pour one tablespoon of radiator rust inhibitor or antifreeze into the pump inlet. Turn the pump several revolutions to coat the internal surfaces.

Conversion Tables

Area

144 square inches.....1 square foot
9 square feet.....1 square yard
43,560 square feet.....1 acre
4,840 square yards.....1 acre
160 square rods.....1 acre
640 acres.....1 square mile
2.5 acres.....1 hectare

Length

1 inch.....2.54 centimeters.....25.5 millimeters
1 foot.....12 inches
1 yard.....3 feet
1 rod.....5.5 yards.....16.5 feet
1 mile.....320 rods.....1,760 yards.....5,280 feet
1 meter.....39.4 inches.....1.09 yards
1 kilometer.....1,000 meters.....0.62 miles

Volume

1 tablespoon (tbs).....3 teaspoons (tsp)
1 fluid ounce.....2 tablespoons
8 fluid ounces.....16 tablespoons.....1 cup
16 fluid ounces.....2 cups.....1 pint
32 fluid ounces.....4 cups.....1 quart
128 fluid ounces.....4 quarts.....1 gallon
1 liter.....33.9 ounces.....1.06 quarts

Weight

1 ounce.....28.3 grams
1 pound.....16 ounces.....453.6 grams
2.2 pounds.....1 kilogram.....1,000 grams
1 ton.....2,000 pounds.....907 kilograms
1 metric ton.....1,000 kilograms.....2,205 pounds

CHAPTER 5: HOST AND SITE IDENTIFICATION

LEARNING OBJECTIVES

After reviewing this chapter, you should be able to:

- Know why host identification is essential.
- Describe the differences between conifers and broadleaf trees.
- Understand how trees are classified.
- Understand how trees are distributed across Wyoming.
- Be aware of the forest types found in Wyoming.
- Define forests, forest nurseries, forest seed producing areas, windbreaks, and downed timber.

Wyoming is home to 10.5 million acres of forestland. Many forest pests are restricted to certain tree species, distinct types of trees, or specific tree associations. By knowing about Wyoming forest types, their growth and development, and sites where pesticides are applied, you will gain a better understanding of the tree/pest relationships in your area.

HOST IDENTIFICATION

Before any forest pest control program can be started, an applicator must be able to properly identify trees and **shrubs**. Plant identification is essential because some insects only attack a few tree species, whereas others have a wide range of hosts. Dwarf mistletoe and certain pathogens are tree specific. You must also know how to identify currant bushes (*Ribes* spp.) because they are an **alternate host** to white pine blister rust.

Lanceleaf cottonwood

Tree and shrub identification

A tree is a woody plant with a single erect **perennial** trunk at least 3 inches dbh. Most trees have **crowns** of foliage and attain heights in excess of 13 feet. In contrast, a shrub is a small, low-growing woody plant with multiple stems. A vine is a woody plant that derives its support from climbing, twining, or creeping along a surface.

Generally trees are divided into two main categories: **conifers** and broadleaf trees. **Broadleaf** trees are considered **hardwoods** and the conifers are **softwoods**. Most conifers are **evergreen**.

Trees known variously as conifer, evergreen, or softwood	Trees known variously as broadleaf, deciduous, or hardwood
CONIFER - Trees with needles or scale-like leaves and cones	BROADLEAF - Trees with leaves that are broad, flat, and thin and generally shed annually
EVERGREEN - Perennial plants that normally keep foliage or needles through the entire year	DECIDUOUS - Perennial plants that are normally leafless for some time during the year
SOFTWOOD - Usually evergreen, bear cones, and have needles or scalelike leaves. Wood hardness varies among species, and some are actually harder than some hardwoods	HARDWOOD - Trees with broad, flat leaves. Wood hardness varies among species, and some are actually softer than some softwoods
EXAMPLES - Douglas-fir, pine, spruce	EXAMPLES - aspen, cottonwood, willow

Identification of conifers is based on the location, number, and length of needles. Needles may be attached to the twig in a solitary fashion or arranged on the twig in **fascicles**. Solitary needles occur in firs and spruces. Needles in fascicles are found in all other pine trees. The number of needles in a fascicle and their length is a good indicator of the species.

Broadleaf species are characterized by broad leaves, varied fruit, and deciduous leaves.

TIPS ON IDENTIFYING TREES

- Leaves, flowers, bark, twigs, shape, and fruit are all used to identify tree species. Colors, textures, and smells will also help in identification.

- Many sources of identification use a key. A dichotomous key is a tool that allows the user to determine the identity of items in the natural world, such as trees. Keys consist of a series of choices that lead the user to the correct name of a given item.

- Tree species are not distributed at random but are associated with unique habitats. You can possibly eliminate trees that don't normally live wild in the forest in your area.

Tree classification

It is necessary to classify trees so that relationships with other trees can be determined. For example, all members of a particular species will have similar developmental characteristics and exist in similar environments. Most often, tree species are classified based on similarities in appearance (morphology). Pest species are also classified in the same manner.

The hierarchy used to classify ponderosa pine, is as follows:

Phylum - Plantae

Class - Pinopsida

Order - Pinales

Family - Pinaceae

Genus - *Pinus*

Species - *ponderosa*

This universal method is used to prevent confusion among geographic regions of the world. Consequently, the **scientific name** *Pinus ponderosa* refers to the same tree species in the U.S. as it does anywhere else in the world. However, common names are often used on pesticide labels.

Representative host plants

Wyoming Trees	
Name	**Leaf or Needle Characteristics**
Bristlecone pine *Pinus aristata*	Evergreen, needles in bundles of 5; commonly 1-1.5 inches long; curved; glossy and dark green. Needles are close together and persist on the branches for 12–14 years or even more, making the branches look like a long brush
Limber pine *Pinus flexilis*	Evergreen, needles 1–2 inches long in bundles of 4–5
Lodgepole pine *Pinus contorta*	Evergreen, needles 1–2 inches long in bundles of 2, more of a yellow-green color than other conifers
Pinyon pine *Pinus edulis*	Evergreen, needles mostly in bundles of 2; 0.75–2 inches long; yellow-green; slightly thicker than most pine needles, curved, and sharp-pointed
Ponderosa pine *Pinus ponderosa*	Evergreen, needles 3–7 inches long, in bundles of 2–3
Colorado blue spruce *Picea pungens*	Evergreen, 0.75–1.25 inches long, yellow-green to bluish or white. Needles rigid, sharp to the touch, and almost spine-tipped
Engelmann spruce *Picea engelmannii*	Evergreen, 4-sided needles 1 inch long that are sharp, flexible, and bluish-green. Needles attached singly to twig
Subalpine fir *Abies lasiocarpa*	Evergreen, needles attached singly to twig, flat, with rounded tips and soft to the touch; often arc upward so that the tips point skyward
White fir *Abies concolor*	Evergreen, single, flattened, soft, 1.75–3 inches long, sometimes curved, and pointed or notched at the tip. Whitish on both sides with double parallel white lines on lower side. Silver-blue, pale green, or blue-green becoming dull green. Usually spread out from the sides of twig horizontally rather than in all directions
Douglas-fir *Pseudotsuga menziesii*	Evergreen, needles 1 inch long, flat, with a rounded tip and a short stalk attaching them to the twig
Rocky Mountain juniper or Red cedar *Juniperus scopulorum*	Evergreen, leaves small, scale-like, occurring in pairs, pale green to grayish-green
Utah juniper *Juniperus osteosperma*	Evergreen, scale-like, most are tight to the twig in opposite pairs, resulting in a slightly square twig; yellow green
Quaking aspen *Populus tremuloides*	Broad, oval leaves 1–3 inches long with thin, flattened stem
Narrowleaf cottonwood *Populus angustifolia*	Leaves alternate, 2–3.6 inches long, broadest near the middle tapering to a point, fine-toothed along the margin
Gambel oak *Quercus gambelii*	Leaves have variable shape, and are often deeply lobed, with lobes rounded, not pointed; 2–6 inches long, 2–3 inches wide; leathery texture, bright or dark green on the top surface
Wax currant *Ribes cereum*	Simple, alternate, deciduous, palmately lobed with 3–5 lobes, 0.5–2 inches long, irregularly round toothed; dark green above, paler and glandular and hairy below; often the leaves are sticky

Distribution

The distribution of tree species is dependent on many factors, such as annual precipitation, soil type, altitude, competition with other species, and physical disturbances to the area.

In the montane zone (5,000–8,000 feet), ponderosa pines are more abundant on sunny southern exposures while Douglas-fir trees prefer cooler and damper north-facing slopes. Lodgepole pine and aspen commonly become established in areas previously disturbed by mining and logging operations and by fire. Two-needle pinyon and juniper are successful in environments that are too dry to support other trees. Colorado blue spruce and narrowleaf cottonwood are confined to areas near rivers or other water sources.

Life zones

The following table shows which trees dominate each life zone.

FOREST TYPES

Forest type, or forest cover, refers to the dominant tree species in the overstory of a given site. The distribution of forest types across the landscape is determined by factors such as climate, soil, elevation, aspect, and disturbance history. A number of forest types exist throughout Wyoming, with the most extensive being spruce-fir, ponderosa pine, lodgepole pine, aspen, and pinyon-juniper. Other Wyoming forest types include Douglas-fir, southwestern white pine, bristlecone pine, limber pine, Colorado blue spruce, and cottonwood-willow.

Spruce-fir

It is comprised of the slow-growing Engelmann spruce in association with the smaller subalpine fir. The spruce-fir combination often results in a climax-type forest at high elevations, despite the existence of many uneven-aged stands. This is because both species are shade tolerant and tend to quickly repopulate shaded areas in the forest.

Life Zones		
Life Zone	**Elevation (ft) (approximate)**	**Dominant Trees & Shrubs**
Plains	3,500–5,500	Cottonwoods
Upper Sonoran	up to 7,000	Semi-desert shrublands and pinyon-juniper woodlands at their upper limits
	up to 8,000	
Foothills	5,500–8,000	Gambel oak & mountain mahogany or pinyon-juniper woodlands & sagebrush
Montane	8,000–9,500	Ponderosa pine, douglas-fir, lodgepole pine, aspen
Subalpine	9,500–11,500	Subalpine fir, Engelmann spruce, bristlecone pine, lodgepole pine
Alpine	11,500–14,000+	Treeless zone (tundra)

Ponderosa pine

The ponderosa pine is the most widely distributed pine in North America and occupies a vast area in the West. It is generally the dominant lower timber species in the montane zone. It is well adapted to high temperatures and low moisture.

Ponderosa pine

Lodgepole pine

Lodgepole pine is an important species in the montane and subalpine forests of the Rocky Mountains. It tolerates a wide variety of climatic and soil conditions, but achieves its best growth on gentle slopes and in basins with well-drained, slightly acidic, sandy, or gravely loams.

Aspen

Aspen can occur over a wide variety of sites ranging from dry, high-elevation grasslands to poorly drained meadow sites. It regenerates through sprouts or suckers that are produced by its roots in response to increased soil or root temperatures. Because of this sprouting response, aspen is often first to colonize forest clearings. As stands grow and shade on the site increases, conifer species begin to invade and may eventually replace the aspen. The open canopy and high light levels of aspen stands lead to a more lush understory than that of neighboring conifers.

Aspen

Pinyon-juniper

Pinyon-juniper woodland tree species have developed resistance to both drought and cold. Juniper tends to grow at lower elevations and in more arid areas as its scaled foliage allows it to conserve water more effectively than pinyon pine. Juniper-dominated woodlands tend to include open savannas of scattered trees without a significant shrub component, except in areas where big sagebrush has become dominant as a result of grazing.

Pinyon-juniper communities

SITE IDENTIFICATION

Forests

A forest is a dense growth of trees, plants, and underbrush covering a large area. It is rarely economically feasible or environmentally favorable to apply pesticides to large acreage of forestland. Forest managers instead concentrate on keeping forests healthy and productive.

Forest nurseries

Forest tree nurseries are intensively managed sites that use considerable amounts of pesticides. Forest nurseries employ the latest techniques available to produce quality seedlings. Production of quality seedlings requires the use of fungicides, herbicides,

and insecticides in conjunction with other silvicultural activities as part of an IPM program.

Ponderosa pine seedlings

Forest seed producing areas

Forest seed producing areas are natural or cultivated stands of trees used for seed production. They supply the demands of nursery production for reforestation efforts. Tree improvement programs began when selected forest stands were set aside as seed production areas. These areas were rogued of inferior species and trees lacking desirable characteristics. Later, seed orchards were established from grafts of trees with superior traits. Progeny from these orchards have been planted to evaluate their growth, form, yield, and disease resistance. These valuable seed orchards are managed to ensure development of high-quality seed.

Windbreak

Windbreaks

Windbreaks are strips of trees and/or shrubs that are planted and maintained to redirect and reduce the air flow over a specific area. They reduce wind erosion, provide shade and shelter for livestock, wildlife, and humans, and provide wildlife habitat. Windbreaks protect buildings, livestock, and wildlife from hot dry summer winds and from icy, wintry winds and snow.

Downed timber

Downed timber includes old dead trees, shallow-rooted trees, and weakened trees that fall or are blown down by high wind or other weather conditions. Downed timber poses wildfire hazards, safety risks to people and property, and increased susceptibility to insect and disease outbreaks.

CHAPTER 6: FOREST PEST CONTROL

LEARNING OBJECTIVES

- Know basic insect anatomy.
- Know what an arthropod is and the classes of arthropods.
- Understand insect growth and development.
- Know the characteristics of insect orders.
- Know which forest insects are common pest problems in Wyoming and how to identify them.
- Be able to identify the hosts for each forest pest.
- Understand the life cycles of forest insect pests.
- Know what damage each insect pest causes in forests.
- Be able to describe IPM methods to manage forest insect pests.

Dieback from *Phomopsis juniperovera* on a red cedar.
Robert L. Anderson, USDA Forest Service, Bugwood.org

The forest is a fragile environment. Its management is a major concern to many people, including forest and wildlife managers, lumber companies, recreational-area managers, and homeowners.

Insects and mites are always present in forests. They play a role that is nearly always subtle but at times very turbulent. Insects are known mostly for their destruction, yet their equally beneficial role often goes unnoticed.

A disease is a condition that alters or prevents the normal expected growth and function of the affected trees. A disease may be caused by both non-infectious factors (such as drought, excessive moisture, lack of nutrients, and chemical injuries) and infectious factors (including fungi, bacteria, viruses, and nematodes). Growth abnormalities caused by insects, mites, and animals are usually considered distinct from "disease," even though symptoms may be similar.

Besides insects and diseases, the third area of concern is the vegetative cover of forests. It directly or indirectly affects productivity, watersheds, wildlife, and the aesthetic values of these resources. The proper management of unwanted vegetation is a major concern for many people involved in forest management.

Dealing with insect pests on plants involves a carefully planned procedure, just as it should be with any other pest problem being considered. You should have some knowledge about the situation, then use this knowledge in the proper sequence to achieve the best results.

PROCEDURES

In general, the procedure for dealing with insect and mite problems is as follows.

Examination of the situation

Know what the normal or healthy condition of the plant looks like. If the plant deviates too far from this condition, look for possible causes.

Identification and assessment

If insects or mites, or conditions apparently caused by them, are found, determine what the pest is and the seriousness of the problem. Not all insects on plants are pests. Some may be incidental visitors and some may be beneficial. On the other hand, some pests may be causing little damage at the moment, but the problem may become serious in a short time. Even if the plant is healthy, it may be vulnerable to attack from pests, so it's important to know which insects or mites are likely to be pests.

Prescription

This may involve preventive action, curative action, or no action at all, depending on the identification and assessment of the situation.

Preventive action often involves maintaining tree vigor by proper site selection. The sanitary practices of pruning out dead or unhealthy plant parts and cleaning up ground litter that may harbor pest insects are also helpful.

Other cultural (non-chemical) practices may be useful against some pests. In some cases, insecticides are used to protect plants from becoming infested.

Curative action involves restoring infested plants to a healthy condition. Sometimes natural controls are sufficient to give the plant an advantage to overcome the pest attack.

In other cases, control with pesticides may be necessary. The most common of the points to consider when selecting and using an insecticide or miticide are these:

- Is the use of this pesticide safe to you and others in the situation in which you want to use it?
- Is the pesticide likely to harm the plant you want to protect? If so, under what conditions?
- Will the pesticide also kill beneficial insects or other beneficial animals in this situation?
- Are there clear label directions for using the pesticide for this purpose?
- When is the proper time to use this pesticide for this particular pest?
- How and to what parts of the plant is the pesticide applied?
- Is the pesticide registered with EPA for this use?

No action might be prescribed when the pest isn't a serious one or when the corrective action would give rise to problems more serious than the one at hand. Sometimes a pest may be causing extensive damage, but there are no practical methods of control during this stage of the insect's development. Taking no action might be prescribed until the insect is in a vulnerable stage.

Application

Knowing what the problem is and what to do about it doesn't solve the problem until you carry out the prescription properly. Some of the common problems are:

- Calibration errors.
- Inadequate coverage of the plant with the spray solution. Plants usually should be thoroughly wetted.
- Tendency of the spray to separate or settle out unless the spray solution is kept agitated. If the spray solution is allowed to settle during spraying, some plants will be overdosed and others under-dosed.
- Improper timing of sprays. If applied too early, the effect of the insecticide may have disappeared by the time the main insect population is present. If the spray is delayed, the insects may have developed to a more resistant stage or may have bored in where the spray can't reach them.
- Adverse effects due to weather conditions. Rains following spraying may wash off the pesticide before it has accomplished its full effects. Temperature extremes may injure the plant, reduce toxicity of the pesticide, increase pest resistance, or volatilize the pesticide.

Evaluation

Did the prescription work? This should be based on the considerations discussed under prescription.

Signs of insect and mite presence

The insect or mite causing damage may not be present or visible when its damage is discovered. However, there may be evidence of its presence. The following are some general signs to look for.

- Silk shelters: Made entirely from silk; usually don't enclose foliage, except an occasional leaf. The caterpillars feed outside the shelter and use it only for protection from predators, weather, etc.
- Scale and aphid coverings: Most scales and some aphids excrete a protective waxy covering.
- Insect and mite remains, including egg shells; shed nymphal, larval, and pupal skins; cocoons; frass; and trails of silk.
- Honeydew: Sticky liquid sugar excreted by scales and aphids. A black, sooty mold may grow on the honeydew.
- Sawdust, wood chips, and pitch balls: Usually found on or below the host plant. Mostly the result of feeding by bark beetles, wood borers, and shoot borers.

INSECT BIOLOGY AND IDENTIFICATION

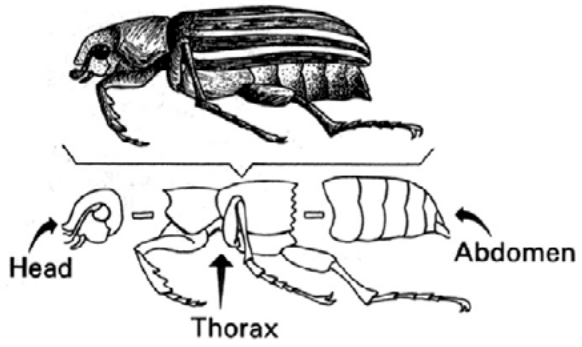
All species of trees are affected by a complex of insect pests. Every part of a tree may be fed upon by insects. Insects may attack trees of any age. The types and numbers of insect pests affecting a specific tree will depend on the age, vigor, location, and susceptibility of the tree. Stressed trees are

often more susceptible to insect attack than healthy trees. Stunting, distortion, weakening, or death of a tree is frequently caused by some combination of adverse environmental factors and insect attack.

It is important to realize that not all insects are pests; in fact, only a small percentage cause damage to trees. Most forest insects play important roles in forest ecosystems.

INSECT ANATOMY

Insects have three body regions: **head**, **thorax**, and **abdomen**. The head functions mainly for food and sensory intake and information processing. Insect mouthparts have evolved for chewing (beetles, **caterpillars**), piercing-sucking (aphids, bugs), sponging (flies), siphoning (moths), rasping-sucking (thrips), and chewing-lapping (wasps). The thorax provides structural support for the legs and, if present, for one or two pairs of wings. The three pairs of jointed legs may be adapted for running, grasping, digging, or swimming. The abdomen functions in digestion and reproduction.



An insect has 3 body regions

INSECTS AND THEIR RELATIVES

Insects have several important relatives. The insects, together with **spiders**, mites, centipedes, and **crustaceans** belong to a larger group (phylum) of animals, the **arthropods**. The word arthropod means "jointed foot," a characteristic shared by all arthropods. Other characteristics are:

- a body that is segmented
- appendages that are jointed
- an **exoskeleton** for protection from the environment and natural enemies
- the need to periodically shed and regrow the exoskeleton (**molting**) in order to grow

Arthropods are subdivided into smaller groups, each with its own additional unique features. Each of these is known as a class, the largest of which is Insecta, which includes all of the insects.

Members of the class **Arachnida**, including spiders, mites, ticks, and scorpions, have four pairs of legs and possess only two body regions. The head and the area of the body containing the legs is fused together into the **cephalothorax**. They are wingless and possess a large abdomen on the hind end that contains most of the organs needed to digest food and to reproduce.

Centipedes, members of the class Chilopoda, are also arthropods. Most centipedes have a long, flattened body with a pair of legs on each body segment. Another group of wormlike arthropods is the millipedes, class Diplopoda. Millipedes possess many small legs, usually two per body segment.

The crustaceans (class Crustacea) include animals such as crayfish, shrimp, and crabs. Most occur in water, although a few occur on land, such

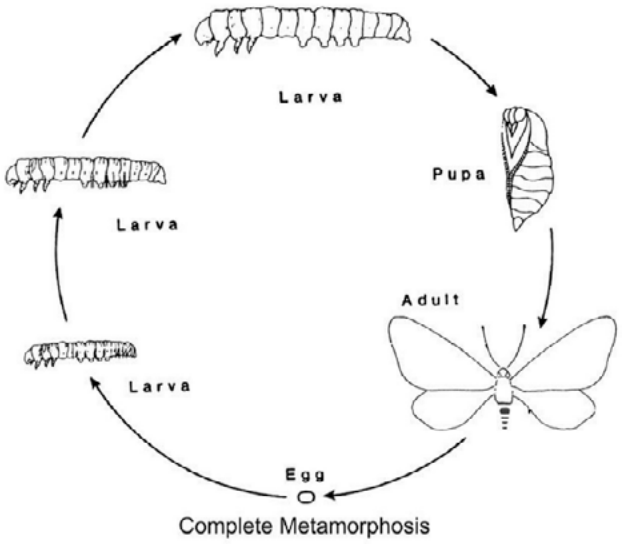
as the sowbugs and the pillbugs ('roly-polys'). Crustaceans have 5–7 pairs of legs and two body regions (cephalothorax and abdomen).

Some other kinds of pest organisms, such as **molluscs**, are similar to insects in many ways, but are not arthropods. They cause similar damage and usually can be managed with techniques similar to those used to manage insects. Molluscs are a large group of land and water animals including slugs and snails.

