

Pest Management Strategic Plan
for
Christmas Trees
in
Oregon, Washington, and Idaho



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Table of Contents

Work Group Members	3
Summary of Critical Needs	5
Introductory Pages:	
Process for this Pest Management Strategic Plan	6
Regulatory Background	7
Christmas Tree Production Overview	8
Christmas Tree Export Markets.....	13
Targeting Pests in Christmas Tree Production.....	15
Christmas Tree Pests Outline	17
Major Christmas Tree Pests by Crop Stage (Quick Reference List)	19
Christmas Tree Field Activities by Crop Stage.....	20
Christmas Tree Pests and Management Options:	
I. Major Pests	22
a. Insects and Mites.....	22
b. Diseases.....	43
c. Weeds	57
II. Major Regulatory Pests.....	65
III. Vertebrate Pests in Christmas Tree Production	70
IV. Sporadic and Minor Pests	74
V. Other Disorders.....	88
References	91
Appendices	
1. Activity Tables	92
2. Seasonal Pest Occurrence Tables	93
3. Efficacy Ratings for Insect and Mite Management Tools in Christmas Trees	94
4. Efficacy Ratings for Disease Management Tools in Christmas Trees	97
5. Efficacy Ratings for Weed Management Tools in Christmas Trees	99

Work Group Members

The following people generously offered their knowledge and skills in the development of this Pest Management Strategic Plan for Christmas Trees. Many of them contributed significantly to both the writing and editing of the document.

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Summary of Critical Needs

(Pest-specific and crop-stage-specific aspects of these needs, as well as additional needs, are listed and discussed throughout the body of the document.)

Research:

- Develop economic thresholds for all insects, mites, diseases, and weeds that have a negative effect on Christmas tree growth and production.
- Verify the efficacy of current systemic insecticides, and identify and evaluate new systemic chemistries for insect and mite management.
- Develop effective controls to minimize the occurrence of regulatory pests such as Douglas-fir needle midge, wasps, Douglas-fir twig weevils, and slugs, which can and do impede exports.
- Research the pros and cons of cover crops in preplanted fields versus established Christmas tree plantations to find the right balance between tree and soil health, and weed and rodent control.

Regulatory:

- Have the Environmental Protection Agency (EPA), the Washington State Department of Agriculture (WSDA), the Oregon Department of Agriculture (ODA), and the Idaho State Department of Agriculture (ISDA) come to a consensus on the regulatory terms referring to Christmas trees, especially as they relate to pesticide registrations and labels.
- Maintain the registration of chlorothalonil (Bravo), which is an effective fungicide important to the Christmas tree industry for the management of many diseases that attack Christmas trees.
- Explore further impediments to trade (national or international) with regard to potential regulatory pests, such as the pinewood nematode.
- Determine existing regulatory pest populations in export markets.

Education:

- Educate growers on pest identification, especially for pests such as aphids, needle casts, and mites.
- Educate growers on the benefits of developing an Integrated Pest Management (IPM) program for Christmas trees.
- Develop a best management practices (BMP) document for Christmas tree growers that will include BMPs for meeting export market requirements.
- Establish a forum (e.g., via an electronic mailing list server) for growers to discuss current problem pests and control strategies.

Process for this Pest Management Strategic Plan

In a proactive effort to identify pest management priorities and lay a foundation for future strategies, Christmas tree growers, commodity group representatives, pest control advisors, regulators, university specialists, and other technical experts from Oregon, Washington, and Idaho formed a work group and assembled this document. Members of the group met for 2 days in February, 2009, in Aurora, Oregon, where they drafted a document containing critical needs, general conclusions, activity timetables, and efficacy ratings of various management tools for specific pests in Christmas Tree production. The resulting document was reviewed by the work group, including additional people who were not present at the meeting. The final result, this document, is a comprehensive strategic plan that addresses many pest-specific critical needs for the Christmas tree industry in Oregon, Washington, and Idaho.

The document begins with an overview of Christmas tree production, followed by discussion of critical production aspects of this crop. The remainder of the document is an analysis of pest pressures during the production of Christmas trees, organized by pest type (insect and mite, disease, weed, vertebrate, and other). Key control measures and their alternatives (current and potential) are discussed.

Each pest is mentioned in alphabetical order (not in order of importance), and entries include references to cultural controls (including resistant cultivars), biological controls, and chemical controls (including preplant pesticide treatments) currently utilized for each pest. The biology and life cycle of each pest are described in detail.

Trade names for certain pesticide products are used throughout this document as an aid for the reader in identifying these products. The use of trade names does not imply endorsement by the work group or any of the organizations represented.