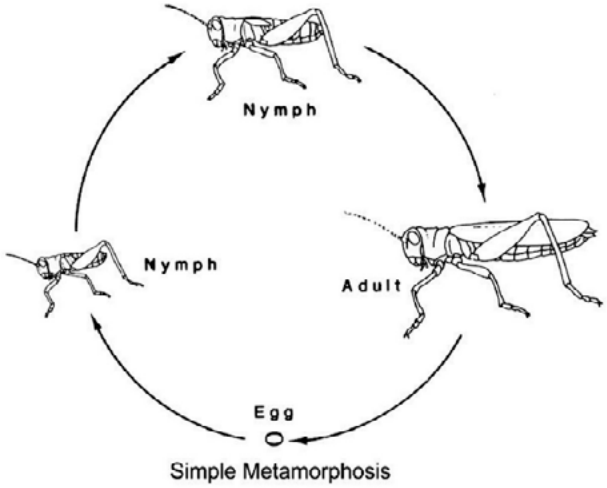
INSECT GROWTH AND DEVELOPMENT

Insects typically pass through four distinct life stages: egg, larva or nymph, pupa, and adult. Eggs are laid singly or in masses, in or on plant tissue or another insect, on inanimate objects, or in the soil. The embryo within the egg develops and eventually a larva or nymph emerges from the egg. There are generally several larval or nymphal stages (**instars**), each progressively larger and requiring a molt between each stage. In general, neither eggs, pupae, nor adults grow in size; all growth occurs during the larval or nymphal stages.

The two types of **metamorphosis** typical of insect pests and natural enemies are **complete** and **simple** metamorphosis. Complete metamorphosis includes four distinct stages: egg, larva, pupa, and adult. Typically the larva and the adults differ greatly in appearance, often live in different habitats, and may have very different behavior. The wormlike immature insects, called larvae, may be legless or have legs, or leg-like appendages on the abdomen. They usually have chewing mouthparts, even in the groups in which the adults have sucking mouthparts. The wings develop internally during the larval stages and appear externally only during the pupal stage. In this stage, the pupa does not feed or move around much. It may be covered by a protective **cocoon**. Eventually the insect molts for the last time and emerges as an adult. Examples of insects that undergo complete metamorphosis include beetles, flies, bees, lacewings, butterflies, and moths.



Complete Metamorphosis



Simple Metamorphosis

Characteristics of Insect Orders			
Order	**Metamorphosis**	**Mouthparts**	**Wings**
Coleoptera (e.g., beetles)	Complete	Chewing	2 pair, forewings hardened
Diptera (e.g., flies)	Complete	Sponging	1 pair, membranous
Homoptera (e.g., aphids and true bugs)	Simple	Piercing-sucking	2 pair, membranous or 2 pair leathery at base, forewings membranous at tip
Hymenoptera (e.g., bees)	Complete	Chewing-lapping	2 pair, membranous
Lepidoptera (e.g., moths, butterflies)	Complete	Siphoning (adults), Chewing	2 pair, wings covered with scales
Orthoptera (e.g., grasshoppers)	Simple	Chewing	2 pair, forewings leathery
Thysanoptera (e.g., thrips)	Simple and Complete	Rasping-sucking	2 pair, fringed

Simple metamorphosis, also known as gradual metamorphosis, includes three stages: egg, nymph, and adult. Both the immature insects, called nymphs, and adults are similar in appearance, but may differ in size and color. Nymphs and adults usually live in similar habitats and have similar hosts. Wings, if present, develop externally during the nymphal stages. Examples of insects that undergo simple metamorphosis include **true bugs** and grasshoppers.

A few groups of insects have growth forms that fall between these types of metamorphosis. Thrips and whiteflies are examples.

FOREST INSECTS AND MITES

Following are descriptions of pests that occur in Wyoming forests. They are grouped according to the part of the plant they feed on (leaves or shoots, twigs, trunks, and roots) and the kind of injury they cause (chewing or sucking). Please note that specific insecticides are not listed to control each pest. For current pesticide products, rates, precautions, and more on treatment decisions, please consult the pesticide label.

Always read pesticide product labels thoroughly and follow all instructions, restrictions, and precautions.

DEFOLIATORS

Defoliators attack leaves in a variety of ways, but all damage the foliage directly and visibly with their chewing mouthparts. There are three basic groups of defoliators, classified according to the type of damage each causes:

1. Leaf chewers feed on and destroy the entire leaf.

2. Leaf **skeletonizers** feed on the surface and eat only the tissue between the veins, leaving the veins and midribs.

3. Leaf miners feed between the epidermal layers of the leaf.

Although some insects may be leaf miners during one part of their life cycle and leaf chewers later, most usually remain consistent in feeding habits throughout their life. The majority of defoliators come from the two orders Lepidoptera (butterflies and moths) and Hymenoptera (sawflies, parasitic wasps, ants, wasps, and bees), but some members of the Coleoptera (beetles), Orthoptera (grasshoppers, crickets, and katydids) and Diptera (flies) are also defoliators.

Defoliation affects trees in a number of ways, but the result is always to reduce or stop growth. A tree can withstand substantial defoliation, but loss of leaves reduces photosynthesis (the source of energy) and interferes with transpiration and transport of nutrients. Unless a very high percentage of the leaf surface is destroyed, the tree will generally survive, but it may be weakened. As a general rule of thumb, if a tree loses more than 60 percent of its foliage for two to three consecutive years, the tree may die or become highly susceptible to other pests.

Deciduous trees and shrubs usually can tolerate considerable defoliation without affecting tree vigor. Evergreens, on the other hand, can be seriously affected by heavy defoliation. This is because evergreens replace only a portion of their total amount of foliage each year. (Pines, for example, replace about one-third, and if the new needles are eaten, the tree will be missing about one-third of its needles for three consecutive years.) Also, evergreens usually use their leaves or needles to produce growth regulators (hormones) and to store food reserves for the next year. If these leaves or needles are eaten, so are sites for growth-regulator production and food storage. New foliage is the most efficient producer of plant food. If this foliage is lost to defoliators, the current year's food production can be reduced considerably.

Generally, late-season defoliation of deciduous trees and shrubs is less important than early-season defoliation because food necessary for growth has been produced and stored. Late-season defoliation of evergreens can be important because of the factors discussed above.

The ultimate effect of defoliation is that it generally weakens the tree, making it much more susceptible to the attack of other insects, especially bark beetles or borers. These beetles usually attack only trees weakened by drought, fire, defoliation, or other causes.

Resistance to defoliation depends on a number of factors, including type and species of tree. Hardwoods are relatively resistant and can successfully withstand three or more years of successive defoliation. Such hardiness is attributable to their ability to store large amounts of food and to replace the destroyed tissue almost immediately. Deciduous conifers such as larch are also relatively resistant, whereas evergreen conifers such as fir and spruce are quite easily killed.

The two most common types of leaf-chewing insects are caterpillars and leaf beetles.

CATERPILLARS

Evergreen bagworm

(*Thyridopteryx ephemeraeformis*)

Description: Larvae are 1 inch to 1⅓ iches long; adults have a 1 inch wingspan. Larva is a light brown worm with a brown head and thorax. Adult female is a soft, wingless, yellowish-white moth with ring of woolly hairs around rear end. Adult male is a densely hairy, black moth.

Life cycle: One generation per year. Overwinters as pale, whitish eggs that hatch in late spring after

trees have leafed out. Young larvae develop and pupate in bags. In the fall, males emerge, fly to the females (still in bags), and mate. Females protrude only their abdomens during mating, then withdraw into the bag, deposit eggs, wriggle out of the bag, drop to ground and die.

Hosts: Shade trees and ornamental shrubs, especially conifers.

Habits: Larvae feed on needles and spin bags, using foliage, and enlarge them as worms develop and pupate. Eggs are laid and overwinter inside bags. Adults don't feed.

Damage: Heavy infestation defoliates and eventually kills tree.

Control: Several species of flies and wasp-like parasites attack worms, but bags protect larvae and eggs from birds.

Douglas-fir tussock moth

(*Orgyia pseudotsugata*)

Description: Larvae are ¾ inch to 1 inch long; adult females are ¾ inch long and wingless; adult males are 1 to 1¼ inches long, with a 1 inch wingspan. Mature larvae are gray or light brown caterpillars with brightly colored toothbrush-like tufts of hair along body; two long brush-like tufts behind shiny black head that suggest horns; similar, longer tuft at rear end; and many red spots and orange stripes along body. Adults are dull, brownish-gray moths; females are wingless.

Life cycle: One generation per year. Overwinter as eggs that hatch in early spring as small, hairy caterpillars (larvae) that migrate (often windblown) before settling to feed on new foliage in June. Larvae mature in August, then pupate. Adults emerge in late August and mate; females lay eggs; adults die.

Hosts: Douglas-fir, Colorado blue spruce, and all true firs.

Habits: During feeding, larvae drop from branch to branch on long silken strands, often blown by wind. Pupate in brownish, spindle-shaped cocoons attached to trunk and larger branches. Eggs are laid on top of old cocoons, covered with frothy, white substance mixed with mother's hair. Eggs are one of the primary identification factors.

Damage: Larvae defoliate tree, beginning at top and continuing downward. If unchecked, defoliation is rapid, and trees die if defoliated two to three years in a row or succumb to attack by bark beetles.

Control: Tachinid fly larvae live and feed inside caterpillars. The small, wasp-like *Trichogramma minutum* feed on the eggs. Epidemics can be controlled by a viral disease introduced into past populations.

Western spruce budworm moth

(*Choristoneura occidentalis*)

Description: Larvae are 1 inch to 1½ inches long; adults are ½ inch long, with a 1 inch wingspan. Mature larva is an olive-brown or reddish-brown caterpillar with ivory-colored splotches and tan or light chestnut-brown head and collar. Adult moths have gray-brown or orange-brown forewings that are somewhat mottled, with a white dot on the margin. Eggs are oval, light green, and about 1.2mm long.

Life cycle: One generation per year. Overwinter as young larvae that begin feeding on needles in the spring, then move to swelling buds. After destroying budding foliage, they move back to feed on old needles. Larvae mature 30 to 40 days after attacking buds, then pupate. Adults emerge in July and early August and mate; females lay eggs and

die. Eggs hatch in about 10 days; larvae don't feed but spin hibernacula for winter shelters.

Hosts: Fir and spruce, occasionally ponderosa and lodgepole pine.

Habits: Larvae feed on buds and needles, overwinter in protective cases in silken hibernacula among lichen or under bark scales, and pupate in either new or existing webs. Each female lays about 150 eggs, in overlapping masses of 25 to 40, on the undersides of needles.

Damage: Larval feeding destroys new-growth buds, which causes stems to fork; tree appears as though singed with crown fire. Heavy infestation may destroy nearly all new needles, buds, and shoots. Young and weakened trees are especially susceptible to defoliation; four to five years of sustained attack kills tree, starting at the top.

Control: About 40 species of wasps and flies are primary parasites of larvae. Predators include spiders, ants, snake flies, true bugs, some beetle larvae, and some birds.

Fall webworm

(*Hyphantria cunea*)

Description: Larva is a pale yellow to brown, sometimes greenish, caterpillar. Has dark strip down back and yellowish stripes down each side of body covered with tufts of long, silky, gray hairs sprouting from blackish-orange tubercles. Adults are winged, satiny-white moths, sometimes with brown or black spots.

Life cycle: Two generations per year. Overwinter as pupae in cocoons on the ground or in bark. Moths emerge during the spring and early summer and lay eggs from May to July. Eggs soon hatch; larvae feed about four weeks, then crawl down the tree and pupate. Adults emerge in late summer and lay eggs for a second generation in the early fall. This generation develops to pupal stage, and then spins cocoons for overwintering.

Hosts: More than 100 species of forest and shade trees.

Habits: Larvae spin lightly woven webs, sometimes covering several branches, that are more unsightly than damaging; they pupate in cocoons on, or just below, soil surface or on bark. Adults don't feed.

Damage: Larvae feed on leaves; heavy infestation can defoliate tree.

Control: Remove webs by hand before moths emerge in spring (first generation) and late summer (second generation). Trimming the affected area is not a viable control method.

Spongy moth

(*Lymantria dispar*)

Previously known as the gypsy moth. Isolated spongy moth infestations have occurred in the West. Spongy moths have been identified in 11 Wyoming counties. Although spongy moths have been eradicated from surrounding states using the Bt virus as a control agent, it's important to understand some basic facts about this serious forest defoliator, its biology, and how to recognize it so that newly developing infestations can be identified.

Historically, the spongy moth was purposely introduced into the United States in 1869 by a French scientist who had hoped to crossbreed this species with the silkworm moth. Escaping larvae became well-established throughout the New England states. Severe tree defoliation now occurs on hundreds of thousands of acres each year. New infestations outside of the New England states are being discovered with alarming frequency.

Long-distance spread has been attributable to human activities, such as moving infested material (trailers, recreational vehicles, etc.) containing egg masses or other life stages.

Spongy moth is a nuisance to people in addition to being a forest pest. Larvae are normally very numerous and interfere with acceptable outside activities such as camping, picnicking, or merely enjoying one's own home grounds. Trees may be killed by two or more years of complete defoliation, but mortality can be variable. Factors such as tree type, age, growing site, amount of defoliation, and environmental conditions will influence the impact on the tree.

Life cycle: The spongy moths undergo complete metamorphosis, maturing from egg to larva to pupa to adult. There is one generation per year. The overwintering eggs are capable of surviving temperatures as low as -22 °F (-30 °C) without the protection of snow; under snow cover, eggs can survive colder temperatures. During April or early May, eggs hatch, and young larvae move to the tops of trees, where they spin down on silken threads, allowing air currents to blow them considerable distances. This is the principal means of natural dissemination. Larvae feed on most hardwood species, but oak, poplar, apple, birch, and willow are preferred hosts.

Newly hatched larvae feed on the leaf bases, then leaf surfaces, where they chew holes in the leaves. The older larvae feed inward from the leaf edges, completely consuming the leaves and leaving only midribs and larger veins.

Larvae are hairy caterpillars about 2 inches long with blue spots on the first five body segments; the last six are brick-red. They mature in late June and pupate. Pupae are normally located on the bark of trees or in a place protected from the weather. Adults emerge about mid-July; both males and females are winged, but only the males can fly. Females, white moths with a buff or yellowish abdomen and a wingspan of 2 inches, lay their eggs near the pupal case from which they emerged.

Males, dark brown moths with a wing expanse of 1½ inches, find females by means of a pheromone (sex lure produced by the female). This scent or odor, which attracts males up to ¾ of a mile, has been chemically duplicated. This chemical, known as disparlure, is used to bait sticky traps to detect new infestations or determine the extent of old ones by trapping males.

Army cutworm

(*Euxoa auxiliaris*)

Description: Adult moths are about 1 inch long and variable in color. They are usually gray or brown with two characteristic light spots on each wing. Larvae have a pale grayish body color that is splotched with variable white or light markings. Full-grown larvae are 1½–2 inches long.

Life cycle: Overwinters as partially grown larvae. Resumes feeding during warm periods in late winter and spring. When full-grown, they burrow shallowly in soil to pupate. Adults (Miller moths) emerge after 3–4 weeks, feed on nectar, and migrate to upper elevations during summer. Eggs are laid at lower elevations in late September and October.

Hosts: Nursery, windbreaks; Conifers and broadleaf plants.

Damage: Larvae feed on leaves and seedling plants in early spring. Damage is limited to seedling nurseries.

Control: Biological controls include tachinid flies, parasitic wasps, and ground beetles. Clean cultivation can reduce adults during egg-laying periods. Microbial, pyrethroid, and

organophosphate insecticides are currently available for control.

Pandora moth
(*Coloradia pandora*)

Description: Adults are gray, thick-bodied moths with a wingspan of 3–5½ inches. Forewings are brownish-gray, hindwings pinkish-gray, with a black dot and dark wavy line on each wing. Larvae are 2½–3 inches long, gray caterpillars with a white stripe down the back. A few stout, branched spines appear on each segment. Larvae are covered with stinging hairs.

Life cycle: Two-year life cycle. Overwinter as young caterpillars on the tree the first year and resume feeding with the return of warm weather. In June or July, mature larvae crawl down tree and pupate in loose soil. Pupation typically lasts for about a year, but occasionally may extend up to four years. Adults emerge the following June or July and mate. Females begin to produce eggs 1–2 days later, laying clusters on needles, bark, and occasionally in ground litter or brush. Eggs hatch in August, and young larvae feed on needles until fall, then overwinter.

Hosts: Forest; Lodgepole pine, ponderosa pine.

Damage: Larvae feed on older foliage. Infested trees have reddish tops with foliage only at branch tips. Heavy damage is not common and usually occurs only where soil is loose enough to allow caterpillars to burrow and pupate. Defoliation occurs in alternate year episodes during outbreaks.

Control: A wilt disease (probably a virus) infects mature larvae. Natural control usually suppresses outbreaks before tree-kill occurs. Stomach poisons as well as contact insecticides are effective.

Western tent caterpillar
(*Malacosoma californicum*)

Description: Adults are variable, generally light brown moths with forewings divided into three bands by two white lines. Wingspan ranges from 1–2 inches. Larvae are light brown, hairy caterpillars with powdery blue markings along the sides and a blue head. Full-grown caterpillars may reach 2 inches in length.

Life cycle: One generation per year. Overwinter as young larvae inside eggs, laid in masses. Larvae emerge in May to feed and begin building tents in branch crotches. The tents serve as bases in which the colony of caterpillars rests, molts, and hides for protection during inclement weather. Larvae mature in 30–40 days, then pupate. Adults emerge and egg laying occurs from mid-July to early August.

Hosts: Forest, nursery, windbreak; Aspen, mountain mahogany, chokecherry, and some other hardwoods.

Damage: Defoliation can be severe, especially if aspen is the host. Infestations reduce growth, and several consecutive years of severe defoliation may kill the tree or make it susceptible to canker fungi. In infestation cycles in early summer, trees are completely defoliated but refoliate in late summer. Tents are often considered unsightly and roving mature caterpillars can be a nuisance.

Control: Controlled by several insecticides, including Bt, when applied from May to June to early instar larvae. Horticultural oils applied to twigs during the dormant season control overwintering eggs.

Cottonwood leaf beetle
(*Chrysomela scripta*)

Description: Adults are light tan, oval beetles marked with black spots, about ½ inch long. Young larvae are nearly completely black and as they get older, they become gray with black dots.

Life cycle: Overwinter as adults, scattered around previously infested trees. After leaves emerge, adults move back to trees and feed on leaves. Eggs are laid and larvae emerge two weeks later. Larvae feed as a group (gregariously) and skeletonize leaves. Full-grown larvae pupate attached to leaves. Adults emerge in early summer and produce a second generation.

Hosts: Nursery, windbreaks; Cottonwood, but other *Populus* species and willow are occasional hosts.

Damage: Larvae chew on new leaves, occasionally causing severe defoliation. Adults feed on tender twigs and skeletonize leaves, but do much less damage than larvae skeletonizing leaves.

Control: Rarely reach levels that seriously retard growth. Larvae are controlled by many insecticides.

Elm leaf beetle
(*Xanthogaleruca luteola*)

Description: Adults are about ¼ inches long, yellowish-tan with two dark stripes down the back. Larvae are up to ½ inches long and yellow with two black stripes down the back.

Life cycle: Two generations per year. Overwinter as adults in protected locations and emerge in late April and early May to feed on expanding leaves and lay eggs. Eggs hatch and the immature larvae feed on the underside of leaves between veins and midribs, giving them a skeletonized appearance. Larvae go through three instars, cease feeding, and pupate. Most pupation takes place at the base of the tree, although some occurs in folds in the bark. Within 1–2 weeks, adults emerge. A second generation occurs in midsummer.

Hosts: Forest, windbreaks; Elm.

Damage: Adults chew small holes in the leaf and larvae skeletonize leaves. Heavily infested leaves die and give trees an unsightly, general brown color. However, plants often recover by putting out new foliage. Elm leaf beetles DO NOT transmit Dutch elm disease.

Control: Contact insecticides are effective when sprayed on foliage after most eggs are laid but before the larvae start to cause significant injury to the leaves. Systemic insecticides can be absorbed by plant roots after soil application or may be injected into the trunk. Some control of elm leaf beetle populations is possible by banding trunks with insecticide.

Pine sawfly
(*Neodiprion* spp.)

Description: Adults are small (¼ – ½ inches), dark, non-stinging wasps. Larvae are medium brown-colored elongate larvae about 0.4 inches long when mature. They have dark brown heads and shields on the thorax and posterior and prolegs are prominent.

Life cycle: Also known as conifer sawflies. One generation per year. Overwinter either as eggs inserted in the needles or as fully grown larvae within cocoons mixed in the litter at the base of previously infested plants. Pupation occurs in late winter or early spring and adults emerge a few weeks later and lay eggs. Larvae emerge and begin to feed on needles in April and early May; other species may have a midsummer peak of feeding.

Larvae feed gregariously, then drop to the soil and pupate.

Hosts: Forest, windbreaks; Pines (particularly pinyon and ponderosa pine) and, rarely, Douglas-fir.

Damage: Larvae feed on old needles and during outbreaks can seriously weaken and slow the growth of infested trees. Damage is most common to small- or medium-sized trees and is particularly severe when other pest insects feed on new growth.

Control: Natural controls include parasitic wasps. Larvae are readily controlled with several contact insecticides applied late April through July, depending on species.

Large aspen tortrix

(*Choristoneura conflictana*)

Description: Adults are dull, light gray moths with a wingspan of 1–1½ inches. Larvae are olive-green to black caterpillars, ½ – ¾ inches long when mature, with a dark head and first body segment.

Life cycle: One generation per year. Overwinters as a second instar larvae, usually in crevices of bark. In spring, larvae feed on developing buds, later moving to newly formed leaves. During feeding, larvae commonly tie together two leaves, feeding and later pupating within the structure. Adult moths appear in late June and July and lay shingle-like egg masses on the leaves. Eggs hatch and larvae move to the tree trunk to overwinter.

Hosts: Forest; Aspen and occasionally other *Populus* species.

Damage: Outbreaks are sporadic and aspen is quite tolerant of defoliation.

Control: Apply insecticides to early instar larvae in May.

LEAF AND NEEDLEMINERS

Leafminers and needleminers feed inside leaves or needles, producing tunneling injuries. Several diverse groups of insects with chewing mouthparts, including larvae of moths (Order: Lepidoptera), beetles (Order: Coleoptera), sawflies (Order: Hymenoptera), and flies (Order: Diptera), develop by feeding between the surfaces of leaves and needles. Many of these insects feed for their entire larval period within the leaf mine and many even pupate within the plant tissues. Their tunnels may be straight, twisted, or blotchy.

Aspen leafminer

(*Phyllocnistis populiella*)

Description: Adults are tiny moths with wingspan of about ¼ inches, with narrow lance-like wings mottled white and brown. Larvae are tiny, slightly flattened caterpillars, about ¼ inches long when mature.

Life cycle: One generation per year. Overwinters as an adult moth. Pupate within the leaves and adults appear in late summer.

Hosts: Nursery, forest; Aspen.

Damage: Winding, serpentine, silver leaf mines appear in spring and summer. Infestations are rarely serious enough to cause tree damage

Control: Controls have not been developed.

Ponderosa needleminer

(*Coleotechnites ponderosae*)

Description: Adults are small, fragile, dark gray moths with a wingspan of ½ inches. Larvae are slender caterpillars about ½ inches long when mature.

Life cycle: Adults emerge in late summer to mate and lay eggs, usually inside old, previously mined needles. Eggs hatch and the tiny larvae move to green needles, bore in near the tip, and begin mining. Larvae complete their development in a single needle, pupating in midsummer.

Hosts: Forest; Ponderosa pine

Damage: Larvae bore into needles, often causing the needle tips to die back and turn brown. Outbreaks periodically occur in forested areas.

Control: Apply insecticides at egg hatch in September. Apply systemics from April to June.

BORING INSECTS

Some beetle and moth species larvae attack trees by chewing into the wood of branches or main trunks. These pests are commonly called "borers", and they may attack conifers as well as deciduous trees and shrubs.

Among the most damaging are moths from the Tortricidae; Pyralidae families. The metallic wood borers or flatheaded borers (Family: Buprestidae), and the longhorned beetles or roundheaded borers (Family: Cerambycidae). It is important to identify the borer pest species you are trying to control as there may only be a short period of time in their lifecycle when they can be treated effectively.

A few species of borers feed actively in sapwood; others may tunnel into heartwood. Once in the heartwood, the pests are out of reach for insecticide treatment. A few species of borers will attack healthy trees, but most attack trees already weakened or injured from such things as drought, mechanical injury, improper root systems, transplant shock, and sun scald.

Borer damage produces either girdling wounds in the cambium or weakened trees through their tunneling. Sawdust, and wood chips produced as the insects chew into the bark, and or pitch produced by the tree in response to the injuries may be found on or below the tree.

Borer control on a large scale in forest situations is not practical. Insecticides to control may be used effectively in windbreaks and Christmas tree plantings to kill newly emerged larvae. Preventative treatments, where it can be practiced in ornamental landscapes and parks works better than than control measures after trees are infested. Keep landscapes healthy by:

- Keep trees adequately watered.
- Don't crowd root systems with concrete walks, driveways, or patios.
- Wrap trunks of young trees during the winter to prevent sun scald.
- Keep dead branches pruned out.

The following are examples Lepidoptera (moths) and Coleoptera (beetles) pests that bore into woody plants are provided to illustrate the critical times in these tree pest's life cycles when they are vulnerable to control measures.

WOOD BORERS - MOTHS

Pinyon pitch mass borer
(*Dioryctria ponderosae*)

Description: Adults are gray-brown snout moths with white zigzag markings, approximately ½-¾ inches long. Larvae are creamy or pale pink caterpillars with a dark head.

Life cycle: Require over 1 year to complete development. Adult moths are active and lay eggs from late June through August. Larvae tunnel under the bark and feed during the warmer months, undergoing 4 molts before pupating.

Hosts: Forest; Pinyon, ponderosa pine.

Damage: Larvae tunnel into the cambial area causing large gouges that ooze a light pinkish pitch. Damage occurs on trunks and large branches. Wounding disfigures and weakens trees. Heavily infested branches may break.

Control: Preventive trunk sprays applied at egg hatch, from April to August, can reduce new attacks. Repeat applications to reduce infestations.

Zimmerman pine moth

(*Diorytria zimmermani*)

Description: Larvae are generally dirty white caterpillars, occasionally with some pink or green. Adults are mid-sized moths, with gray wings blended with red-brown and marked with zigzag lines.

Life cycle: One-year life cycle. Overwinter as young caterpillars inside small cocoons underneath bark scales. Become active in late April and May and tunnel into the tree. In late spring, they migrate to the base of branches, tunneling into the whorl area. Once full-grown, they pupate within a chamber in the pitch mass at the wound site. Adult moths mate and lay eggs in late July and August. Eggs hatch and larvae feed for only a brief time before preparing to overwinter.

Hosts: Forest, nursery, windbreaks; Pines, particularly Scots and Austrian pines.

Damage: Dead and dying branches, most often in the upper half of the tree, commonly indicate infestations. First external symptoms of injury are popcorn-like pitch masses at wound sites. Pitch masses may reach golf-ball size and ultimately resemble clusters of small, pale grapes.

Control: Apply drenching trunk sprays that penetrate the bark scales around mid-April or in August to kill active, exposed larvae before they enter tree trunks.

WOOD BORERS – BEETLES

This order of insects contains a large number of injurious species. Adult beetles are easily recognized because the insect body is hard and smooth, and the wing covers meet in a straight line down the middle of the back.

The adults of the flatheaded wood borers (Buprestidae) generally are brightly metallic-colored, boat-shaped, and 1/3 to 1 inch long. Adults are commonly called metallic wood-boring beetles because of their color. The adults of the roundedheaded borers are commonly called longhorned beetles due to most pest species adults having antennae as long or longer than their body.

Both families of beetle borers are frequently destructive to newly transplanted trees. Visible signs of borer activity: A sawdust-like material at the base of the tree comes from the tunnel made by the borer. If sawdust is present, further examine the tree for small punctures in the branches and trunk. Generally there will be a discharge of sap from the tunnel opening that wets and discolors the bark below it.

Note: *Don't confuse bird damage with insect damage*

Certain birds known as sapsuckers cause damage that is often attributed to wood-boring insects. Holes in the bark made by sapsucker birds are

typically in a vertical column with the lowest hole in the bark accumulating the sap flow for feeding.

Flathead apple tree borer
(*Chrysobothris femorata*)

Description: Adults are dark olive-gray to brown, boat-shaped, and ½ inches long. Adults are commonly called metallic wood-boring beetles because their wing covers have a metallic luster. Larvae are yellowish-white, legless grubs with a broad, flat enlargement just behind the head. Mature larvae are up to 1 inch long.

Life cycle: One generation per year. Overwinter in larval (flathead borer) stage, under the bark. Larvae feed during late winter and early spring, then bore into the trunk and pupate. Adults (metallic wood borers) emerge from mid-May to August. Adults feed on leaves and mated females lay eggs in cracks and crevices of large branches or trunks. Larvae emerge by chewing through the bottom of the egg and tunneling directly into the tree.

Hosts: Forest, nursery; Almost all broad-leaved fruit, forest, and shade trees.

Damage: Borers tunnel under the bark of trunks and larger branches. Attacks are concentrated around wounds, cankered areas, and on trees in generally poor health. Damage is first concentrated on the sun-exposed sides of the tree, but later can expand.

Visible signs of borer activity: A sawdust-like material at the base of the tree comes from the tunnel made by the borer. If sawdust is present, further examine the tree for small punctures in the branches and trunk. Generally there is a discharge of sap from the tunnel opening that wets and discolors the bark below it.

Control: Maintain trees in a healthy, vigorous condition and prevent injuries. Keep dying trees and newly cut wood away from susceptible trees. Preventive use of insecticides, applied to trunks and branches before egg laying has sometimes provided good control, although performance has been erratic in some reports.

Poplar borer
(*Saperda calcarata*)

Hosts: Forest; Primarily aspen, but cottonwood, poplar, and willow are also hosts.

Description: Adults are gray beetles with a central yellow stripe on the thorax and fine yellow and black stippling on the wing covers. They are about 1¼ inches long. Larvae are large, yellowish, roundheaded grubs, about 1½ inches long when mature, and found only within their tunnels.

Life cycle: Extended life cycle that likely requires three years to complete; shorter life cycle may occur in warmer areas of Wyoming. Adults present from mid-June through early fall, and feed on bark of young twigs. After mating, females chew pits in the bark and insert eggs. During the first year, young larvae overwinter under the bark. In spring, larvae enter the sapwood and heartwood where they feed for two years, producing large, black, swollen scars on trunks and limbs. After the larval stage is complete, they form a chamber under the bark, where they pupate and overwinter.

Damage: Interior limbs and trunks can become "honey-combed" with galleries produced by the larvae. A black varnish-like stain commonly forms on the bark below points of borer attack and the larvae push out stringy sawdust as they feed. Branches and trunks may break off in high winds and trees may be invaded by wood rot. Wound sites also develop rough growths on the bark.

Control: Manage for high vigor. Apply preventive insecticides prior to late April.

TIP MOTHS, TWIG, AND TERMINAL BORERS

Several species of insects attack terminal growth of woody plants, usually causing dieback of terminal growth. Most common are the larvae of various moths and white pine weevils.

Pine tip moth

(*Rhyacionia neomexicana, R. bushnelli*)

Description: Adults are small moths with mottled reddish patterns on their forewings and light-tan colored hindwings. Larvae are reddish-orange to yellow caterpillars, about ½ inches long when mature.

Life cycle: Adults emerge and lay eggs on buds and new shoots of young pines up to 15 feet tall in April and May. Eggs hatch and larvae bore into developing shoots, feed, and grow within shoots. Full-grown caterpillars leave the shoots, crawl down the trunk, and pupate on the side of the trunk, just below the soil line.

Hosts: Forest, windbreaks; Ponderosa, mugho, and Scotch pines.

Damage: Feed on and destroy new growth. Injury often is quite conspicuous. Although little real injury to the health of the infested tree results from attacks, tree growth can be delayed and the form altered to a bushier appearance.

Control: Natural controls include parasitic wasps. Apply insecticides when new shoots are elongating but before the needles are more than ½ inch long. For most pines, this typically occurs from late April through early May.

Cottonwood twig borer

(*Gypsonoma haimbachiana*)

Description: Adult moths are small, grayish-tan tortricids with mottled forewings marked by darker bands and a wingspan of about ⅓ – ½ inches. Larvae are cream-colored with a brown head capsule and reach about ½ inches in length when mature.

Life cycle: : One generation per year. Adult moths emerge and lay eggs in late spring to early summer, typically in May or June. Larvae bore into young twigs and terminals where they feed and develop through several instars. Pupation occurs within the feeding galleries. Overwintering is primarily in the pupal stage inside damaged twigs.

Hosts: Landscape and riparian; Eastern cottonwood, plains cottonwood, hybrid poplars.

Damage: Larvae bore into succulent twigs and shoot tips, causing dieback and flagging of terminals. Infested shoots may wilt, bend, or break. This damage can lead to reduced growth, deformed branching, and increased susceptibility to secondary pests or diseases.

Control: Prune and destroy infested twigs during winter dormancy to reduce overwintering populations. Preventive insecticide applications targeting newly hatched larvae in late spring (around leaf expansion) may limit infestations in high-value trees. Monitor for early signs of shoot wilting.

White pine weevil
(*Pissodes strobi*)

Description: Adults are brown, about ¼ inches long, and covered with white and tan scales, arranged in large and small spots. Larvae are white, legless, grub-like, and approximately ⅓ inches long when fully grown.

Life cycle: One generation per year. Adults emerge in late summer or fall and overwinter in the ground. In the spring, female weevils lay eggs in feeding punctures on previous year's growth. Larvae emerge in 7–10 days and tunnel downward between the bark and wood of shoots. During August, larvae pupate in cocoons under the bark.

Hosts: Forest; Colorado blue spruce.

Damage: Weevil attacks cause four types of damage: growth reduction, stem deformation, increased susceptibility to wood decay organisms, and tree death. Tree death is rare and only occurs in small trees growing very vigorously in full sunlight. Stem deformation is common, resulting in the reduction of wood quality.

Control: Prune infested terminals and branches before adults emerge. Chemical application combined with pruning gives the best results. Insecticides are effective only against adult weevils. Time applications with egg hatch, in late April.

Lodgepole terminal weevil
(*Pissodes terminalis*)

Description: Larvae are ⅕ inch; adults are ¼ inch. The adults are a red-brown color.

Life cycle: One generation per year.

Hosts: This is a common insect in lodgepole pine stands.

Habits: Small larvae mine and pupate in the cambium layer of open-grown trees. Mature larvae mine and pupate in the pith of terminal shoots.

Damage: The developing terminals are attacked and killed, down to the uppermost whorl of branches.

BARK BEETLES

Bark beetles are tiny insects that attack trees by tunneling under the bark and into the cambium area of trees. Some of these beetles will attack trees in sound condition, but many attack trees that are weakened or dying. Some of the bark beetles aid in the transmission of certain fungus diseases, hastening the death of trees. Both coniferous and deciduous trees may be affected by bark beetles.

Bark beetles are so named because most of them live and mine between the bark and wood of trees and shrubs. Host trees attacked and life cycles vary by beetle.

Description: Adults are small, cylindrical beetles reddish to dark brown or black and from 1/16 to ¼ inch long. The larvae are grub-like, thick-bodied, legless, and generally broadly C-shaped. They are white- or cream-colored, and have a distinct head.

Life cycle: Adult egg-laying habits and life cycles vary extensively with the different species.

Habits: Adult beetles make tunnels between the bark and wood, in which they lay their eggs. After the eggs hatch, the larvae mine the area, making mines that radiate out from the egg tunnels. Larval tunnels are always packed with their feces. Extensive tunneling of this kind can girdle and thus

kill trees and shrubs. When adults bore out through the bark, they leave the surface as though riddled by buckshot. Don't confuse these bark-beetle exit holes with sapsucker damage.

Control: Some chemical insecticides can be applied to the host tree prior to bark-beetle attack to kill bark beetles as they attempt to bore into the tree. Insecticides vary depending on which beetle is present.

Ips beetle

(*Ips* spp.)

Description: Adults, also known as engraver beetles, are ⅛ – ¼ inches long and reddish-brown to black in color. They have a pronounced cavity at the rear end, which is lined with 3–6 pairs of toothlike spines. Larvae are small legless grubs, white to dirty gray in color with dark heads, and about ¼ inches long when mature.

Life cycle: Two to five generations may develop per year. They overwinter as adults and bore into the bark and construct "Y" or "H"-shaped egg galleries. Eggs are laid along the gallery and young larvae hatch and begin tunneling small lateral galleries that lightly etch the sapwood. Attacks are made by these bark beetles after the arrival of warm weather in the spring.

Hosts: Forest, nursery; Pines and spruce, very rarely Douglas-fir.

Habits: Adult beetles bore into cambium, where they excavate egg galleries. This group of beetles normally attacks only recently felled trees or those in a weakened condition. Outbreaks in standing and healthy trees are just sporadic.

Damage: Ips beetles attack weakened trees of all sizes, including recent transplants; tops and limbs of mature trees already attacked by other bark beetles; trees injured by construction or topped during powerline clearing; drought-stressed trees; or overwatered trees. This group of beetles has egg galleries free of boring dust. The first evidence of attack by Ips beetles is yellowish or reddish boring dust in bark crevices around the base of trees. They transmit bluestain fungi, which grows within the tree and may weaken or kill the tree. The fungi give a blue-gray appearance to the sapwood. Weakened trees attacked by Ips beetles may be destroyed.

Control: Remove freshly cut material that results from pruning or thinning practices (slash) from the vicinity of valuable trees. Pines and spruce that are under stress and/or are high value can be sprayed with insecticide to help prevent attack. Sprays need to be applied before the spring flight of the beetle and occasionally during the summer to prevent summer flights from attacking the tree.

Mountain pine beetle

(*Dendroctonus ponderosae*)

Description: Adults are cylindrical, stout-bodied beetles, brown to black in color, and 1/6 - ¼ inches long. Mountain pine beetles can be distinguished from other bark beetles by their gradually curved hindwing cover. Larvae are ¼ inch long. Mature larva is a yellowish-white, legless grub with dark head. Eggs are pearly white.

Life cycle: They have a one-year life cycle and overwinter as larvae under the bark of living trees. Larvae feed in the spring and transform into pupae in June and July. Most adults emerge and exit trees during late July (lodgepole pine) and mid-August (ponderosa pine); some stragglers emerge as late as September. They fly to other trees, bore in, and the females lay eggs under the bark. Coordinated mass attacks are common. Each beetle pair mates, forms a vertical tunnel (egg gallery) under the bark, and produces about 75 eggs. Following egg hatch, larvae tunnel away from the egg gallery, producing a characteristic feeding pattern.

Hosts: Forest; Ponderosa, lodgepole, and limber pines.

Habits: Adult beetles bore through the bark to the cambium, where they excavate egg galleries. Eggs are laid individually along each side of the gallery. Larvae feed on the winter bark and mature inside galleries. Adults migrate to other trees to begin new generation.

Damage: Popcorn-shaped masses of resin, called pitch tubes, are found on the trunk where beetle tunneling begins. Attacks may extend from near ground level to treetop. During early stages of an outbreak, attacks are usually limited to trees under stress. Infested trees usually die, but weakened trees are most susceptible to attack; saplings are usually spared. Direction and spread rate of infestations are impossible to predict. However, attacked trees usually are next to or near previously killed trees. Adults transmit bluestain fungi.

Control: Once infested, nothing practical can be done to save the tree. Natural controls include woodpeckers and insects such as clerid beetles that feed on adults and larvae under the bark. Beetle larvae in cut trees can be killed by solarizing the wood by wrapping it in clear plastic sealed around the edges with soil, by burning, or by debarking. Certain formulations of carbaryl, bifenthrin, and permethrin may be used to prevent attacks on individual high-value trees. Apply preventive sprays to living green trees before mid-July to repel or kill attacking beetles.

Douglas-fir beetle

(*Dendroctonus pseudotsugae*)

Description: Adult beetles are about ¼ inch long and resemble mountain pine beetle. Some are all black, while others have a black head and thorax with reddish-brown wing covers. Larvae are white grubs with brown heads.

Life cycle: One generation per year. Overwinters as large larvae or adults under the bark. Adults emerge from April through July. Attacking beetles bore under the bark, mate, and lay eggs in small groups along a vertically oriented gallery. Larvae feed outward in the inner bark area, killing the tree.

Hosts: Forest, downed timber; Douglas-fir.

Damage: The needles of infested trees turn red a few to several months after initial attack. Gallery construction and feeding on the inner bark of trunks usually kills host trees. Large groups of Douglas-fir may be killed during multi-year outbreaks.

Control: Controls are generally similar to mountain pine beetle. However, since adults can emerge earlier, developing beetles must be destroyed and preventive sprays applied by late April. Population buildup may be prevented by quick removal of downed timber (which attracts beetles). Beetle larvae in cut trees can be killed by solarizing the wood by wrapping it in clear plastic sealed around the edges with soil, by burning, or by debarking.

Fir engraver beetle

(*Scolytus ventralis*)

Description: Adults are ⅕ inch long, shiny black; males have a long tubercle on underside of abdomen tip.

Life cycle: One generation per year, two years required in northern parts of region. Flights occur any time during late spring to early fall. Some or all of the trunk may be colonized.

Hosts: Forest; True firs.

Damage: Attacks many pole-sized and mature trees, resulting in tree death, top-kill, or patches of dead cambium. Stressed trees with trunk diameters over 6 inches are preferred. Attacks may or may not kill the host. A brown-staining fungus is introduced into infested trees. Pattern and scoring of wood separates it from other bark beetles attacking fir.

Control: Beetle larvae in cut trees can be killed by solarizing the wood by wrapping it in clear plastic sealed around the edges with soil, by burning, or by debarking.

Spruce beetle
(*Dendroctonus rufipennis*)

Description: Adult beetles are dark brown to black with reddish-brown or black wing covers. They are cylindrical and ¼ inch long. Larvae are cream-colored, stout, legless grubs that pass through four instars and reach ¼ inch at maturity.

Life cycle: Typically has two-year life cycle. Adults emerge from May to October and attack spruce. Eggs are laid in egg galleries in phloem tissue. Eggs hatch and larvae bore outward and feed on bark. Most larvae pupate approximately one year after attack. During the second winter, adults overwinter near base of tree. Approximately two years after attack, adults emerge and attack new trees.

Hosts: Forest, downed timber; Spruce.

Damage: Attack lower surfaces of windthrown and downed trees and spreads to standing spruce. Attack all or one side of standing trees. Outbreaks cause extensive tree mortality and modify stand structure by reducing average tree diameter, height, and stand density.

Control: Population buildup may be prevented by quick removal of downed timber (which attracts beetles). Beetle larvae in cut trees can be killed by solarizing the wood by wrapping it in clear plastic sealed around the edges with soil, by burning, or by debarking. Use aggregating pheromones with trap trees to attract beetles into trees to be cut or discourage infestation of high-value trees. Apply insecticides, such as carbaryl and pyrethroids, to uninfested trees to kill attacking adults.

Western balsam bark beetle
(*Dryocoetes confusus*)

Description: Adults are ¼ inch, dark brown, and inconspicuously covered with sparse hairs.

Life cycle: Biology is poorly understood; life cycle may require 1–2 years. Adults overwinter in egg galleries. Peak adult flight and attacks occur in midsummer. Once under the bark, adults construct egg galleries. Egg-laying is split between fall and spring.

Hosts: Forest, downed timber; True firs, including subalpine, corkbark, and white.

Damage: Capable of causing widespread tree mortality in high-elevation forests. During epidemics, large areas of subalpine fir turn deep red.

Control: Population buildup may be prevented by quick removal of downed timber (which attracts beetles). Beetle larvae in cut trees can be killed by solarizing the wood by wrapping it in clear plastic sealed around the edges with soil, by burning, or by debarking.

Western cedar bark beetle
(*Phloeosinus* spp.)

Description: Adults are ⅛ inch long, reddish-brown to black shiny beetles. Wing covers are marked by rows of small puncture marks. Larvae are small, white grubs, found within their tunnels.

Life cycle: Life cycle is little known in the Rocky Mountain region. Probably one generation per year. Overwinters as larvae found under the bark. Adults emerge in late spring or early summer and feed on twigs. Pairs of beetles excavate brood chamber. Larvae feed perpendicular to the central egg gallery and girdle the branch.

Hosts: Forest; Junipers including Eastern redcedar.

Damage: Trees or branches subject to attack are almost always dead, dying, or severely stressed. Adults feed on and may girdle small twigs, typically several inches back from the tip. Larvae feed under the bark and kill the infested branch. Attacks result in flagging of foliage on the affected part of the tree.

Control: Silvicultural practices that improve vigor can usually eliminate most threat of future attacks. Infested branches should be removed when flagging is observed, to remove developing larvae. Standard bark beetle treatments applied to maintain coverage during the period of adult activity (June, July) should be effective. Beetle larvae in cut trees can be killed by solarizing the wood by wrapping it in clear plastic sealed around the edges with soil, by burning, or by debarking.

SUCKING PIERCING INSECTS

Aphids (leaf curl producers)

Ash leaf curl aphid

(*Prociphilus fraxinifolii*)

Identification: The aphids are pear shaped, ⅛ inch long or less, and cover themselves with white wax. Their body is pale green or yellowish and has no distinct cornicles, a pair of tubelike projections near the hind end of the body that distinguishes most aphid species from other insects.

Several Prociphilus spp. aphids are reported on ash and they can be difficult to distinguish. The same species of aphid may look different depending on the host plant, season, and the part of the plant it is feeding on.

Life cycle: Ash leafcurl aphids overwinter as eggs on bark and nymphs on roots. The aphids can be abundant on leaves from spring through fall. Throughout most of the growing season, adult females (which may be winged or wingless) give birth to live young without mating. In the fall, a sexual generation of winged males and females is produced and the aphids mate and disperse. They have several generations per year.

Hosts: All Ash species

Damage: Aphid-infested ash leaves curl, distort, and drop prematurely. The aphids excrete copious honeydew and flocculent waxy material, making a mess beneath trees and promoting the growth of dark sooty mold. Abundant winged aphids can be a nuisance when they migrate between bark, foliage, or roots, especially in the fall.

Control: Certain ash species and cultivars appear to be less susceptible to ash leafcurl aphid, but there are no research-based recommendations that identify resistant ash. The aphids apparently do not harm trees in landscapes, but their root feeding can damage small plants in nurseries.

Generally, no control is needed in landscapes to protect the survival of otherwise healthy trees. Where intolerable, they are difficult to manage without using systemic insecticide.

Honeysuckle witches' broom aphid
(*Hyadaphis tartaricae*)

Description: Aphids are small insects, typically less than ⅛ inch. Colors range from bright orange or red to dull gray, and some may have patterning.

Life cycle: Alternate between a woody perennial winter host and summer hosts. Eggs, usually deposited near buds of the winter host, hatch shortly after bud break and the emergent "stem mother" begins to produce young. Several generations may be completed on the plant. By early summer, most leave the host plant for an alternate summer host. Later generations return to the winter host to lay eggs. Honeysuckle witches' broom aphid develops only on honeysuckle.

Hosts: Nursery, windbreaks; Ash, honeysuckle.

Damage: Feed on emergent foliage, inducing leaf curls that greatly deform the new growth. Heavily infested foliage often dies by midsummer.

Control: Biological controls, including syrphid fly larvae and various parasitic wasps can provide good control. Dormant season applications of horticultural oils can kill overwintering eggs and prevent early season leafcurling. After leaves have begun to curl, only insecticides with systemic activity are effective.

Aphids (exposed on plant)

Giant conifer aphid
(*Cinara* spp.)

Description: Aphids are small insects, typically less than ⅛ inch. Colors range from bright orange or red to dull gray, and some may have patterning.

Life cycle: Overwinter as eggs attached near the bud of a perennial plant. Eggs hatch in spring and aphids immediately begin to feed. Adult forms may be winged or remain wingless. Females give live birth throughout the growing season. Life cycles vary with some remaining on the overwintering plant throughout the season and others migrating to various herbaceous summer host plants. The latter return to the perennial host in fall.

Hosts: Nursery, forest; Conifers.

Damage: Suck sap from leaves, stems, and flower buds. Under extreme infestations, premature leaf drop or some dieback may result. Problems in nurseries result from excreted honeydew, which is sticky, detracts from plant appearance, and is attractive to wasps and bees. Plants are often covered by a sooty mold that grows in the honeydew and gives the plant a blackish appearance.

Control: General aphid predators as well as parasitic wasps commonly feed on aphids. Exposed aphids can be controlled by many nursery insecticides.

Spider mites

Spider mites, tiny creatures with eight legs instead of six, are close relatives of insects. Their mouthparts consist of tiny, needle-like stylets that pierce leaf cells, causing a fine stippling or flecking on leaves and needles. These tiny pests vary from 0.25 to 1 mm in size and attack evergreens and deciduous trees and shrubs. They are often difficult to see with the unaided eye.

In heavy infestations, the foliage becomes yellowed or bronzed, sometimes resulting in lost leaves or needles. All spider mites spin some webbing on affected plant parts; this webbing serves as protection for mites feeding beneath. Presence of dust on foliage seems to encourage mite infestations.

The mites go through a six-legged larval stage, then through two nymphal stages before becoming adults. Males tend to be smaller in size and somewhat more slender in body. Many generations are produced during warm summer months.

Chemical control generally involves pesticides that are specifically developed for spider mite control. Most insecticides are ineffective for spider mites and many even aggravate problems. Horticultural oils can be effective spider mite treatments.

Spruce spider mite

(*Oligonychus ununguis*)

Description: Mites are small, 1 mm, dark green or dark red depending on the season. Newly hatched mites are light salmon to pale red with a single dark area on the abdomen.

Life cycle: Multiple generations occur. Overwinter in the egg stage, attached near the base of needles. Eggs hatch in midspring and the newly emerged nymphs feed on older growth. All stages feed on the sap of needles. Development can be completed in about two weeks.

Hosts: Forest, nursery, windbreaks; Most conifers, but injury is particularly common on spruce and junipers.

Damage: Tiny light-colored flecks are produced at feeding sites on needles. Infested trees become grayish and may prematurely defoliate. During heavy infestations, a fine netting of silk at the base of needles may be produced.

Control: Natural controls, including minute pirate bugs, predatory plant bugs, spiders, and various predatory mites, are important in keeping populations low. Apply miticides to control all stages from mid-late summer or dormant oils in October or from March to April.

Twospotted spider mite

(*Tetranychus urticae*)

Description: Generally straw-colored with a pair of dark blotches in the middle of the body that run along the outside. Orangish forms indicate the mites are in a semi-dormant condition.

Life cycle: Multiple generations occur. Under favorable conditions, each generation is completed in as little as 10 days. Overwinter as adult females hidden in protected areas. Late in the season, mites change to non-feeding stage and migrate to sheltered areas.

Hosts: Nursery, windbreaks; Rose, viburnum, euonymus, dogwood, and many other plants; Widest host range of any spider mite in the world.

Damage: Pierces plant cells and feeds on the sap, causing small white flecking injuries. Discoloration, typically bronzed-colored, occurs as infestations progress. Vigor of plants may be seriously reduced. Premature leaf drop occurs on heavily infested plants. Produce more webbing than other mites commonly found on shade trees and shrubs.

Control: Natural controls include minute pirate bugs and predatory mites. Difficult to control with chemicals. High levels of resistance have developed in many populations.

Scales

Scales are small, usually dark-colored, motionless insects that are often difficult to spot. Scales can be divided into two groups: armored scales and soft (unarmored) scales.

Armored scales are the most common and are found on trees and shrubs. These scales secrete a hard, waxy covering (armor) over their bodies,

which may be circular, oblong, or pear shaped. Armored scales vary from 1/7 – 1/2 inches in size.

Soft scales resemble aphids. The waxy secretion of soft scales is part of the scale's body rather than an external coating. These scales may be flattened, lightly convex, or hemispherical and vary from 1/13 – 1/2 inches in length. Most species produce honeydew.

The scale insects most commonly found in Wyoming overwinter either as eggs or immatures. In most species, the female deposits eggs under her shell or scale. The young, mobile stage of some species (crawlers) feed on leaves during the summer, then move to twigs in the fall. When the crawlers settle and begin to feed, the characteristic soft or armored scale covering is developed.

Most species of trees and shrubs are subject to attack by scale insects. Scale insects feed by sucking sap from trees and shrubs and are capable of killing the entire plant or parts of the plant. Infested plants appear unhealthy, grow poorly, and have stunted and yellowed foliage. Infestations often appear as gray or brownish encrustations on the bark of twigs and branches. Plants are often covered by a sooty mold that grows in the honeydew secreted by the scale insects and gives the plant a blackish appearance.

Scale feeding can reduce the plant's vigor, which makes the infested plant more susceptible to injury caused by drought, severe winters, attack by other insects (especially borers), or infection by diseases.

A thorough application of a superior dormant oil according to label instruction just prior to "bud break" will effectively control most of the common soft and armored scales. It can be applied to most evergreen and broadleaf woody plants. Bud break varies with the species of plant and the severity of the spring season, but superior dormant-oil sprays usually should not be applied after early April in the West. Dormant-oil sprays kill scale insects by suffocation.

Insecticides applied thoroughly according to label instructions are effective in controlling the most common soft and armored scales. However, since these sprays won't penetrate the waxy scale covering, spraying must be timed to coincide with the presence of the crawlers. Timing of the presence of the crawler stage varies with the species.

Oystershell scale

(*Lepidosaphes ulmi*)

Description: Newly hatched crawlers are pale and smaller than a pinhead. Adults are about 1/8 inch long, brown or gray, slightly banded, and the general shape of an oyster shell.

Life cycle: In most areas, there is only one generation per year. Where two generations exist, second generation egg hatch occurs in July and August. Overwinters in the egg stage. Eggs are underneath the old scale covering of the mother scale. Eggs hatch and crawlers find a suitable location to feed and attach themselves to the bark of twigs and branches. They molt and are soon covered with a waxy, protective scale and are immobile.

Hosts: Windbreaks; Aspen, ash, cotoneaster, willow, and lilac are among the most commonly damaged plants.

Damage: Feed on the plant by sucking out plant sap and can weaken and even kill the plant when infestations are abundant. Makes many plants susceptible to infection by cytospora fungi.

Control: Where very heavy infestations exist, consider pruning. Highly refined summer or superior oils may be used safely on most trees for crawler control.

Pine needle scale
(*Chionaspis pinifoliae*)

Description: Crawlers are minute, rosy-purple, and somewhat resemble tiny aphids. Adults are about ⅛ inch long, white to grayish-white, and always found attached to the needles of evergreens.

Life cycle: At higher elevations, produces only one generation per year. However, at lower elevations a second generation is common in mid- to late summer. Overwinter in the egg stage beneath the body of the mother scale. Some mother scales survive the winter and continue laying eggs into the spring. Eggs hatch and crawlers move around for hours to days before inserting their mouthparts into the needles. Scales molt and produce a golden brown protective waxy covering. Female scales remain stationary throughout the rest of their lives and male scales feed for a period of a few weeks and emerge as winged adults.

Hosts: Windbreaks; Pine, spruce, and fir. Serious damage is most common on mugho pine.

Damage: Feed on needles. During outbreaks, needles may be nearly covered with the bodies of the scales, giving an appearance that the plant is spattered with a white paint. Heavily infested needles drop prematurely, and sustained outbreaks cause dieback of the plants.

Control: Natural controls include lady beetles and parasitic wasps. Dormant oils are recommended for pines. Summer oil applications can kill young, settled scales, as well as crawlers and eggs. Crawler sprays are very effective. On many plants, infestations are localized and can be controlled with spot sprays.

Pinyon needle scale
(*Matsucoccus acalyptus*)

Description: Adult males are winged, fly-like, and rarely seen. Adult females are black, armored, mobile scales, about 1/15 inch long. Nymphs (crawlers) are minute, mobile, and dark colored. Second instar nymphs are legless and remain attached to needles.

Life cycle: One generation per year. Overwinters as a second instar nymph. Molt to mobile adult form and mate in early April. Eggs are laid in masses and are covered by a white cottony wax. Newly hatched nymphs settle on the previous year needles. Second stage is formed in late summer.

Hosts: Forest; Pinyon.

Damage: Feeding by adult females and nymphs causes needles to turn yellow and prematurely fall. Most defoliation occurs on older needles, producing a tufted appearance with younger needles primarily persisting on infested trees. Repeated yearly attacks can kill young trees and weaken large trees, which then become susceptible to bark beetle attacks.

Control: Apply drenching trunk sprays of dimethoate in early spring before egg laying. Sprays used against other scale insects should also be effective.

GALL-MAKERS

Galls are abnormal plant growths induced by the action of fungi, bacteria, insects, mites, and other organisms. Galls resulting from activity of insects and mites typically develop around the gall-maker to house, protect, and provide a steady food source for the organism within the gall.

All gall-making insects and mites create galls unique for the specie,s and they are almost invariably restricted to a single plant species. Galls may have many forms. Most insect galls are fairly simple and are the result of stunting and/or thickening of leaf tissues. These are sometimes referred to as indeterminate galls. Other insects and some mites cause very abnormal plant growth, radically different in structure from the original tissues, called determinate galls.

Galls can cause problems for trees when they seriously interfere with transport of food and water. However, little, if any, significant injury to the plant results from most galls. Abnormal growths often attract attention and concern.

Since only actively growing tissues are susceptible to gall-making, most galls are produced solely during the rapid growth period of late spring. Once galls are initiated, their formation is irreversible. Although galls are often conspicuous and may be unattractive, rarely does any real plant damage occur. Under most circumstances control of galls is not recommended.

A few gall-making insects and mites overwinter on the trees and may be controlled by dormant oil applications. However, most galls can only be controlled by insecticides that cover the leaves during the egg-laying period. Because the quality of the insecticide coverage diminishes as leaves expand, repeat applications are often necessary.

Honeylocust podgall midge

(*Dasineura gleditschiae*)

Description: Larvae are cream-colored maggots. Adults are tiny, delicate gray-brown flies.

Life cycle: Multiple generations per year. Overwinter as adults in soil. Adults emerge and lay eggs. Eggs hatch and larvae feed on leaflets, forming pod galls. Inside each pod gall, 2–8 larvae or pupae may be found. After the adult midges emerge, the galls drop, leaving bare leaf stalks.

Hosts: Nursery, windbreaks; Honeylocust.

Damage: Infested leaflets curl and thicken, forming small pod galls instead of expanding normally. Leaflets that have already expanded are not injured by the honeylocust podgall midge. Infestations can be severe enough to temporarily destroy all new growth.

Control: Natural controls include severe weather and a small parasitic wasp. Applications of insecticides during egg-laying periods can result in some reduction of gall production, but control is poor if egg laying is heavy. Repeat insecticide applications.

Poplar twiggall fly

(*Hexomyza schineri*)

Description: Maggots are yellow-green in color. Adult poplar twiggall flies are stout-bodied, shiny, dark flies about ⅛ inches long.

Life cycle: One generation per year. Overwinters within the gall as a full-grown maggot. Pupation occurs within the gall in late winter or early spring. Adult flies emerge from the pupae and become active. After mating, females move to developing twigs and insert eggs into the stems. Larvae hatch and produce distinctive swelling in response to their feeding. Galls typically contain 2–3 larvae, which grow slowly within the gall all summer.

Hosts: Forests, nursery; Primarily aspen, but poplars may also be attacked.

Damage: Causes galls to develop on twigs and branches. Galls become large knots on trunks and larger branches, giving the plants a gnarled,

bonsai-like appearance. Galled areas are eventually incorporated into the growing twigs and branches and may ultimately appear as large swollen bands on trunks and branches. Old injuries produce a permanent disfigurement, but do not threaten tree health.

Control: Natural controls include a small parasitic wasp, chickadees, and other birds feeding on pupae. At present, no effective chemical controls have been identified.

Cooley spruce gall adelgid
(*Adelges cooleyi*)

Description: On spruce, nymphs are covered by a waxy substance and occur within chambers in the gall. On Douglas-fir, the insect exists as a woolly aphid exposed on the needles. Winged forms sometimes are produced.

Life cycle: Requires Douglas-fir and spruce to complete life cycle. On spruce, overwinter as immature females underneath young branches. In the spring, females mature and lay eggs near developing buds. Eggs hatch and young nymphs feed at the base of growing needles, producing galls that they develop inside of. By midsummer, galls dry out and winged forms emerge, leave the original tree, and migrate to Douglas-fir trees. On Douglas-fir, eggs are laid on the needles and several generations are produced. No galls are produced on Douglas-fir. Late in the summer, some woolly aphids develop wings and fly back to spruce to deposit eggs, which produce the overwintering population. Others are wingless and remain on Douglas-fir trees.

Hosts: Nursery; Spruce, Douglas-fir.

Damage: Galls usually do not cause any serious harm to the tree. Extremely heavy infestations may cause minor retardation of tree growth and some distortion.

Control: Control is rarely needed to protect tree health. Apply treatments in fall, after overwintering females have settled on the plants, or in spring before the insects have begun to swell with eggs. Horticultural oils, applied prior to development of new shoot growth in the spring, can kill the overwintering stages. Soil injections of imidacloprid can be used, but treatments often fail to kill many of the insects until after the galls are formed.

Eriophyid mite
(*Eriophyidae*)

Description: Very small, requiring 15X+ magnification to be observed. Have an elongate, carrot-shaped body and two pairs of legs.

Life cycle: Multiple, overlapping generations are produced annually. Overwinter as adults under the scales of buds or within previously produced galls. Become active as new growth is produced in the spring and are usually present in highest populations during late spring and early summer. Favored by dry conditions and plant stress.

Hosts: Windbreaks; Many woody plants including fruit trees, linden, Rocky mountain maple, aspen, boxelder, willow, alder, ash, elm, honeylocust, lilac, and pine.

Damage: Commonly present on leaves as “leaf vagrants.” Populations may develop to damaging levels under favorable conditions. Affected leaves appear light in color, yellow, or bronzed. Small fingerlike galls, pocket galls, or felty masses of plant hairs on leaf surfaces are common types of galls.

Control: Natural controls include predatory mites, predatory thrips, and minute pirate bugs. Dormant

season application of horticultural oils controls most overwintering mites. Carbaryl and some pyrethroids are usually effective insecticides.

ROOT FEEDERS

Black vine weevil

(*Otiorhynchuys sulcatus*)

Identification: Adult weevils are hard-bodied, flightless, snout beetles about 1/2 inch long. As their name implies, they are black with small patches of white scales on the forewings. Adults have elbowed (sharply bent), clubbed antennae and their head and mouthparts are elongated. Larvae are oblong and whitish to pale yellow with a brown head. Larvae are legless and when disturbed or exposed commonly have a C-shaped posture.

Life cycle: Majority of black vine weevil overwinters as late instars (older larvae) or prepupae, and pupate in late winter to spring. Adult weevils emerge in spring, feeding at night on the foliage of host plants. Adults only walk to new sources of food, they do not fly. Peak adult populations and leaf damage occur in summer and early fall. About 4 weeks after adults emerge, female's lay eggs in soil near the base of plants. A single female can lay as many as 500 eggs. Larvae hatch from the eggs and develop through 6 instar stages as they feed underground over a period of 8 to 10 months. There is generally 1 generation per year.

Host plants: affect many types of plants ranging from herbaceous, woody plants, and many garden plants. Azalea and rhododendron tend to be very susceptible.

Damage: The larvae can cause major damage to the crowns and roots. Larval feeding can kill or weaken certain hosts, especially azalea and rhododendron. This damage also allows the infections of root diseases.

Adults feed on leaves or flowers, which tend to have a notched or ragged appearance. Leaves or needles may be clipped from twigs and when bud break coincides with adult emergence, a high percentage of primary buds and new shoot tips may be consumed.

Control: When possible select cultivars that are less susceptible to weevils. For small areas, handpicking or trapping can reduce adults to reduce the later abundance of larvae and their feeding damage. Natural controls include parasitic nematodes that can be drenched into the soil to reduce larval abundance. Applying a systemic insecticide such as imidacloprid to soil or trunks can control both adults and larvae. Contact insecticides like spinosad and carbaryl, can be sprayed on the leaves in the evening about 1 week after adult chewing is first observed.

Strawberry root weevil

(*Otiorhynchus ovatus*)

Description: Adults are dark gray or black snout beetles about ⅓ inch long. The back is marked with gold flecking. Larvae are pale-colored legless grubs.

Life cycle: One generation per year. Overwinter as larvae in the soil around the root zone of plants. Larvae resume feeding in spring and can extensively damage roots during May and June. Full-grown larvae pupate in the soil and adult weevils emerge in June. After about two weeks, eggs are laid around the base of plants. Eggs begin to hatch in midsummer and larvae feed on plant roots.

Hosts: Windbreaks; Several shrubs, particularly euonymus, lilac, Taxus, and rhododendron.

Damage: Adult weevils feed on leaves at night, producing characteristic notching wounds along the leaf margin. When abundant, plants may be heavily defoliated. Larval stages feed on plant roots, causing dieback problems. These injuries may be more destructive than those caused by adult feeding.

Control: Very resistant to insecticides. Pyrethroids and organophosphates can be used to control adults. Bifenthrin incorporated/drenched into potting media has proven effective in limiting movement of larvae in nursery stock.

CHAPTER 7: FOREST DISEASE CONTROL

LEARNING OBJECTIVES

- Know abiotic and biotic factors affecting forests.
- Understand the disease triangle.
- Be able to describe what fungi are, describe how they reproduce, and list disease symptoms that can be caused by them.
- Know what bacteria are, how they reproduce, and list disease symptoms that can be caused by them.
- Know what phytoplasmas are and list disease symptoms that can be caused by them.
- Be able to describe what viruses and viroids are, describe how they reproduce, and list disease symptoms that can be caused by them.
- Be able to describe what parasitic higher plants are, describe how they reproduce, and list disease symptoms that can be caused by them.
- Understand the stages in a disease cycle.
- Know which forest diseases are common pest problems in Wyoming and how to identify them.
- Be able to identify the hosts for each forest disease.
- Understand the symptoms and disease cycles of forest diseases.
- Know what damage each disease causes in forests.
- Be able to describe IPM methods to manage forest diseases.

Plant disease is the malfunctioning of cells or tissues of the host plant because of interaction with a pathogenic agent or environmental condition that leads to the development of symptoms. The common causes of infectious diseases of trees are fungi, bacteria, and viruses. Fungi cause the greatest amount of damage to trees and are the most common target for control with pesticides (i.e., fungicides). Chemicals used to control fungi generally are not effective on bacteria. Viruses are not controlled directly by pesticides but are controlled by eliminating vectors and by cultural controls (non-chemical), which protect susceptible trees from infection. Pesticides have very limited use for forest disease problems.

ABIOTIC FACTORS AFFECTING FORESTS

Stresses associated with forests growing under less than ideal conditions can result in abiotic (non-living) conditions that affect plants. These environmental factors cause abiotic disorders that mimic infectious diseases and insect damage. Many abiotic disorders are poorly understood and difficult to diagnose. Abiotic causal agents are non-infectious; they cannot spread from plant to plant. Although disorders can predispose plants to infection by pathogens, disorders are not directly treated using pesticides.

Causes of abiotic disorders include:

- Moisture extremes - drought, leaf scorch, excessive moisture or flooding
- Nutrient imbalance - nutrient deficiency
- Temperature extremes - foliar frost injury, stem sunscald injury
- Chemicals - herbicide injury, road salt injury
- Cultural practices - transplant shock

BIOTIC FACTORS AFFECTING FORESTS

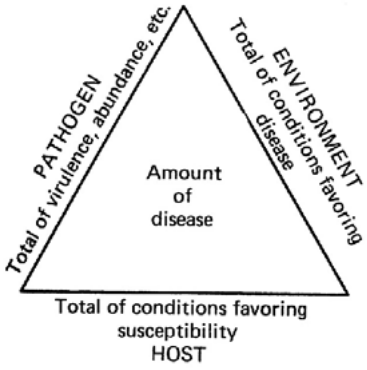
An infectious or biotic disease results when a pathogen lives in close association with the host plant. Pathogens are the biotic (living) entities that initiate disease. They are infectious and pass from plant to plant.

They reproduce, disseminate, and survive by a variety of mechanisms. An accurate diagnosis is based on the presence of symptoms on the host as well as recognition of specific signs of the pathogen on the host.

The disease triangle

Although relationships resulting in disease are often complex, three factors interact and are necessary for disease development:

- a pathogen
- a susceptible host
- the proper environment permitting infection of the host



PLANT PATHOGENS

Fungi

A fungus is a small (usually microscopic) threadlike organism made of tiny filaments called **hyphae**. The body of the fungus, made up of many hyphae, is called the mycelium.

Fungi reproduce by spores. Spores can be formed in a **sexual** process or **asexually** from fragments of hyphae that develop thickened cell walls and separate from the mycelium. Asexual fungal spores are called **conidia**. Some fungi can produce both sexual spores and conidia. Others have no sexual stage and produce only conidia.

Spores are often produced in specialized structures called fruiting structures, or **fruiting bodies**. Mushrooms and conks are some of the largest fungal fruiting structures. Most fruiting structures are much smaller and visible only with a hand lens or microscope.

Plant infection by fungi occurs via a variety of mechanisms. Some species directly penetrate plant surfaces or enter through natural openings, while others require wounds or injury for infection. During disease development, spores are dispersed by wind, water, or other means. Each spore may cause a new infection, resulting in a rapid increase in disease incidence and severity. Some fungi form special **resting spores** (**sclerotia**), which permit survival for long periods of time (several months or years) in soil or plant debris.

The presence of fungi may be difficult to detect without a microscope. Commonly only their fruiting structures appear on the surface of the diseased plant parts. Symptoms of fungal diseases include galls, **leaf spots**, distortions, stunting, wilting, damping-off, **blights**, necrosis, rots, rusts, cankers, and **witches' broom**. Signs of fungal diseases include mushrooms and mycelium.

Bacteria

Bacteria are single-celled, microscopic organisms. They reproduce primarily by simple cell division and do not form any visible fruiting structures on infected plants. Because bacteria lack a physical form that allows them to firmly anchor themselves to plant surfaces and they do not have a means to penetrate cell walls, they usually require injuries or natural openings in plant surfaces in order to enter their hosts. Bacteria are disseminated by infested planting material, plant debris, soil, water, air, infested equipment, and on insects. Symptoms of bacterial diseases include leaf spots and blights, cankers and galls, soft rot, and wilt. Ooze is a sign of bacterial disease.

Phytoplasmas

Phytoplasmas are closely related to bacteria but do not have the rigid cell wall typical of bacteria. They are amoeba-like in shape and colonize only the phloem tissues of infected plants. Phytoplasmas are commonly vectored by phloem-feeding leafhoppers, planthoppers, and psyllids. Symptoms of phytoplasma diseases include witches' broom, distortions, general **chlorosis** and **necrosis**, and leaf drop and decline.

Viruses

Viruses and **viroids** are among the smallest plant pathogens and can be seen only with the aid of an electron microscope. They are made up of protein and genetic material (viruses) or genetic material with no associated protein (viroids). Viruses are contained within living plant cells and do not survive in the environment unprotected. In order for disease to spread, these particles must be physically inserted into a living host cell by vectors, including insects or humans, or they may be transmitted through seeds, tubers, grafts, or by physical contact between healthy and infected plants. The method of transmission for a specific virus or viroid is a characteristic of that pathogen and the disease it causes. Once inserted into a host, they disrupt and take over the cell metabolism and induce the host plant cell to make more viral particles. Symptoms of viral diseases on leaves include chlorotic mosaics and ringspots, distortions, stunting, and necrosis. Plant viruses as a rule are named after the first plant on which they are found.

Parasitic higher plants

Parasitic higher plants are true plants that reproduce by seed. Some have little or no chlorophyll so they must obtain all their nutrients by parasitizing other plants. Others have chlorophyll but they must obtain water and minerals from their hosts. These true-seed-bearing plants are disseminated by any means that

will move seed. A major means is by plant seed contaminated with seeds of the parasitic plant. Some expel their sticky seeds explosively. The most obvious feature of parasitism by higher plants is the presence of the parasitic plant. Symptoms expressed by the host plant include stunting, decline, wilting, and yellowing.

THE HOST

Levels of resistance or susceptibility of the host plant affects disease development. Plants with high levels of resistance are essentially immune or non-susceptible and do not allow the pathogen to become established, even if present. Plants with lower levels of resistance may become infected but only allow the pathogen to develop slowly, limiting the economic impact of the disease to acceptable levels. Stress, such as that brought on by an unfavorable environment, affects a host plant's ability to resist infection and therefore also affects disease development.

THE ENVIRONMENT

Environmental conditions play a large role in disease development and disease severity. The disease triangle shows that the environment influences disease development by interacting with both the host and the pathogen. Temperature, moisture, and wind are important environmental factors that affect pathogen growth, reproduction, and dispersal.

PLANT DISEASE DEVELOPMENT

Every biotic disease requires a series of sequential events in order for disease to develop. This series of events is called the **disease cycle**. Although the specific characteristics are unique for each disease, the stages in the disease cycle are:

- **Inoculation** - the coming together of pathogen and host
- Penetration – invasion of the host by the pathogen
- Infection – the pathogen obtaining food
- Dissemination – spread of the pathogen by active or passive means
- Overwintering/Oversummering – survival of the pathogen during unfavorable periods

Each pathogen has a life cycle, or succession of stages of growth and development. The life cycle may be very similar to the disease cycle. Some plant pathogens require more than one plant host to complete their life cycles. These plants, called alternate hosts, are from different plant families. Different stages of the pathogen's life cycle occur on each host. One or both of the hosts may be economically important. This is not to be confused with an **alternative host**, which is another plant species or a weed where the pathogen can be found. Alternative hosts play important roles in survival of pathogens.

FOREST DISEASES

Following are descriptions of pests that occur in Rocky Mountain forests. They are grouped according to the part of the plant they feed on (leaves or shoots, twigs, trunks, and roots). Please note that specific fungicides are not listed to control each pest. For current pesticide products, rates, precautions, and more on treatment decisions, please consult the pesticide label. **Always read pesticide product labels thoroughly and follow all instructions, restrictions, and precautions.**

CONDITIONS ASSOCIATED WITH FOLIAGE

Septoria leaf spot
(*Mycosphaerdila* spp.)

Hosts: Forest, nursery, windbreaks; Cause leaf spots on aspen, cottonwood, poplar, maple, and dogwood. They can also produce cankers on eastern cottonwood and some poplars.

Symptoms: Leaf spots vary from small flecks, to white or silvery spots, to brown circular spots, to larger irregular spots with tan centers. Rings or zones can occur within the larger spots, giving them a target appearance. Tiny black fruiting bodies form within the lesion.

Disease cycle: Overwinters in dead leaves and stems from the previous year's infection. Primary infection occurs by spores released in the spring that infect the lower leaves of the tree. Secondary disease cycles occur when conidia are produced in leaf lesions during wet weather.

Damage: Early infections are rarely serious. Heavy secondary infections cause premature leaf loss on infected trees.

Control: Plant resistant cultivars/species. Fungicides are available but not usually recommended.

Marssonina blight
(*Marssonina* spp.)

Hosts: Forest, nursery, windbreaks; Predominantly aspen. Cottonwoods and poplars are also susceptible.

Symptoms: Dark brown flecks, often with yellow margins, are scattered over leaf surfaces. In mid to late summer, spots may enlarge to large dead patches. Infected leaves are often reduced in size, turn bronze in color, and shed prematurely. Elongate black lesions may develop on leaf petioles and succulent new shoots. Small lens-shaped fruiting bodies containing a white gelatinous mass of conidia form within leaf lesions. As spores are released, the epidermis ruptures, forming a small ring-like blister.

Disease cycle: Overwinters in previously infected leaf debris on the ground. In spring, infection occurs when spores are released and carried by wind and rain to developing leaves. Secondary infection results later in the summer when fruiting bodies on the newly infected leaves produce spores and are blown to adjacent leaves.

Damage: Tree death is rare unless there are several consecutive years of defoliation and there are other stresses such as scale insects, drought, or cytospora canker. Repeated attacks can make trees susceptible to branch dieback, other diseases, and winter injury.

Control: Remove infected leaves on the ground to help reduce infection. Apply fungicides at bud break, before infection takes place on young, expanding leaves.

Juniper tip blight
(*Kabatina juniperi, Phomopsis juniperovora*)

Hosts: Forest, nursery, windbreaks; Eastern redcedar, creeping juniper, Rocky Mountain juniper, Savin juniper.

Symptoms: Kabatina causes tip dieback in early spring and does not cause damage during the summer. Phomopsis tip blighting symptoms appear in the summer months. Affected foliage initially turn dull green, then red, yellow, or brown. Lesions or cankers containing small black or gray fruiting

structures develop on branches. Lesions eventually girdle small branches, leading to tip dieback.

Disease cycle: Spores of kabatina infect young shoots in late summer or early fall. Spores of phomopsis infect young shoots throughout the growing season, as long as conditions are favorable.

Damage: Damaging to seedlings, in nursery settings, or to mature junipers in windbreaks.

Control: Chemical control usually not needed due to lack of moisture and humidity. In nurseries, applications of Bordeaux mixture (4 lbs hydrated lime and 4 lbs copper sulfate in 50 gal water [1.8 kg/1.8 kg/190 l.]) or copper to control phomopsis blight may be necessary during wet years.

Cercospora needle blight of junipers

(*Cercospora sequoiae* var. *juniperi*)

Hosts: Eastern redcedar, Rocky Mountain juniper, and other junipers planted for ornamental or windbreak use are susceptible to several needle-disease fungi.

Symptoms: An applicator can easily tell *Cercospora* needle blight from other juniper diseases, because older foliage becomes infected first, rather than the newer foliage at branch tips.

Initial needle infection occurs during late June and early July. Infected needles first turn brown at the leaf tips, then gradually become completely brown. Smaller shoots and branchlets of the inner tree crown are usually infected first. Affected branchlets will often fall from the tree during late autumn.

The disease slowly progresses from the interior of the tree crown outward, and from the lower branches to the younger, higher branches. Severely infected trees may have only a small tuft of green foliage on the branch tips.

The fruiting bodies (sporodochia) of the fungus will form under the right environmental conditions. The tiny sporodochia are dark gray-green and inconspicuous, so they aren't usually seen. Close examination of the foliage with a hand lens is necessary to spot fruiting bodies. Spores of the fungus develop in the sporodochia and are spread to nearby branches and trees during rainy periods.

Disease development: Junipers have three recognized needle types. These types differ in their susceptibility to infection. Juvenile needles are sharply pointed and characteristic of seedling junipers. All juvenile needles are susceptible to infection. Spur needles are the flattened, blunt needles most abundant on older trees. Current-year spur needles are resistant, but older needles are susceptible. Whip foliage is the elongated shoot extremities of side branches. Whip foliage apparently isn't susceptible to Cercospora needle blight.

Spores of the fungus may be dispersed from late April through October, but significant spore release doesn't occur until mid- to late June. Spores spread by rainfall infect susceptible foliage as early as late June or early July. Shoots and small branchlets eventually die after all the leaves have been killed by the fungus.

Control: Bordeaux mixture effectively controls the disease. At least two applications are necessary for best control.

The first fungicide treatment should be applied during the second or third week in June, just prior to the initial infection period. The second treatment should be applied about the third week in July. The second application will prevent infections for the remainder of the season. A drip-irrigation system installed at the base of shrubs is a water-saving alternative.

Additional applications may be necessary during periods of frequent rains. Rain favors disease development and reduces fungicide longevity.

Handle all pesticides safely. Read all label instructions before using any pesticide. Store all pesticides safely, away from children, pets, and livestock.

Powdery mildew

Powdery mildews are fungal diseases that are very common in dry climates. They form superficial mycelium (a mat of fungal tissues) over the surface of foliage. This mat has structures called haustoria that absorb water and food from the host plants. The characteristic fruiting structure of this group of fungi is the cleistothecium, a tiny sphere about 0.1 to 0.2 mm in diameter. These tiny spheres form in the mycelium on the leaf surface and are usually black at maturity, giving a "salt and pepper" appearance to the leaf surface.

This disease is most common in the West on maples, cottonwoods, apple trees, and roses. Apple trees and roses are most susceptible while new shoots and fruits are developing, but in some hosts, the mature foliage is most susceptible. Powdery mildew can also affect tree roots.

Control: Often these fungi can be washed off with a garden hose if infections are light. Chemical sprays can control these diseases if necessary. triflourine (Funginex) and Dinocap (Karathane) are registered for powdery mildew control and are effective on all powdery mildew hosts.

Branch diameter (outside bark)	Distance of infection on branch from truck
under 1.0 inch	6 inches
1.1 - 2.0 inches	8 inches
2.1 - 3.0 inches	10 inches
3.1 - 4.0 inches	12 inches

RUSTS

Rust diseases are caused by fungi that form orange, rust-colored spores, thus giving this group its name. Most trees affected by rusts are conifers but several foliar rusts cause problems on hardwood trees such as cottonwoods and aspen. Most rust fungi require two unrelated plants to complete their life cycle. Rust fungi cause cankers, witches' brooms, galls, and leaf spots.

Rust fungi spread from host to host by rain or windblown spores. Infection almost always takes place through leaves. Local climate conditions and location of the alternate host affects how many infections will take place. High humidity and rain is needed for spore production and infection.

Leaf rusts

Hosts: Forest, nursery, windbreaks.

Symptoms: Pustules of red, orange, or yellow spores appear on undersides of leaves or needles. Leaf yellowing, browning, curling, and drop may also occur. Infections are most noticeable in late summer and early fall after the host has completed most of the year's growth.

Disease cycle: Complex life cycles; some have five spore stages and require two hosts to complete a life cycle.

Damage: Minimal damage most years. However, yearly rust infections and accompanying leaf drop can cause a reduction in carbohydrate reserves in plant roots. Infected trees or shrubs may be more susceptible to decline and winter injury.

Control: Resistant tree and shrub varieties may be available. Chemical control is rarely needed, and most fungicides labeled for normal leaf spots are not effective against rusts. Apply fungicides at leaf expansion in the spring.

Juniper rusts

Hosts: Forest, nursery, windbreaks.

Disease cycle: Two-year life cycle. Overwinters on juniper and cedar. Galls begin to form during the following spring and require 20 months to mature and form telial horns, spore producing gelatenous structure, and resting spores called teliospores. Teliospores germinate and produce basidiospores. Rainsplash or wind to broadleaf hosts disperses basidiospores.

Damage: Galls cause little or no dieback of woody twigs, but severe infections may cause some branch death. Fungi that cause witches' brooming can deform trees, stress trees, and cause death. Infection is unsightly on hosts and alternate hosts. Repeated defoliation of broadleaf host may result in stress and eventual decline.

Control: Because fungus requires both plant hosts for completion of disease cycle, elimination of one host from the vicinity will reduce new infections. Protectant fungicides may provide control.

CONDITIONS ASSOCIATED WITH SMALLER BRANCHES AND TWIGS

Bacterial blight

(*Pseudomonas syringae*)

Hosts: Nursery, windbreaks; Occurs on a wide range of host plant species. Commonly affects lilac and cotoneaster.

Symptoms: Symptoms vary with the host plant. Leaves develop brown/black spots or blotches, often with yellow halos, which run together and quickly involve the entire leaf. Infected flower clusters turn brown and die, and infected lilac often have blackened shoots. Infected plant parts often turn black and lesions on woody green stems may appear as black streaks. Symptoms look like late spring frost.

Disease cycle: Overwinter on plant surfaces, in association with buds. Bacteria invade succulent tissues or wounds any time cool, wet conditions prevail.

Damage: Results in dead flowers, leaves, and young twigs.

Control: Select less susceptible varieties that are adapted to the growing area. Remove infected shoots several inches below visible cankers. Do not use overhead irrigation. Keep nursery stock dry and warm in spring. Apply copper fungicides 2–3 times when new growth appears. Spray every 7–10 days when conditions are favorable for infection.

Botrytis blight

(*Botrytis cinerea*)

Hosts: Nursery; Conifers.

Symptoms: Commonly infects young branches, particularly lower shaded branches. Black sunken cankers, which eventually girdle the stem, are usually visible low on the stem. Fungus can be seen as a thin, gray web of mycelium on infected plant parts during periods of high humidity.

Disease cycle: Overwinter as small black sclerotia. Fruiting bodies grow from infected tissue and mycelium and produce clusters of dark, oval spores. Fungus is spread by airborne spores.

Damage: Losses often confined to pockets of seedlings, but can cause heavy mortality.

Control: Modify environment to increase aeration and decrease humidity around seedlings. Fungicides are effective; however, some resistance has developed.

Fire blight
(*Erwinia amylovora*)

Hosts: Nursery, windbreaks; Cotoneaster, hawthorn, mountain ash, pear, crab apple.

Symptoms: Flowers and new leaves appear water-soaked, quickly wilt, and turn brown to black. Leaves remain attached to stems. Stem tips curl over with a "shepherd's crook" appearance. Symptoms appear quickly, as though the host had been scorched by fire. Bacteria move down to the shoot base, causing a limb or trunk canker. Cankers are dark colored, and wood in the cankered area becomes sunken as surrounding wood continues to grow. Canker margins have a narrow (pencil lead size), raised callus ridge on branches.

Disease cycle: Overwinter in blighted branches and at the edge of cankers. In spring, when conditions are warm and wet, bacteria multiply on the surface of flowers and other plant tissues and may appear as amber-colored droplets (ooze) on the surface of cankers. Bacteria are moved by wind, water, insects, or many other vectors to young, succulent plant parts. Flowers and wounds make suitable infection sites. Repeated infections can occur from inoculum developed in primary infections during the growing season if wet conditions and succulent tissues are present.

Damage: All flowers and leaves above the point of infection die.

Control: Use resistant varieties. Remove and destroy newly infected young twigs as soon as possible. Use chemical sprays as preventive treatments. Apply chemical sprays if there is abundant shoot growth or there are fruit injuries from hail or other agents. Copper sprays are best used during dormancy and bud break because they may damage leaves and fruit.

CONDITIONS ASSOCIATED WITH LARGER BRANCHES AND STEMS

Cankers
Cankers are dead areas on the stem bark and cambial area caused by fungi, bacteria, or other living agents. Cankers can kill plants especially if the plant is stressed and cannot defend itself well. Canker-causing organisms spread from tree to tree by wind and occasionally by insect vectors. Canker-causing organisms usually enter the tree through wounds or branch crotches. Canker-causing organisms grow in the bark and kill the tree by killing the cambium.

Prevent disease by improving the growing environment, reducing stresses, and planting disease-resistant species. Some cankers can be removed if the plant is healthy. There are limited chemical treatments for canker problems.

Cytospora or Leucostoma canker
(*Cytospora* spp.)

Hosts: Forest, nursery, windbreaks; Aspen, cottonwood, poplar, elm, willow, alder, birch, maple, mountain ash, linden, honeylocust, ash, sycamore, mulberry, oak, and spruce.

Symptoms: Yellow or orange-brown to black discolored areas on the bark of the trunk and branches. Liquid ooze on aspen is common. Cankers, sunken dead areas of bark with black pinhead-sized speckling or pimples, may be evident. The pimples are the reproductive structures of the fungus. Under moist conditions, masses of spores may ooze out of the pimples in long, orange, coiled, threadlike spore tendrils. Reddish-brown

discoloration of the wood and inner bark also may be evident.

Disease cycle: Overwinters in cankered bark. Spores from fruiting bodies on cankered branches are spread by rain, wind, insects, etc. Infection occurs through wounds. The fungus grows and kills the bark, then expands until the entire branch is killed.

Damage: Attacks injured, weak, or stressed trees and can cause death.

Control: Prevent infection by preventing stress on the tree. Once infection occurs, increase plant vigor and sanitation. Remove all infected limbs and other areas. Clean wounds to avoid further spread of the infection. No fungicides are effective to treat this disease.

Tubercularia and Nectria cankers

Sexual Stage: *Nectria cinnabarina*
Asexual Stage: *Tubercularia ulmea* and *T. vulgaris*

Hosts: Nursery, windbreaks; Siberian elm, shrub dogwood, honeylocust, linden, maple, mulberry.

Symptoms: Two forms of cankers appear in spring: 1) girdling cankers that cause twig or branch dieback, often leaving branches with dead leaves still attached, and 2) oval or elongate, slightly sunken non-girdling cankers. Canker area may be discolored, exude gum, or not show until cracks form at the margins of the areas. Vigorous sprouts may develop below cankered areas. Small, cushion-like fruiting structures that are first pink-orange and blacken with age may grow out of lenticels on the bark surface or be present under a papery thin layer of bark.

Disease cycle: Overwinters as fruiting bodies and mycelium in cankered bark. Spores released from fruiting bodies travel via wind and rain to dead trees or to live trees that have been wounded.

Damage: Cankers at the base of hardwoods are usually fatal. Main stem or branch crotch cankers may completely girdle the tree, depending on the tree's health. Stressed trees cannot stop the fungus, but healthy trees may be able to stop canker expansion and recover.

Control: Remove and destroy affected twigs and limbs, pruning back to the nearest living branch beyond the canker. Disinfect pruning tools and prune during dry weather near the end of dormant period. Spray wounds in the spring.

PARASITIC PLANTS

Dwarf mistletoe

(*Arceuthobium* spp.)

Hosts: Forest; Lodgepole pine, limber pine, pinyon pine, ponderosa pine, and Douglas-fir are the most common hosts.

Symptoms: Appears as small leafless plants on branches. Parasite is yellow to green or brownish-green. Causes brooming of branches on hosts.

Disease cycle: Life cycle from germination to dissemination is 4–8 years. Reproduction occurs when sticky seeds explosively discharge from the plant and adhere to the branches and needles of adjacent trees. Seeds generally are dispersed in August and early September.

Damage: Rob trees of nutrients and water. Heavy infestation causes deformation, stunting, and death of trees. Predisposes trees to attack by insects, diseases, and wildfire.

Control: Silvicultural methods, including pruning and removing trees, are the best management measures available to reduce or eliminate infestations. Prune infected lower branches, leaving at least ⅓ of the live crown. Mistletoe shoots die as soon as the tree branch is cut. Chemical sprays of the plant growth regulator ethephon remove mistletoe shoots, reduce seed production, and prevent infection of new trees. This does not kill the plant, so retreatment is necessary until infected trees are removed and new trees are planted.

In heavily infested areas, non-susceptible trees can be planted to replace cut trees. Ponderosa pine areas can be replanted to:

- Douglas fir
- Pinion pine
- White fir
- Limber pine
- Blue spruce
- Rocky Mountain juniper

In lodgepole pine areas, the following trees can be substituted:

- Englemann spruce
- Subalpine fir
- Douglas fir

Hardwoods such as ash, birch, and aspen also can be planted in affected areas, because dwarf mistletoes don't attack hardwood trees.

CONDITIONS ASSOCIATED WITH ROOTS

Fusarium root rot

(*Fusarium* spp.)

Hosts: Nursery; Douglas-fir, pines

Symptoms: Also known as late damping-off. Terminal needles turn yellow or purple and wilt. Needles on entire plant eventually turn brown and dry out, appearing to be drought damaged. Roots are often dark, swollen, and lack actively growing tips.

Disease cycle: Occurs on seedlings 1–3 months old. Fungus is dormant as resting spores in soil or organic matter. Spores germinate when conditions are favorable and fungus grows over and penetrates the root surface, resulting in death and decay of root tissues.

Damage: Causes seedling mortality in the nursery, increased numbers of culls, and reduced survival after outplanting. Losses vary greatly depending on tree species, seedlot, geographic area, and soil type.

Control: Observe strict sanitation. Reduce soil temperature by irrigating and mulching. Fumigate with a soil fumigant before planting. Fungicides are inconsistent.

Phytophthora root and crown root

(*Phytophthora* spp.)

Hosts: Nursery, windbreaks; Juniper.

Symptoms: Stunting, poor growth, early fall coloration, dieback, wilt, and eventual death. Discoloration of the inner bark and wood at the base of the infected plant is usually present and visible if the outer bark is scraped away. Distinct margin between healthy and diseased crown

tissues. Reddish-brown liquid may exude from the cankered area. Affected area becomes shrunken and cracked.

Disease cycle: Spread by movement of contaminated soil or diseased plants, or by splashing water. Enters host tissue near the root collar via wounds or the succulent parts of small roots. Cause lesions at and on the adjacent parts of major roots or smaller roots of trees or shrubs.

Damage: Collar rots are lethal to many of the plants they affect, especially single-stemmed trees with root collar cankers. Effects on multi-stemmed plants are limited to the stems and roots infected.

Control: Avoid overly saturating root zones with poor drainage or wounding plants at the crown or below. Remove diseased plants. Soil applications of fungicides provide effective control in nurseries.

Pythium

(*Pythium* spp.)

Hosts: Nursery, windbreaks.

Symptoms: Small, yellow, chlorotic foliage, reduced growth; scorch; tufted leaves at the end of branches; and branch dieback. Fungal fruiting bodies (mushrooms or conks) at tree base and white fungal growth under the bark.

Damage: Reduce tree's mineral- and water-absorbing capability. Suppress growth, decay food-transporting cells, reduce food storage, and reduce structural support.

Control: Keep the tree healthy and vigorous. Avoid any practice that injures the roots, including soil compaction, soil depth changes, mechanical injury, and improper watering and fertilization techniques. If the root system is severely damaged, tree removal usually is recommended.

CHAPTER 8: FOREST WEED CONTROL & VEGETATIVE MANAGEMENT

LEARNING OBJECTIVES

- Know the common life cycles of weeds.
- Know how weeds can be classified.
- Understand growth forms of weeds.
- Know which weeds are common pest problems in Wyoming and how to identify them.
- Understand the habitat and distribution of forest weeds.
- Be able to describe the biology and ecology of forest weeds.

No single chemical or method of application is suitable for all forest or site conditions. Planning your program in advance of application will provide the best control at the least cost per acre. One must assess a given site according to tree or brush size and number of stems to be treated, then choose the proper chemical and carrier, select the right method of application, and later evaluate the results accurately. The use of herbicides is most often recommended because they are economical, environmentally safe, effective, and versatile in application. These are the basic considerations in a successful program of chemical application in the manipulation of forest vegetation.

Recognition of the weed pest species is as important in forest weed control as it is with any other pest control problem.

WEEDS

Weeds are plants that interfere with land management objectives. Weeds cause more forest losses than all other pests combined. Inadequate control of forest weeds is causing a major shortage in future supplies of high-quality wood products. Weeds may be classed as:

- Weed trees
- Brush
- Vines
- Herbaceous weeds

Weed trees

Weed trees often cause significant losses in forest production. They affect both young and old commercial trees within the stand. Weed trees include:

- Non-commercial hardwood and conifer species.
- Deformed, defective, or undersized individuals of commercial species (such as crooked trees or those with heart rot).
- Off-site species (commercial species in a location where they can't develop well).

Some weed trees may be removed by mechanical methods. Some of these can be sold as pulp or fuel. Chemical control methods include:

- Broadcast foliar application of herbicides.
- Directed basal-cut application of herbicides to individual trees.
- Directed basal-bark application of herbicides.
- Broadcast soil application of herbicides.

Brush

Dense brush keeps light from tree seedlings. It also can deprive taller commercial species of water and nutrients. It interferes with planting and can create habitat for wildlife species that may damage tree seedlings. Brush includes:

- Woody shrubs
- Non-commercial stump sprouts

Broadcast applications of foliar herbicides are used for general or selective control of susceptible brush species. If the brush isn't more than 20 feet high, air-blast sprayers may be used for ground application. Aircraft are usually used on taller vegetation.

Application of chemicals to individual stems can be expensive if large numbers of stems per acre are treated. Basal-bark applications are effective but are costly in labor, chemicals, and fuel oil. Systemic brush-killing herbicides do the best job of controlling large, woody vegetation.

Common brush species include such plants as sagebrush (several species), rabbitbrush, chokecherry, snowberry, bitterbrush, buckbrush, and kinnikinnick.

Vines

In some areas of the country, vines are serious pests, especially on better forest soils. They strangle trees, drag down branches and crowns, and compete for light and nutrients. Poison ivy is a human health hazard. Vines are hard weeds to control—they have vigorous sprouting habits. Systemic herbicides kill their root systems.

Herbaceous weeds

Herbaceous weeds compete with seedlings in new plantings. Tree seedlings and introduced grass seedlings may develop poorly or die, especially in times of drought. Herbaceous weeds also create favorable cover for tree-damaging animals such as mice, gophers, and moles. Control herbaceous weeds with herbicides labeled for this forest use. Killing all ground cover for several years can cause soil damage, especially from loss of nutrients and from erosion. Use banded application in areas with summer rainfall. In dry-summer climates, short-residual herbicides permit winter ground cover to develop.

WEED CONTROL METHODS

The methods used for weed control in forest sites depend on the weed situation and the manner in which the resource is being managed. Methods most often employed are:

- Hand-cutting
- Mechanical control
- Chemical control
- Biological control

Hand-cutting

Hand-cutting of brush and weed trees is rarely practical on a large scale. However, such operations may be applicable to small weed lots or commercial thinning of conifer stands. Many brush and weed-tree species readily sprout from stumps or roots following top removal, thus making the benefits of hand-cutting short-lived.

Mechanical control

Brush removal with a dull dozer or tracked tractor fitted with a blade or brush rake is applicable where trees are grown in rows. Similar mechanical tools are used in site-preparation operations where brushes as well as any existing small conifers are removed. Unless roots and crowns are lifted free from the soil, most broadleaf woody species will readily re-establish.

Biological control

There are several examples of insects that have been introduced to control an undesirable weed. One example is a weevil (*Rhinocyllos*) introduced to control musk thistle and Canadian thistle. Biological controls are also very host specific.

Chemical control

The chemical control of woody plants offers the land manager a more economical and effective method of managing undesirable vegetation than by laborious hand-cutting or mechanical methods.

Several factors have helped make herbicides a standard tool for the establishment and improvement of forests, wildlife habitats, and range pasture lands. One such factor is continuous advances in chemical formulation and application methods. Others include more knowledge about specific action and safety of various herbicides and the accumulation of years of practical experience.

The chemical response, or level of vegetation control obtained after application, will vary according a number of factors:

- Tree or brush size and density
- The kind of herbicide
- The volume applied
- Carrier and active ingredient
- Season and method of application
- Species susceptibility
- Equipment being used

It's imperative that the forest managers, herbicide applicators, and especially the crew foremen familiarize themselves with these factors before application. They can then select the most suitable method or methods for their particular set of conditions. **READ THE LABEL** again before applying the herbicides to be sure the correct formulation has been chosen and applied through proper equipment at the right place and at the right time.

Herbicides commonly used for establishment and improvement of forest and rangelands are currently available under a variety of trade names. Many of these contain nearly the same chemical and concentration, but with varying amounts of inert ingredients and carriers. Therefore, it's better to become familiar with the common names of the chemicals themselves. The advantages of using herbicides are:

- Economy, compared to alternate control practices such as hand-cutting or mechanical methods.
- Time saving: large areas can be covered in a relatively short time.
- Ease of application and low labor requirement.
- Fewer re-treatments to control re-sprouting of herbaceous and woody perennials.
- Selectivity of some herbicides to minimize or avoid damage to conifers.

The disadvantages or limitations of herbicides are:

- Success of weed control programs depends on the selection of the proper type and formulation of herbicides or herbicide mixtures.
- Application timing is often critical in maximizing conifer tolerance and in gaining maximum weed control.
- Non-target plants in gardens or on farms may be adversely affected by spray or vapor drift or through root uptake, causing plant injury or residues.

Herbicides generally move very little in forest soils. They are broken down in place by microorganisms, sunlight, and chemical reactions. A compound that has an effective life of several months will usually move less than a foot or two from the site of application. Therefore, herbicides are not a serious threat to water supplies or fish unless they are placed directly (especially by spillage) into forest streams or on areas that will become waterways during storm periods.

CHOOSING A PESTICIDE

Since the approved use of pesticides is subject to change, only general information about commonly used pesticides is given in this study guide.

REMEMBER:

- Before you choose a pesticide, get a positive identification of your target pest(s).
- Before you buy the pesticide, read the label to be sure it's the correct chemical for your problem. Before you get too involved, be sure of your information. Contact reliable sources, such as University of Wyoming Extension educators, State Forestry, and Local Weed & Pest District for professional advice.

Pesticide labeling

Forestland is considered to be cropland when a stand of commercial trees is present. This means that "non-cropland uses" listed on a pesticide label may not apply to forests. Pesticides used in forests, seed orchards, Christmas tree plantations, or nurseries must bear directions for use on the specific crop and pest species.

Some forestry uses are included on labels mainly devoted to other uses. For example, pesticides may be applied to Christmas trees, seed orchards, or nurseries if the label gives directions for use on ornamentals or shade trees, including conifers, and for the pest you need to control.

Herbicides registered for other crops, range, or non-croplands may be used before crop trees are planted. Some pesticides registered for use in forestry may be tank-mixed. In mixtures of two or more products, the rate of each component may not exceed the rate prescribed on its label. Check labels or a recognized authority for details.

COMMON LIFE CYCLES OF WEEDS

Plants can be classified according to their life cycles as **annuals**, **biennials**, or perennials. These are not strict botanical divisions, but groupings that are important when choosing methods to control unwanted plants.

Annuals

Annual weeds germinate, produce seed, and die in one season and are propagated by seeds. Following the production of seed, annual plants die. Summer annual weeds grow from seeds that sprout in the spring, mature, and reproduce before dying in the winter. Winter annual weeds germinate in the fall or winter and grow until spring when they flower, produce seed, and die. Cheatgrass (downy brome) is an example of winter annual weed.

Biennials

Biennial weeds require two years to develop and complete their life cycles. These plants form basal leaves and a taproot and grow without flowering through the first year. In the second year, the plant flowers, produces seed, and generally dies. Common biennials are bull thistle and houndstongue.

Perennials

Perennial weeds are plants that live three years or longer. These plants flower and set seed without dying. They can live indefinitely; they may lose their foliage during the winter and die back to the ground, but they recover in the spring. Many perennials can store food underground in rhizomes (creeping stems below the soil surface), bulbs, roots, or tubers, which makes these plants difficult to kill by mechanical or chemical means. Common examples are Canada thistle, leafy spurge, and yellow toadflax.

WEED CLASSIFICATION

Weeds can be separated into two groups: the monocots and the **dicots**.

Monocots

When monocots germinate, they have a single primary leaf, or cotyledon. The cotyledon does not emerge above the soil surface—the first leaves you see are actually secondary, or true, leaves. All monocots have narrow leaves with parallel veins and usually have a fibrous root system. They most commonly reproduce by seed, stolons (creeping stems above the soil surface), or rhizomes. The growing point in monocots is protected, frequently at or below the soil surface, particularly in young plants. Monocots include grasses, sedges, and rushes.

Dicots

When dicots emerge from the soil, they have two primary leaves, or cotyledons. The cotyledons often do not look like the later true leaves. Dicots usually have broad leaves with veins that form a net-like pattern. Most dicots have a tap root. Many species can reproduce by seed, but some have vegetative buds either in the crown or on the taproot, and still others reproduce by spreading rootstocks. Dicots can be classified as either herbaceous or woody plants.

GROWTH FORMS OF WEEDS

Growth form refers to the overall size of a weed, whether it is woody or not, and whether it is a grasslike or broad-leaved weed. Most weeds can be placed into one of five groups: grasses, grasslike sedges, grasslike rushes, forbs, and woody plants.

- Grasses have jointed, hollow stems and clusters of small, membranous flowers arranged in spikelets.
- Sedges resemble grasses, but have solid stems that are often triangular.
- Rushes resemble grasses but have round, tough, hollow, or pithy stems lacking joints.
- Forbs are non-woody (herbaceous) plants excluding grasses, sedges, and rushes, that die back to the ground each year. Forbs usually have showy flowers. Most perennial or important forest weeds are forbs, including toadflaxes, knapweeds, and thistles.
- Woody plants develop woody tissue and include trees, shrubs, and vines. Unlike herbaceous plants, which often die back to the ground or are killed by the freezing temperatures of winter, woody plants have a long lifespan and produce new growth each season. They often overwinter in a dormant state.

FOREST WEEDS

Following are descriptions of pests that occur in Wyoming forests. Please note that specific herbicides are not listed to control each pest. For current pesticide products, rates, precautions, and more on treatment decisions, please consult the pesticide label. Always read pesticide product labels thoroughly and follow all instructions, restrictions, and precautions.

FORBS

ANNUAL FORBS

Mayweed chamomile
(*Anthemis cotula*)

Description: Flowers are 0.75 inches in diameter, with 12 white petals and a yellow center. Leaves are divided into narrow segments. Mature plants are 6–24 inches tall, highly branched, and have a foul odor.

Habitat and distribution: Commonly found in abandoned areas, fields, and overgrazed pastures throughout the U.S.

Biology/ecology: Germinates readily in the spring and fall. Dense, fibrous root system spreads rapidly during wet periods. Late summer and fall-germinated seedlings may overwinter as a rosette. Plants flower in mid-May and spring-germinated seedlings flower in June. Flowering stops after a killing frost, usually in October.

Control: Prevent the establishment of new infestations by minimizing disturbance and seed dispersal. Infestations can be mowed several times a year to prevent seed production. Herbicides are effective from the seedling stage up to the bud or early flower stage. Sulfonylurea herbicides are very active through the flowering growth stage.

Scentless chamomile
(*Tripleurospermum inodorum*)

Description: Flowers are 0.75 inches in diameter and resemble daisies with a yellow center surrounded by white petals. Leaves are divided into narrow segments. Mature plants are 10–30 inches tall and have NO foul odor.

Habitat and distribution: Found along roadsides and ditches as well as in urban areas, abandoned areas, and pastures. Can grow in a wide range of soils but prefer moist, poorly drained soils.

Biology/ecology: Germinates readily in the spring and fall. Dense, fibrous root system which spreads rapidly during wet periods. Late summer and fall-germinated seedlings may overwinter as a rosette. Plants flower in mid-May and spring-germinated seedlings flower in June. Flowering stops after a killing frost, usually in October.

Control: Easily confused with mayweed chamomile and should be a priority for immediate eradication if found. Prevent the establishment of new infestations by minimizing disturbance and seed dispersal. Eliminate seed production to decrease its spread and continue to deplete the seed bank for 4–6 years. Infestations can be mowed several times a year to prevent seed production. Herbicides are effective from the seedling stage up to the bud or early flower stage. Sulfonylurea herbicides are very active through the flowering growth stage.

BIENNUAL FORBS

Plumeless thistle

(*Carduus acanthoides*)

Description: Flowers are purplish-pink and clustered in heads that are 1–2 inches in diameter. Lower rosette leaves are usually 4–8 inches long with spiny lobes. Stems are covered with leaflike spines that extend up to the flowering heads. Mature plants are 1–4 feet tall and have a stout, fleshy taproot.

Habitat and distribution: Locally abundant in pastures, stream valleys, fields, and roadsides. Has the potential of becoming a widespread noxious weed.

Biology/ecology: Seedlings emerge from early spring to late fall. A single taproot is formed and stem elongation takes place in early May. Flowering begins in early June and lower branches continue to flower until mid-August.

Control: Elimination of seed production is key. Rosettes can be pulled or dug out by hand before bolting. Apply carboxylic acid or benzoic acid in the rosette to very early bolt growth stages. Once plants have bolted, seed heads must be removed to prevent production of viable seed.

Bull thistle

(*Cirsium vulgare*)

Description: Leaves are prickly and hairy on the upper side, giving them a rough texture and cottony below. Leaf tips form a spear shape. Has spine-tipped, pinkish to dark purple flower heads. Mature plants range between 2–5 feet tall.

Habitat and distribution: Grows in dry to moist habitats. It cannot withstand deep shade, and is nearly absent if light is reduced to less than 40% of full sunlight. Found at elevations between 5,000–10,800 feet.

Biology/ecology: Reproduces solely by seeds. Forms a basal rosette in the spring following germination. Rosette grows until winter, partly dies back, and begins to grow again in early spring. Age at bolting is dependent upon plant size and almost all plants require a period of cold temperature to bolt. Flowering occurs from July through September. After flowering and seed production, the plant dies.

Control: Apply carboxylic acid or benzoic acid to rosettes in early spring.

Houndstongue
(*Cynoglossum officinale*)

Description: Leaves are rough, hairy, and lack teeth or lobes. Leaves often appear dusty and insect-ridden. Produces a single flowering stem that is stout, heavy, and 1.5–3 feet high. Flowers are five-petaled and reddish-purple (occasionally white) in color. Produces four fruit per flower. Fruit is barbed and clings to clothing, fur, hooves, shoes, etc.

Habitat and distribution: Prefers areas with more than 10% bare ground and is commonly found on gravelly soils. It requires disturbed or bare areas to establish. Once established, quickly forms dense monocultures. It is found up to 9,000 feet.

Biology/ecology: Produces a rosette the first year. During the second year, the flowering stem bolts and produces fruit. Reproduces solely by seed. Very toxic to grazing animals, especially horses.

Control: Mow bolted plants before spraying to decrease seed production. Treat plants in spring with sulfonylureas or carboxylic acid. Repeat this process for several years to exhaust the seed bank.

BIENNIAL OR SHORT-LIVED PERENNIAL FORBS

Spotted knapweed
(*Centaurea maculosa*)

Description: Can be distinguished from other similar-looking knapweeds by the dark tips and fringed margins of the floral bracts. Flowers are pinkish-purple or, rarely, cream colored. Rosette leaves are up to 6 inches long and are deeply lobed. Mature plants are 1–3 feet tall with one or more stems.

Habitat and distribution: Well adapted to glaciated soils. Not tolerant of shade. Tends to inhabit somewhat moister sites than diffuse knapweed, preferring areas that receive 12-30 inches annual precipitation. Commonly found between 4,000–6,000 feet, but has been found as high as 10,000 feet.

Biology/ecology: Germinates in spring or fall. Seedlings develop into and remain as rosettes for at least one growing season while root growth occurs. Usually bolts for the first time in May of its second growing season and flowers from August to September. Individual flowers bloom for 2–6 days. Plants are self-fertile and are also cross-pollinated by insects. Spreads only from seed, but does not tumble with the wind as does diffuse knapweed.

Control: Early detection and prompt control of small infestations are the most economical ways to manage this weed. Readily controlled with herbicides such as carboxylic acids but will reinvade unless a healthy plant community is re-established to inhibit reinvasion by plant competition. Herbicides should be applied before the mature plants set seed to maximize effectiveness. Biological control agents are available. Mowing after flowering, but before seed set, may be an effective way to decrease seed production. However, seeds can remain dormant in the soil for nearly a decade, requiring any cutting program to be repeated annually to be effective.

Diffuse knapweed
(*Centaurea diffusa*)

Description: Flowers are usually white, but may be rose-purple to lavender colored. Floral bracts have yellow spines with fringed sides appearing like the teeth on a comb along the spine margins. Lower leaves are stalked and divided into narrow, hairy segments. Stems are upright, 4–24 inches tall with short, stiff hairs.

Habitat and distribution: Found on light, dry, porous soils in open habitats and shaded areas. Elevations up to 8,500 feet.

Biology/ecology: Plants first form low rosettes and may remain in this form for one to several years depending on environmental conditions. Grows as a rosette until it reaches a critical size, then bolts, flowers, and usually dies. Flower buds are formed in early June and flowering occurs in July and August. Mature seeds are formed by mid-August. Spreads only by seed. About 50% of dead plants break off and tumble across the landscape over the winter, dispersing seed in the process.

Control: Treatment depends on each situation. Most effective method of control is to prevent its establishment. Areas that are adjacent to known patches should be monitored 2–3 times a year and any new rosettes should be destroyed. Established plants or stands can be pulled or spot treated with herbicides. Herbicides such as carboxylic acids should either be applied before the mature plants set seed, or to rosettes in the fall to maximize effectiveness. Biological control agents are available.

PERENNIAL FORBS

Dalmatian toadflax

(*Linaria dalmatica* and *L. genistifolia*)

Description: Easily identified by its bright yellow flowers that resemble snapdragons. Unlike yellow toadflax, flowers usually lack an orange throat. Leaves are spade-shaped, broad and rounded at the base and tapering toward the end. *L. dalmatica* is broad-leaved and *L. genistifolia* is narrow-leaved. Stems are thick walled and somewhat woody. Mature plants grow up to 3 feet tall.

Habitat and distribution: Can adapt its growth to fit a wide range of environmental conditions and is tolerant of low temperatures and coarse-textured soils. *L. dalmatica* is widespread; it is commonly found between 5,000–6,500 feet and has been found growing at elevations of up to 9,000 feet.

Biology/ecology: Spring emergence occurs about mid-April and depends primarily on temperature. During the first year, the plant forms a rosette and develops a deep root system. Prostrate stems emerge in September and produce leaves. After overwintering, upright stems emerge about the same time as new seedlings in mid-April. Flowering occurs from May to August and seeds mature from July to September. Seeds are winged and are readily dispersed by wind. Can also reproduce vegetatively from root buds as early as 2–3 weeks after germination from root fragments as short as 0.3 inches in length. Buds can grow their own root and shoot systems and become independent plants the next year.

Control: Management must focus on both reducing the rate of vegetative spread and reducing seed production. Successful control can be obtained by killing the plants with herbicides, including carboxylic acids, from flowering through fall. Since the plant also spreads through vegetative propagation and the seeds can remain dormant for up to 10 years, this process must be repeated every year for at least 10 years to completely remove a stand. Biological control agents are available.

Yellow toadflax

(*Linaria vulgaris*)

Description: Identified by its yellow, snapdragon-like flowers. Distinguished from Dalmatian toadflax by slender stems and pointed leaves. Mature plants have 1–25 smooth erect floral stems and are usually 1–2 feet tall, but can be over 5 feet tall.

Habitat and distribution: Highly variable habitat that depends on environmental factors such as shading, grazing, and soil type. Often grows in patches. It is typically found from 6,000–8,500 feet, but can be found at 10,000 feet and higher.

Biology/ecology: Spring emergence occurs around mid-April and depends primarily on temperature. Normally does not flower until at least July, especially at higher elevations. Seeds mature from July through October. Does not self-pollinate and relies on insects for pollination. Can reproduce both by seeds and vegetatively.

Control: Limit vegetative spread of established colonies. Once current seed production has been controlled, toadflax seedlings that emerge from the soil seed bank must be destroyed every year until the seed bank is diminished. Effectiveness of herbicides is highly variable. Herbicides, such as carboxylic acids, should be applied during flowering or early fall. Biological control agents are available, but have had limited success.

Canada thistle
(*Cirsium arvense*)

Description: Flower heads are white to purple, in clusters of 1–5 per branch, with a strong vanilla scent. Leaves are spiny, oblong, or lance shaped. Mature plants range from 2–4 feet in height.

Habitat and distribution: Mainly invades disturbed areas. Adapted to a wide range of soil types and environmental conditions. However, it does not tolerate permanently waterlogged or poorly aerated soils. Commonly found in disturbed areas statewide at elevations from 4,000–12,000 feet.

Biology/ecology: Overwintering roots develop new underground roots and shoots in January and begin to elongate in February. Shoots emerge between March and May and form rosettes. Early in the spring, plants remain near the soil surface until long days trigger flowering and stem elongation. Male and female flowers are produced on separate plants. Flowering occurs and seeds mature from June to October. Reproduces primarily vegetatively through creeping horizontal roots and can quickly form dense stands. Every piece of the root system is capable of forming a new plant.

Control: Combine mowing with herbicides to further enhance control. Apply herbicides, including carboxylic acids, in the spring or fall depending on local environmental conditions. A gall fly, a stem weevil, and a flower weevil are available as biological control agents.

Leafy spurge
(*Euphorbia esula*)

Description: Flowers are yellowish-green, small, and arranged in small clusters surrounded by heart-shaped, showy bracts. Plant foliage is smooth and hairless. Mature plants are up to 3 feet tall. The entire plant contains white, milky latex, easily seen when stems are opened.

Habitat and distribution: Grows in a wide range of habitats, but is most aggressive in riparian areas. Grows on all kinds of soils, but it is most abundant in coarse-textured soils and least abundant on clay soils. Common on disturbed soils between 5,000–6,500 feet, but can be found at elevations up to 9,000 feet or more.

Biology/ecology: One of the earliest plants to emerge in the spring, usually in mid- March to early April. Flowering typically occurs in mid-April to late May and into June. If conditions are favorable, may produce flowers throughout the summer and into the fall. Seeds mature about 30 days following pollination. Peak germination occurs from late-May to early June. If adequate moisture is present,

germination can occur throughout the growing season. Primarily reproduces vegetatively through its extensive lateral root system.

Control: Persistent monitoring of areas with known or potential infestations is crucial to management. New infestations are much more easily controlled than established infestations. Herbicides, including carboxylic acids and imidazolinones, are commonly used for control. However, due to the plant's extensive root system and general hardiness, follow-up applications are necessary for herbicides to be effective. Mowing can actually increase the density of leafy spurge and may not be effective even when combined with herbicide. Biological control agents include root and foliage feeding beetle species and a stem and root boring beetle. A management scheme that combines control methods over 4–5 years is recommended.

Orange hawkweed
(*Hieracium aurantiacum*)

Description: Flowering heads are clustered at the top of the leafless stems and have orange to red petal-like ray flowers with notched tips. Stems are 6–18 inches tall and both stems and leaves have stiff hairs.

Habitat and distribution: Favors open and forested areas. Prefers moist soils. Elevations range from 5,000–10,500 feet.

Biology/ecology: Forms rosettes in the spring and early summer and spread primarily by stolons. Plants flower in June to July and quickly produce seed. Overwinter as rhizomes and regrow the next spring. Reproduces by seeds, stolons, and rhizomes.

Control: Spreads primarily by vegetative reproduction and is difficult to control once established. Focus on detecting and eradicating infestations as early as possible, and on implementing land-use practices that promote a healthy cover of perennial vegetation. Mowing will prevent seed production, but encourages increased vegetative reproduction. Herbicides such as carboxylic acid effectively control populations.

WOODY PLANTS

Weed trees displace native or stand trees. Weed trees can include those mentioned below and such species as Ponderosa pine, lodgepole pine, white fir, Engelmann spruce, aspen, and willow.

Big sagebrush
(*Artemisia* spp.)

Description: Usually less than 3 feet tall but can reach heights over 10 feet in deep soils. Evergreen with blue-green strap-shaped leaves with three distinct lobes at the tips.

Habitat and distribution: Exists in a variety of climatic conditions, including low-elevation semidesert habitats and moist, cool, mountainous areas. Found at elevations of 4,000–10,000 feet. On moist sites it may reach 10 feet tall, but typically it is under 5 feet tall.

Biology/ecology: Flowers appear in late August. Reproduce by seeds. Seed formation and shed occurs from October to December.

Control: Treat with herbicides, burning, or mechanical removal.

Gray rabbitbrush
(*Ericameria nauseosa*)

Description: Strongly scented with many branches. Stems are silky or white, woolly covered, and range

in height from 2–4 feet. Flowers are in large clusters at the tips of the stem and yellow in color.

Habitat and distribution: Grows well on dry soils and in openings in sagebrush, pinyon-juniper, and ponderosa pine stands.

Biology/ecology: Establishes from seed and by sprouting. Flowers from mid-summer to fall. Seed ripens from late fall to early winter. Seed set occurs in late September at higher elevations and in late November at lower elevations. Seed dissemination starts before all flowers are fully mature. Germination occurs from March through June.

Control: Control is difficult due to its ability to resprout from the crown after being sprayed or burned. Can be susceptible to herbicides such as 2,4-D, but results vary widely according to type of treatment, rate of application, and date and year of treatment.

Gambel oak

(*Quercus gambelii*)

Description: Usually a shrub or a small tree with an average height of 20–30 feet and width of 15 feet. Leaves are about 5 inches long with several rounded, deeply cut lobes on each side of the central vein. Twigs are brownish in color, usually crooked and distorted. Branches usually are ascending, forming an irregular crown. Fruit is a typical acorn. Bark is red-brown to gray with rough furrows on older stems.

Habitat and distribution: Found at elevations of approximately 4,000–8,500 feet.

Biology/ecology: Produces buds in winter for the following spring.

Control: Burning and top-kill promotes vegetative sprouting. Control with herbicides is extremely variable depending upon growing season and herbicide used. Application of hormone-type herbicides is recommended before full leaf stage or in late August before the end of fall regrowth.

Snowberry

(*Symphoricarpos* spp.)

Description: Deciduous shrub that is densely branched. Plants vary in height from 3–4.5 feet.

Habitat and distribution: Found in ponderosa pine, Douglas-fir, and subalpine fir forest habitats.

Biology/ecology: Initiates budding in early May. Leaves are full-grown about one month after emergence. Flowers appear any time from May to August and may be present as late as September. Peak flowering time is June and July. Fruit ripens during late August and early September, coinciding closely with fall leaf drop. Fruits commonly remain on the plant over winter.

Control: Metsulfuron, applied after the brush has leafed out but before the leaves begin to turn in fall, will reduce the canopy significantly for at least six years. 2,4-D applied in spring is less effective. Retreatment the following year is required. Burning and mowing can be used to encourage even regrowth, which can then be treated with herbicides when plants are first flowering.

Chokecherry

(*Prunus virginiana*)

Description: Native, deciduous, thicket-forming erect shrub or small tree. Stems are numerous and slender, either branching from the base or with main branches upright and spreading. Heights range from 3–20 feet. Flowers are borne on leafy twigs of current year's growth. Has a network of rhizomes and a deep root system established at intervals along the rhizomes.

Habitat and distribution: Grows at low to mid-elevations on silt to sandy loam soils. Persists under closed canopies in mature conifer forests and in riparian areas.

Biology/ecology: Reproduces sexually and vegetatively. Plants leaf out in spring to early summer and flower 1–3 weeks later, with fruits maturing in late summer to fall.

Control: Control of chokecherry is not practical on a large scale. However, several herbicides are effective for control on small scale projects.

GLOSSARY

Abrasive - Physical wearing and grinding of a surface through friction and impact by a material.

Abdomen - The last of the three major body divisions of an insect.

Abiotic - A nonliving, disease-causing entity, e.g., drought, salt, air pollutants.

Absorption - The process by which pesticides are taken into plants by roots or foliage (stomata, cuticle, etc.), animals (including humans), and microorganisms.

Acaricide - A pesticide used to control mites and ticks.

Action threshold - Levels of pest populations at which control should be implemented to avoid significant damage to the ornamental plant.

Action thresholds help determine both the need for control actions and the proper timing of such actions.

Active ingredients - The chemicals in a pesticide product that control the target pest. Abbreviated a.i.

Adjuvant - Any substance in a pesticide formulation or added to the spray solution that enhances the pesticide's effectiveness.

Adult - A full-grown, sexually mature insect.

Agitation - The process of stirring or mixing to keep a pesticide or tank mix from separating or settling in the spray tank.

Agitator - A paddle, air, or hydraulic action or device to keep a pesticide mixed in the spray or loading tank.

Airblast application - Applying pesticides using air and low or high liquid volumes. Used for spraying trees.

Alternate host - One of two kinds of plants on which a parasitic fungus (e.g., rust) must develop to complete its life cycle.

Alternative host - A plant other than the main host that a parasite can colonize. Alternative hosts are not required for completion of the developmental cycle of the parasite.

Annual - A plant that completes its life cycle in a single year.

Antidote - A treatment used to counteract the effects of pesticide poisoning or some other poison in the body.

Application rate - The specific amount of pesticide applied to a treated acre or target system.

Arthropod - An invertebrate with a jointed body and limbs (e.g., insect, mite, spider).

Asexual - Reproduction without the union of individuals or germ cells.

Backpack sprayer - A sprayer that can be strapped on a person's back and used to apply liquid pesticides. The attached hose has a nozzle at the tip that can be aimed at the spot to be treated.

Bacteria - Single-celled microorganisms which usually lack chlorophyll and reproduce by fission (splitting of the cell into two equal halves).

Basal area - The area of a cross-section of a tree, including bark, at breast height. Basal area of a forest stand is the sum of the basal areas of all individual trees in the stand, usually reported as square feet per acre or square meters per hectare.

Beneficial insect - Any insect that is advantageous to humans. Insects that preserve the balance of nature by feeding on other insects, pollinators, and recyclers are examples of beneficial insects.

Biennial - A plant that lives two years, producing a basal rosette of leaves the first year and a full plant, flower, and seed the second year, followed by death of the entire plant at the end of the second year.

Biological control - The use of living organisms, such as predators, parasitoids, and pathogens, to control pest insects. Typically involves some human activity.

Biotic - Relating to living organisms.

Blight - Large dead areas on leaves, shoots, or flowers. Often occurs rapidly.

Bolt - To develop a flowering stem from a rosette.

Borers - The name given to immature stages of beetles and moths that live and feed inside plants by boring through the living tissue.

Bract - A small, leaf-like structure below a flower.

Broadleaf tree - A tree with leaves that are broad, flat and thin; generally deciduous and shed annually as opposed to coniferous or needled trees.

Broad spectrum pesticide - A pesticide that will kill a wide range of pests. The opposite of a selective pesticide.

Calibration - The process of measuring and adjusting the amount of pesticide being applied through a nozzle, sprayer, or granular applicator over a given area.

Cambium - The tissue between the inner bark and wood that produces new cells.

Canker - A well-defined, necrotic (dead), often sunken area on a stem, trunk, or branch of a plant.

Carrier - The inert liquid or solid material in a pesticide product that serves as a delivery vehicle for the active ingredient.

Caterpillar - Larval growth stage of butterflies and moths (Lepidoptera).

Causal agent - An organism, such as a fungus, bacterium, or virus, that produced a disease.

Cephalothorax - The head (ceph) and chest (thorax) area of an arthropod.

Certified applicator - Any applicator with a commercial pesticide applicator license with appropriate category(s).

Chemical control - Reduction of pest populations or prevention of pest injury by the use of materials to poison them, attract them to other devices, or repel them.

Chlorophyll - The green photosynthetic substance in plants that allows them to capture solar energy.

Chlorosis - Yellowish-green coloration in normally green tissues, such as leaves.

Cholinesterase - Enzyme whose role is to break down released acetylcholine in the synaptic gap between nerve cells.

Cocoon - A silken case formed by an insect larva for pupation.

Commercial applicator - is a person eighteen (18) years of age or older who are individuals seeking to purchase, use, or supervise the use of all pesticides (general and restricted) on a for- hire basis or employment. This includes independent contractor

or employed applicators, city, county, state, and federal employees who apply pesticides as part of their job. Commercial applicators are certified in one or more categories and may use pesticides only in the category(s) for which they are certified.

Compatibility - The characteristic of a substance, especially a pesticide, of being mixable in a formulation or in the spray tank for application in the same carrier without undesirably altering the characteristics or effects of the individual components.

Complete metamorphosis - Type of insect development characterized by four distinct stages: egg, larva, pupa, and adult.

Concentrate - Pesticide having a high percentage of active ingredient; occasionally applied full strength, but usually diluted before application.

Concentrated emulsion (EW) - Formulation consisting of a water-based emulsion and an active ingredient paste.

Concentration - The amount of pesticide active ingredient in a given volume or weight of formulation.

Conidia - Asexual fungal spores.

Conifer - Any tree that produces seeds in cones, with no fruit structure around the seed. Leaves are usually needles or scales, narrow and linear in shape, and evergreen.

Contact poison - A pesticide that kills when it touches or is touched by a pest. It does not have to be ingested. Often used in reference to a spray applied directly to the pest.

Corrosion - Process of being worn away gradually by chemical action.

Cotyledon - The first leaf, or pair of leaves, of the embryo of seed plants.

Crawler - An immature stage of a scale insect. The active crawling stage.

Cross-resistance - A pest population that has become resistant to one pesticide also becomes resistant to other chemically related pesticides.

Crown - The live branches and foliage of a tree.

Decay - The decomposition of wood caused by fungi, resulting in softening, progressive loss of strength and weight, and often changes in texture and color.

Deciduous - Term applied to trees (commonly broadleaf) or shrubs that usually shed their leaves annually. Also known commercially as hardwoods.

Defoliation - The removal of foliage from plants, often by chewing insects.

Degradation - The breakdown of a chemical in the environment. Usually occurs via the action of sunlight, temperature, and microorganisms in the soil. This process can transform a toxic chemical into a benign chemical, or can create new, toxic breakdown products.

Diameter at breast height (dbh) - Diameter of a tree at “breast height,” or 4.5 feet above ground level, the accepted point of diameter measurement for most trees. The abbreviation generally is written without capital letters or periods. In practice, the circumference is actually measured, but a special measuring tape (“d- tape”) is used that is marked so that diameter can be read directly.

Dicot - A plant that has two seed leaves or cotyledons; broadleaf plants.

Dieback - The progressive death of branches or shoots beginning at the tips and moving toward the main stem, or trunk.

Diluent - Any liquid, gas, or solid material used to dilute or weaken a concentrated pesticide.

Disease - A condition in which any part of an organism is abnormal as the result of an infectious or noninfectious agent.

Disease cycle - The chain of events involved in disease development, including the stages of development of the pathogen and the effect of the disease on the host.

Disease triangle - The relationship of the following three factors: a susceptible host plant, a pathogen, and the right mix of environmental conditions.

Dormant - Having growth, development, or other biological activity suspended; resting, inactive.

Dormant oil - An oil used on woody plants during the dormant season.

Drift - The movement of airborne particles or vapors away from the intended target area.

Dry flowable (DF) - Formulation made of finely ground pesticide particles, compressed into granules that can be suspended readily in water for application.

Dust (D) - A finely ground, dry pesticide formulation containing a small amount of active ingredient and a large amount of inert carrier or diluent such as clay or talc.

Efficacy - The effectiveness of a given pesticide or pest control method at controlling a particular pest species under a given set of conditions.

Egg - The first stage of development for most arthropods.

Emulsifiable concentrate (EC) - A concentrated pesticide formulation that usually contains a liquid active ingredient, one or more petroleum- based solvents, and an agent that allows the formulation to be mixed with water to form an emulsion.

Emulsion - A mixture in which one liquid is suspended as small droplets in another liquid (e.g., oil in water).

Environmental Protection Agency (EPA) - The government agency that regulates chemical products such as pesticides. The EPA is responsible for ensuring that each product is safe for use for both the consumer and the environment. Before a pesticide may be sold in commerce, it must be registered with the EPA.

Eradication - Destroying an entire pest population in an area.

Ester - A compound formed by the union of an organic acid and an organic base (an alcohol). An example is 2,4-D and isoctyl alcohol to form the isoctyl ester of 2,4-D.

Evergreen - A plant that has foliage throughout the year. An evergreen plant does drop its older leaves each year, though this often occurs over a long period of time and at any season. Foliage may be needles, scales, or broad leaves.

Exoskeleton - A skeleton or supportive structure on the outside of an insect body.

Exposure - Occurs when a person comes into contact with a chemical in their environment. May involve oral ingestion, inhalation, and absorption through the skin or the mucus membranes of the eyes, nose, or mouth.

Family - An animal classification category, consisting of a group of closely related genera of similar animals, such as the tiger beetle family.

Fascicles - A bundle or cluster of stems, flowers, or leaves.

First aid - The first effort to help a victim while medical help is on the way.

Flowable (F) - Formulation made of finely ground pesticide particles that are suspended in a liquid, which is then diluted with water for application.

Foliage - The leaves of a plant. May include the stems.

Foliar - Applied to the leaves of a plant.

Forb - A non-grasslike herbaceous plant; a broad-leaved herb.

Forest - A plant community predominantly of trees and other woody vegetation, growing more or less closely together.

Forestry - The science of establishing, cultivating, and managing forests and their resources.

Formulation - Pesticide product as sold, usually a mixture of active and other (inert) ingredients.

Fruiting body - A fungal reproductive structure containing or bearing spores, such as mushrooms and conks.

Fumigant - Pesticide that is a vapor or gas or that forms a vapor or gas when applied and whose pesticidal action occurs in the gaseous state.

Fungi - Small, often microscopic plants that live either as a saprophyte or parasite. It contains no chlorophyll, has no vascular system, and is not differentiated into roots, stems, or leaves.

Fungicide - A pesticide used to control fungi.

Gall - Abnormal swelling of a portion of a branch, leaf, root, or bud. A tumor.

Gallery - A passage, burrow, tunnel, or mine excavated by an insect (especially by bark beetles) in plant tissues for feeding, oviposition, or shelter.

Gels - Semi-liquid emulsifiable concentrates that are used with water soluble packaging.

General use pesticide - A pesticide that can be purchased and used by the general public without undue hazards to the applicator and the environment as long as the instructions on the label are followed carefully.

Generation - Period from any given stage in the life cycle to the same life stage in the offspring. Typically from egg to egg.

Genus - A group of closely related species (plural: genera). The name of the genus is incorporated into the scientific names of all the member species: *Fenusa pusilla* and *Fenusa dohrnii*, for example, both belong to the genus *Fenusa*.

Girdling - A method of killing unwanted trees by making continuous incisions, through the bark and underlying living tissues, completely around the tree stem. Girdling “starves” roots by depriving them of sugars produced in the leaves.

GPA - Gallons per acre.

GPM - Gallons per minute.

Granular (G) - A dry formulation of pesticide and other components in which the active ingredient is impregnated on discrete particles generally less than 10 cubic millimeters in size such as clay or ground corncobs. They are applied in the dry form.

Groundwater - Water that flows in aquifers underground rather than in rivers, streams, and lakes on the surface. Groundwater is generally accessed via wells and is frequently used for drinking.

Grub - An insect larva; a term loosely applied, usually to larvae of Coleoptera; a larva is thick-bodied with well developed thoracic legs but no abdominal prolegs.

Hardwood - Tree species in the angiosperm group (flowering plants that produce seeds enclosed in a fruit). Hardwood trees are characterized by broad leaves and are usually deciduous.

Hazard - The probability that injury or detrimental effects will result if a substance, mixture of substances, or a process involving substances is not used properly. Hazard is a function of toxicity and exposure.

Hazardous materials (hazmat) - A substance or combination of substances which, because of quantity, concentration, or physical, chemical, radiological, explosive, or infectious characteristics, poses a substantial present or potential danger to humans or the environment.

Head - The frontal body region; the section that bears the antennae, eyes, and mouthparts.

Herbicide - A pesticide used to kill or inhibit plant growth.

Hibernacula - A winter shelter constructed by an insect.

High pressure sprayer - A machine that applies pesticides by using water at high pressure and volume to deliver the pesticide to the target. Same as hydraulic sprayer.

Honeydew - A sweet, sticky fluid excreted by aphids, certain scales, mealybugs, whiteflies, and some leafhoppers.

Horticultural oil - An oil used to control a pest on plants.

Host - The living plant or animal that serves as food for a predator, parasitoid, or pathogen.

Host range - All hosts that a particular pathogen or insect attacks.

Hydraulic sprayer - A machine that applies pesticides by using liquid to deliver the pesticide to the target.

Hyphae - Long, thread-like filaments that make up the vegetative body of most fungi.

Incompatible - Mixing two or more pesticides resulting in a loss in activity, an increase in toxicity or hazard to the applicator, or harm to the plant or the environment.

Inert ingredient - That part of a formulation without toxic or killing properties. Also referred to as “other ingredient.”

Infection - The process of the pathogen gaining entrance to the host and becoming established as a parasite.

Injection - Introducing concentrated chemical pesticides into shallow trunk wounds around the base of a tree or into the soil.

Injection sprayer - A sprayer system in which the pesticide and water are kept in separate containers on the sprayer. When the sprayer is activated, a metered flow of pesticide is injected into the water stream via a mixing chamber, which is situated between the main water tank and the pipe work to

the nozzles. Often a number of pesticide containers and pumps are fitted to allow the applicator to apply more than one product.

Inoculation - The process of transferring inoculum to the host.

Inoculum - Any stage, structure, or form of a pathogen capable of initiating disease.

Inorganic fungicides - Pesticides of mineral origin; they do not contain carbon.

Insect - A type of small animal characterized by a hard exoskeleton, three body sections, six legs, single pair of antennae, wings, and compound eyes. Common examples of insects include grasshoppers, true bugs, beetles, butterflies, moths, flies, bees, and wasps.

Insecticide - Any poisonous substance used to kill insects.

Insect growth regulator (IGR) - A substance, natural or synthetic, that controls or modifies insect growth processes.

Instar - The stage of an insect's life between successive molts. For example, the first instar is between hatching from the egg and the first molt.

Integrated pest management (IPM) - An approach to the management of pests in which all available control options, including physical, chemical, and biological controls, are evaluated and integrated into a unified program.

Label - All written, printed, or graphic matter on or attached to the pesticide product, or the immediate container thereof, and the outside container or wrapper to the retail package of the pesticide product.

Labeling - All information and other written, printed, or graphic matter upon the pesticide product or device or any of its accompanying containers or wrappers to which reference is made on the label or in supplemental literature accompanying the pesticide product or device.

Larva - The immature instars, between the egg and pupal stages, of an insect having a complete metamorphosis (egg, larva, pupa, adult) that differ fundamentally in form from the adult, i.e., grubs, caterpillars, and maggots. Larvae feed and grow but cannot fly, nor can they reproduce. (Plural: larvae.)

Leaf spots - Dead or discolored areas on the leaf tissue that are fairly small and are usually circular.

Lenticels - Slightly raised areas on the bark of stems or roots.

Lesion - A localized area of discolored, diseased tissue (e.g., spots, cankers, scales).

Life cycle - The series of stages an organism passes through during its lifetime.

Maggot - The legless, soft-bodied, wormlike larva of any of various flies of the order Diptera, often found in decaying matter.

Mechanical control - Control of pests by physical means such as the use of barriers and mulching.

Metamorphosis - The series of changes in form through which insects and insect-like organisms pass in their growth from egg to adult.

Mite - A member of the order Acari (ticks and mites).

Miticide - A pesticide used specifically to manage or prevent damage caused by mites. Also called acaricide.

Mode of action - Manner in which pesticides kill or inhibit an organism.

Molluscs - A large group of land and water animals including snails and slugs.

Monocot - Plants that contain one cotyledon, such as grasses.

Molting - The process of shedding the exoskeleton.

Mycelium - The mass of hyphae that make up the body of a fungus.

Natural enemies - Living organisms found in nature that kill, weaken, or reduce the reproductive potential of other organisms.

Necrosis - Death of plant cells or entire portions of a plant, usually resulting in darkening of the affected areas.

Non-persistent pesticide - Controls pests at the time of application, then breaks down rapidly.

Nonselective pesticide - A pesticide that is toxic to most plants or animals.

Non-systemic - A pesticide that stays on the surface of a plant. It does not enter into or move through a plant.

Noxious weed - A legally defined term that refers to a specific plant species that has been designated for mandatory control by branches of local, state, or federal government due to the harm, actual or potential, that the species is capable of inflicting upon the resources and values of society.

Nozzle - Device that controls drop size, rate, uniformity, and thoroughness of a pesticide application.

Nursery - Any area where nursery stock is propagated, held, or grown for sale purposes.

Nymphs - The immature stage of insects undergoing simple metamorphosis (egg, nymph, adult). Nymphs do not fundamentally differ in form from the adult.

Order - One of the primary divisions of the classification system. Consists of a few to many families.

Overwinter - Time spent during the winter months.

Parasite - An organism that obtains all or part of its food from other organisms.

Parasitoid - An organism that feeds in or on another organism, consuming all or most of its tissues and eventually killing it.

Pathogen - Any disease-producing organism.

Pentachlorophenol - A pesticide used as a wood preservative for utility poles and railroad ties.

Perennial - Plants that live or grow for more than one year. Some resprout from a root system or reseed themselves every year.

Persistence - The time during which a pesticide retains its toxic properties. Persistence is often expressed in terms of half-life, the time required for the pesticide to degrade to one-half of its previous concentration.

Personal protective equipment (PPE) - Devices and clothing worn to protect the body from exposure to pesticides or pesticide residues. Includes such items as long-sleeved shirts, long pants, coveralls, hats, chemical-resistant gloves, shoes, respirators, and other safety items as specified on the label.

Pest - An organism that interferes with human activities, property, or health, or is objectionable.

Pesticide - (1) Any substance or mixture of substances that are intended for preventing, destroying, repelling, or mitigating any pest. (2) Any substance or mixture intended for use as a plant regulator, defoliant, or desiccant. Pesticides are also described as insecticides, herbicides, fungicides, nematicides, rodenticides, etc., depending upon the class of pests they are being used to control.

pH - A value expressing the acidity or alkalinity of a solution on a scale of 1 to 14; the neutral point is 7, below 7 is acidic, and above 7 is alkaline.

Pheromone - A substance, such as a sex attractant, that is given off by an insect that causes a specific reaction by other members of the same species; includes trail-making pheromones, sex attractants, and alarm substances.

Phloem - Plant tissue that conducts nutrients (food) through the plant. In woody-stemmed plants, the phloem is the inner layer of the bark.

Phytoplasma - A class of microorganisms that can cause disease in some plants.

Phytotoxic - Said of a chemical or formulation that can injure plants.

Pith - The central core of a stem and of some roots, representing the first year of growth and consisting mainly of soft tissue.

Plant competition - The interaction between plants for light, moisture, and soil nutrients.

Point source pollution - Pollution that arises from pesticides or other materials by spilling or dumping these materials in one location.

Poison control center - An agency that has current information about proper first aid techniques and antidotes for all poisoning emergencies. The Rocky Mountain Poison and Drug Center's telephone number is 1-800-222- 1222.

Pollination - The transfer of pollen from one flower to another, usually with the assistance of insects.

Post-emergence - Application of a pesticide after emergence of the specified plant.

Predator - An insect or animal that attacks, feeds on, and kills other insects or animals.

Pre-emergent - Applied before seedlings or weeds begin to grow (emerge) in the spring. This most often refers to applying a herbicide after the trees are planted, but before the weeds begin to grow.

Pressure gauge - A device that indicates pressure differential above or below atmospheric pressure.

Pressure regulator - A device that controls the pressure of spray material delivered by nozzles.

Prevention - Keeping a pest from becoming a problem.

Private applicator - is an individual eighteen (18) years of age or older who is licensed to apply RESTRICTED USE PESTICIDES (RUP) to their own properties, either owned or leased, or who may apply restricted-use pesticides for other individuals on their properties, owned or leased either for no charge, or as exchange of services, but not for pay, in the production of an agricultural commodity. Applicator classification is not related to either the amount of pesticides applied, or to the amount of acreage treated. Prostrate - Lying flat on the ground.

Protectant - A chemical applied to a plant or animal in anticipation of a pest problem to prevent infection or injury by the pest.

PSI - Pounds per square inch.

Pump - A mechanical device for causing flow, for raising or lifting water or other fluid, or for applying pressure to fluids.

Pupa - The inactive, intermediate stage between the larva and adult stage of insects with complete metamorphosis.

Pupate - To change from the larval stage to the pupal stage.

Pustule - A pimple-like or blister-like elevation.

Rate - The amount of pesticide applied to a site, usually expressed as a liquid or dry measure per unit area, e.g., pounds or pints per 1,000 square foot.

Ready-to-use formulation (RTU) - No further dilution of a formulation is required before application.

Registration - Formal listing with EPA of a new pesticide or new use of a pesticide before it can be sold or distributed. Under FIFRA, EPA is responsible for registration (pre-market licensing) of pesticides on the basis of data demonstrating no unreasonable adverse effects on human health or the environment when applied according to approved label directions.

Regulatory control - Legal methods aimed at excluding, eradicating, or reducing plant pests.

Release - Freeing a tree or group of trees from competition by cutting or otherwise eliminating growth that is closely surrounding them.

Residual pesticide - A pesticide that continues to be effective on a treated surface or area for an extended period following application.

Residue - (1) The amount of a pesticide remaining in or on raw farm products or processed foods. (2) Undesirable persistence of a pesticide at the site of application. (3) The pesticide left on the surface at the time of application.

Resistance - Genetically inherited ability to withstand doses of pesticide that would kill individuals from species whose ancestors had not been exposed to the pesticide.

Respirator - A face mask used to filter out poisonous gases and dust particles from the air so that a person can breathe and work safely.

Resting spore - A sexual or other thick-walled spore of a fungus that is resistant to extremes in temperature and moisture and which often germinates only after a period of time from its formation.

Restricted use pesticide (RUP) - A pesticide that is designated as such by EPA or Wyoming Department of Agriculture because it is felt that it may generally cause, without additional regulatory restrictions, unreasonable adverse effects on the environment, including injury to the applicator. A restricted use pesticide may be used only by, or under the direct supervision of, a certified applicator.

Rinsate - Rinse water from pesticide tank cleaning.

Rodenticide - A pesticide used to control rodents.

Rogue - To remove trees that have an undesirable phenotype, or that have been shown through progeny tests to have a less desirable genotype from a seed orchard, seed production area, or nursery bed.

Root collar - The part of a tree where the main roots join the trunk, usually at or near ground level.

Rosette - A compact cluster of leaves radiating at ground level, often in a circle.

Rot - The disintegration, discoloration, and decomposition of plant tissue.

Runoff - The movement of water and associated materials on the soil surface. Runoff usually travels to bodies of surface water.

Rust - A plant disease that gives a "rusty" appearance to a plant and is characterized by dense masses of reddish-brown spores.

Safety data sheet (SDS) - Formerly known as a Material Safety Data Sheet (MSDS). A document required for each hazardous chemical including pesticides by the Occupational Health and Safety Act. It contains health and safety data as well as physical properties pertinent to the chemical that will aid in an emergency situation. A SDS can be obtained through the distributor or the manufacturer of the pesticide.

Sapwood - The outer layer of wood in a tree that contains living cells. Sap circulates within the sapwood of woody plants.

Scientific name - The internationally recognized Latin name of an animal or plant; the scientific name consists of two parts, the genus and the species.

Sclerotia - A hard, dense, compact mass of mycelia serving as a resting body.

Scorch - The sudden browning of large, indefinite areas on a leaf; caused by infection, chemical injury, or unfavorable weather conditions.

Seedling - (1) Young plant established from seed, up to several feet in height. (2) A nursery-grown tree that has not been transplanted in the nursery.

Selective pesticide - A pesticide that is more toxic to some kinds of plants and animals than to others.

Service container - Any container holding pesticide, whether in a concentrated or diluted form, other than the pesticide's original container, that is of a size and capacity that permits it to be carried or moved by only one individual, unaided by any tool or apparatus.

Shrub - A plant that is usually smaller than a tree and generally has multiple branches originating at or near the ground.

Signs - (1) The visible vegetative and/or reproductive structures of a pathogen. (2) An outward signal of poisoning. (3) Warning signs used for posting.

Silviculture - The practice of controlling forest composition, structure, and growth to maintain and enhance the forest's utility for any purpose.

Simple metamorphosis - Type of insect development characterized by three distinct stages: egg, nymph, and adult.

Site - The area infested by a pest and to which a pesticide is applied.

Site preparation - Preparing an area for reforestation by clearing or other vegetation control.

Skeletonize - The removal of the green portions of a leaf leaving only the veins, midrib, and a transparent membrane.

Softwood - Any tree in the conifer group, including pines, hemlock, cypress, larch, spruce, fir, and junipers. So named because many of the species have wood that is less dense than that of many hardwoods.

Soil organic matter - Partially decayed and partially resynthesized plant and animal residues in the soil.

Soluble - A material that dissolves completely in a liquid.

Soluble powder (SP or S) - Dry pesticide formulation that forms a true solution when mixed with water.

Solution - A homogenous mixture of one or more substances (solutes) in another substance (solvent) that is usually a liquid; the solutes are completely dissolved and will not settle out or separate under normal conditions.

Solvent - A liquid in which one or more substances dissolve to form a true solution.

Sooty mold - A dark or black velvety coating of mycelium of various fungi growing in insect honeydew on the leaves, fruit, or other exposed parts of plants.

Species - A group of similar-looking organisms that can and do reproduce with one another and that cannot breed successfully with other species. Abbreviated “spp.”

Spider - A type of small animal characterized by a hard exoskeleton, two body sections, eight legs, and simple eyes.

Spill - A release of a compound into the environment (e.g., air, water, soil) in any manner other than its intended use.

Spore - A sexual or asexual reproductive unit of a fungus that usually functions for dissemination and/or survival; equivalent in many respects to the seed of plants.

Spot treatment - Applying a pesticide to a small area.

Spray drift - The movement of airborne spray particles from the spray nozzle beyond the intended contact area.

Stage - Any definite period in the development of an insect, e.g., egg, larva, etc.

Stand - A group of trees sufficiently uniform in species composition, size, age, structure, spatial arrangement, and condition to be distinguished from surrounding stands and managed as a single unit.

Stomach poison - An insecticide that is lethal only after it has been ingested by an insect, entering the insect body through the gut.

Strainer - A screen used to prevent scales, rust flakes, and other foreign material from plugging nozzles or other working parts of a sprayer.

Summer oil - An oil used on plants when foliage is present.

Supplemental labeling - Pesticide label information that appears on a separate piece of paper and contains information regarding the site, pest, rate, etc. Supplemental labeling may be supplied at the time of purchase or requested from the dealer.

Surface water - All water naturally open to the atmosphere (rivers, streams, creeks, brooks, reservoirs, ponds, lakes, etc.), whether natural or artificial.

Susceptible - Unable to withstand, without serious injury, attack by an organism or damage by a nonliving agent.

Suspension - A liquid or gas in which very fine solid particles are dispersed, but not dissolved. Example: wettable powder in water.

Symptom - (1) Any detectable change in an organism resulting from the activities of a pathogen or other pest. (2) A warning that something is wrong that is detected by a person who has been poisoned, such as nausea or headache.

Systemic pesticide - Absorbed into and moves (translocates) throughout the host or target pest.

Tank - A major component of a sprayer that holds the liquid used in pesticide application.

Tank mix - The mixture of two or more compatible pesticides in a spray tank in order to apply them simultaneously.

Target - The site or pest toward which control measures are being directed.

Telia - Gelatinous hornlike projections formed on the tissue of a plant infected by a rust fungus.

Temperature inversion - A condition in which air above an area is warmer than air near the ground. This warm air forms a cap that may cause a pesticide vapor or droplets to collect and concentrate.

Thinning - Cutting trees to reduce stand density and increase growth of remaining trees.

Thorax - The insect body region behind the head that bears the legs and wings.

Timber stand improvement (TSI) - Improving the quality of a forest stand by removing or killing undesirable species to achieve desired species composition. TSI practices include applying herbicides, burning, girdling, or cutting.

Toxicity - The degree to which a substance or mixture of substances can harm humans or animals.

Translocation - The internal movement of food, water, minerals, or other materials (e.g., pesticides) from one part of a plant to another.

Tree - A plant that usually has a dominant vertical trunk and reaches heights of 15 feet or more.

True bugs - Insects in the order Hemiptera. Usually characterized by a triangular-shaped section on the back, and two pairs of wings.

True liquid/solution - When the active ingredient is mixed with water, the water remains clear.

Tubercle - A small, knob-like or rounded projection.

Vapor drift - The movement of chemical vapors from the area of application.

Viroid - A parasite consisting only of a piece of genetic material. Viroids are the simplest known "organisms" capable of reproduction; they are smaller than viruses.

Virus - A parasite often consisting only of a piece of genetic material; viruses are so small that they cannot be seen with an ordinary microscope.

Volatilization - The chemical process of passing from a liquid state to a vapor or gas, such as when vapors are released from a liquid pesticide.

Water dispersible granules (WDG) - A pesticide formulation in which finely divided powders are formulated into concentrated, dustless granules that form a suspension in water.

Water-soaked - A dull green coloration of diseased tissues due to membrane leaking of cellular contents into intercellular spaces.

Water-soluble packet (WSP) - A package for wettable powders, soluble powders, and gels.

Watershed - The region draining into a river, river system, or body of water; the total land area, regardless of size, above a given point on a waterway that contributes runoff water to the flow at that point; all the land that serves as a drainage for a specific stream or river.

Water table - The dividing line between the unsaturated zone and the saturated zone. Water below the water table is groundwater.

Wettable powder (WP) - A dry pesticide formulation, usually mixed with water for application. Does not dissolve in water, but forms a suspension.

Wick applicator - A specialized applicator for pesticides that is made of an absorbent material like cloth.

Wilt - The loss of water in the plant, which then causes the leaves and twigs to droop.

Windbreaks - Strips of trees and/or shrubs planted and maintained to alter windflow and microclimate, thereby protecting a specific area.

Witches' broom - Twig growth causing side shoots to elongate equally, forming a dense cluster or broomlike mass of twigs.

Woody plants - Perennials that have a thick, tough stem or trunk covered with bark.

Worker Protection Standards (WPS) - Standards designed to reduce the risks of illness or injury resulting from workers' and handlers' occupational exposures to pesticides used in the production of agricultural plants on farms or in nurseries, greenhouses, sod farms, and forests and also from the accidental exposure of workers and other persons to such pesticides.

Evergreen bagworm

Evergreen bagworm

Western spruce budworm moth
USDA Forest Service - Coeur d' Alene Field Office, Bugwood.org

Spongy moth larva

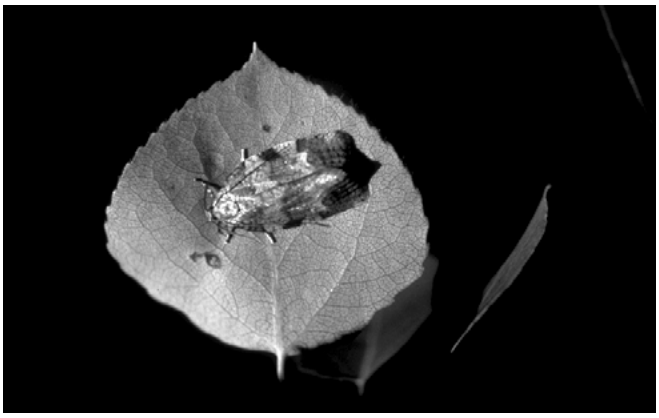
Pine needle scale
William M. Ciesla, Forest Health Management International, Bugwood.org

Engraver beetle boring dust
Jeffrey Eickwort, FL Department of Agriculture and Consumer Services, Bugwood.org

Flathead apple tree borer
Ladd Livingston, Idaho Department of Lands, Bugwood.org

Pair of mountain pine beetle adults constructing an egg gallery in a ponderosa pine, Lincoln, MT
William M. Ciesla, Forest Health Management International, Bugwood.org

Lodgepole terminal weevil
Ron Long, Simon Fraser University, Bugwood.org



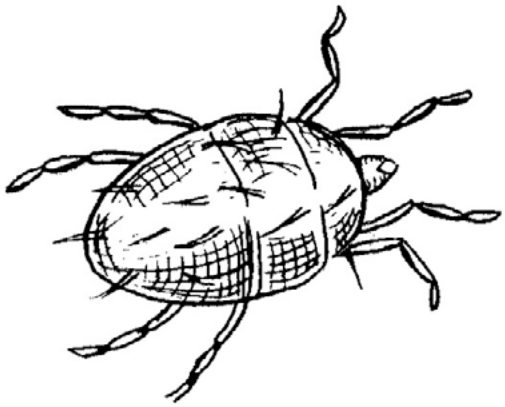
Large aspen tortrix, adult

Poplar borer
Whitney Cranshaw, Colorado State University, Bugwood.org

Mountain pine beetle, adult

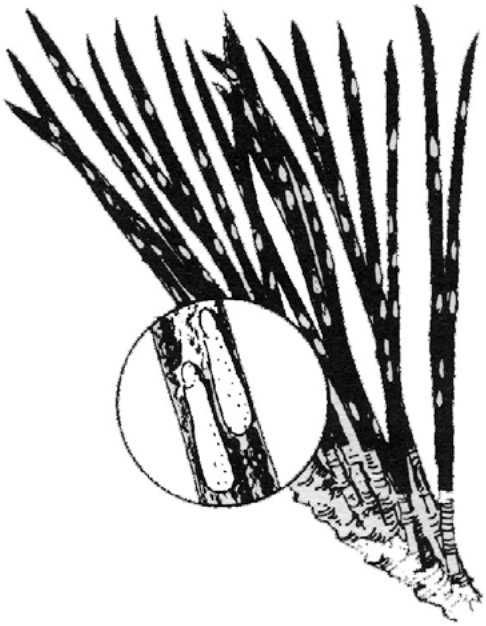
Elm leaf beetle, adult and larva

Aspen leafminer



Spider mites attack most species of trees

Eriophyid mite finger galls on chokecherry



Pine needle scales attached to needles

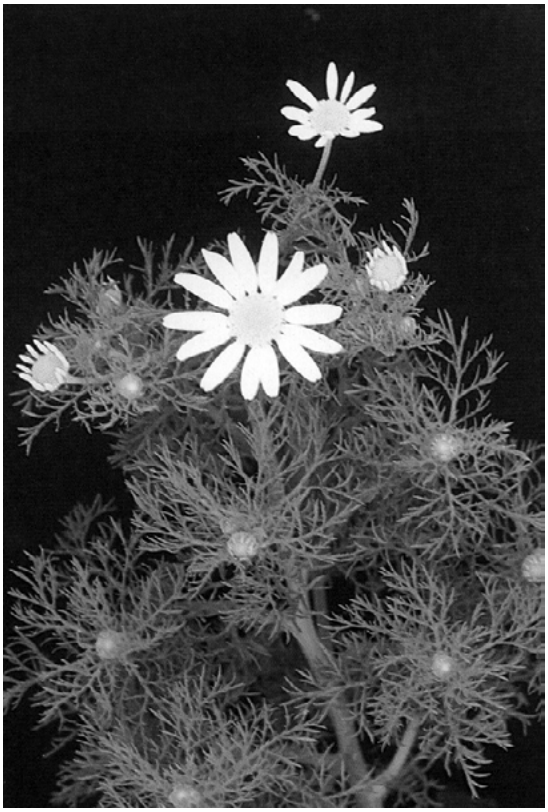
Marssonina blight (*Marssonina populi*) on leaves of an aspen tree.
William Jacobi, Colorado State University, Bugwood.org

A windbreak with juniper blight (*Cercospora sequoiae* var. *juniperi*)

Nectria canker on honeylocust

Dwarf mistletoe on a ponderosa pine
William Jacobi, Colorado State University, Bugwood.org

Powdery mildew on a rose
Penn State Department of Plant Pathology & Environmental Microbiology Archives , Penn State University, Bugwood.org



Mayweed chamomile

Canada thistle

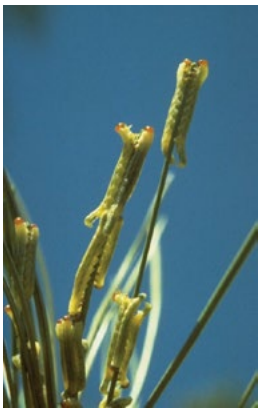
Orange hawkweed

Gray rabbitbrush

Snowberry

Douglas-fir tussock moth, larva on spruce

Western tent caterpillar, larvae and webbing on aspen



Pine sawfly, larvae feeding on needles

Western spruce budworm larva feeding

Ponderosa needleminer injury

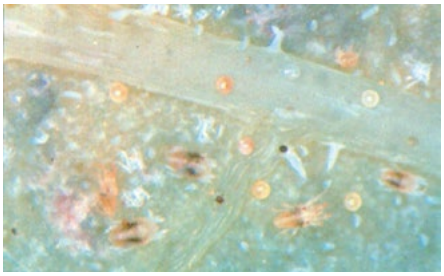
Honeysuckle witches' broom aphid injury

Cottonwood leaf beetle, larval injury to foliage

Ash leaf curl aphid, heavy infestation of ash foliage

Giant conifer aphids on spruce

Spruce spider mite injury to ponderosa pine



Twospotted spider mite

Poplar twiggall fly, adult on aspen leaf

Pinyon tip moth in pinyon pine

Cooley spruce gall adelgid on douglas-fir

Oystershell scale, crawlers

Black vine weevil, adult

Pinyon pitch nodule moth, pitch nodule

White pine weevil larvae in spruce terminal

Ips beetle, tunnelling under bark

Leaf rust

Septoria leaf spot on poplar

Marssonina blight on aspen

Juniper tip blight

Cedar knot gall rust on juniper

Juniper broom rust

Bacterial blight

Fire blight

Cytospora canker

Phytophthora on Scots pine


Plumeless thistle


Bull thistle


Houndstongue


Spotted knapweed


Dalmatian toadflax


Yellow toadflax


Diffuse knapweed


Big sagebrush

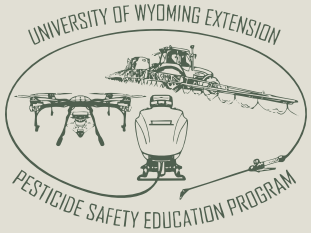

Leafy spurge

Gambel oak


Chokecherry

Category 902

Wyoming Forest Pest Control



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