Regulatory Background

Christmas tree growers, and others associated with the industry, recognize the importance of developing long-term strategies to meet their pest management needs. These strategies may include identifying critical pesticide uses, retaining critical uses, researching pest management methods with an emphasis on economically viable solutions, and understanding the impacts of pesticide cumulative risk. EPA has completed the risk assessments required under the Food Quality Protection Act of 1996 (FQPA) and continues its reregistration process. With the advent of the FQPA and the subsequent risk assessments, several pesticides have been cancelled or now have reduced or more-restrictive label uses.

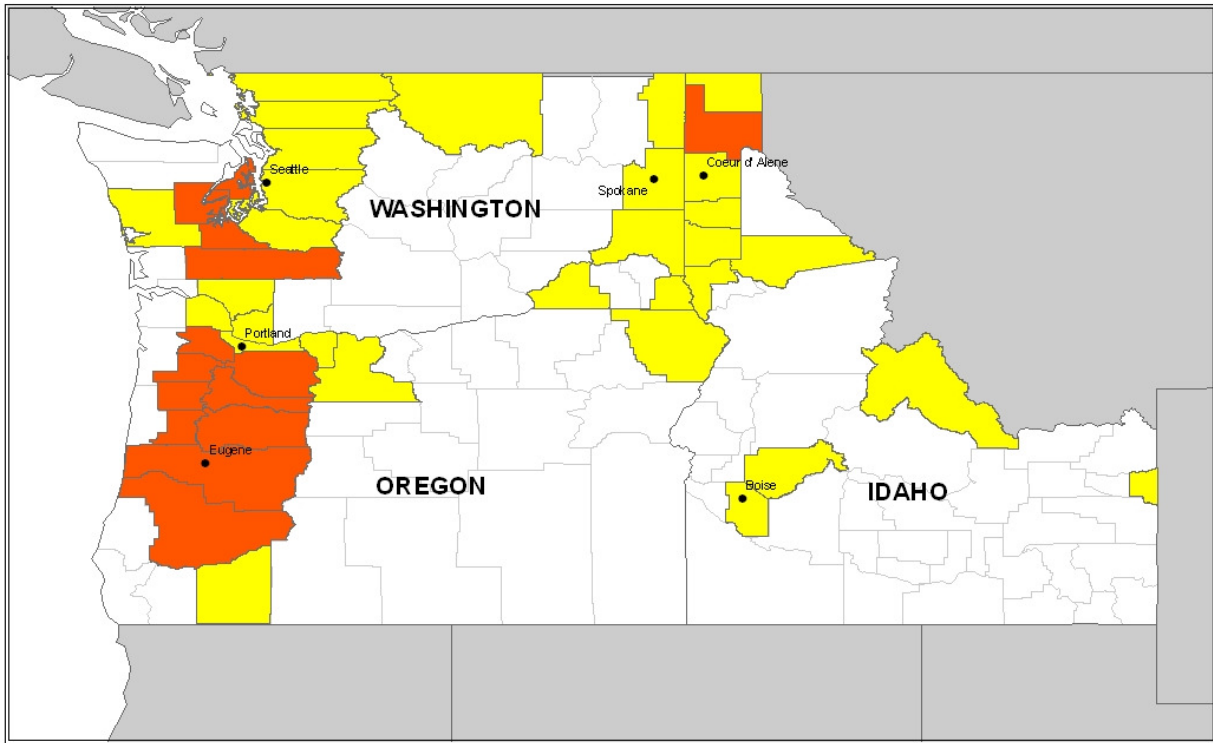
In addition to the risk assessments and reregistration efforts of EPA, the Endangered Species Act (ESA) may also impact the availability or restrict the use of certain pesticides. The ESA requires that any federal agency taking an action that may affect threatened or endangered species, including EPA, must consult with either the National Oceanic and Atmospheric Administration (NOAA-Fisheries), or the U.S. Fish and Wildlife Service, as appropriate. Lawsuits have been filed against EPA alleging the Agency failed to complete this consultation process. One lawsuit resulted in the establishment of buffers for applications of certain pesticides around salmon-supporting waters in Washington, Oregon, and California. Salmon and other threatened and endangered species are located throughout the Christmas tree growing regions of the Pacific Northwest, and there are likely to be further requirements for the protection of these species. The total effects of FQPA and ESA are still transpiring. Clearly, however, new pest management strategies will be necessary in the Christmas tree industry. The strategic plan the industry has produced will help them meet their pest management challenges now and in the future.

Christmas Tree Production Overview



Displaying decorated evergreen trees at Christmas is a holiday tradition dating back hundreds of years. Initially, Americans cut their own trees from local forests. In the 1920s, growers began to deliver these trees to populated areas. Eventually, farmers began growing trees on plantations. These plantation-grown trees currently dominate the markets. Presently, producers in the United States supply about 35 million trees annually to both domestic and foreign markets.

The Pacific Northwest has ideal soil and weather conditions for Christmas tree farming and is home to more than 1,000 individual tree growers. Plantation sizes range from less than 5 acres to as much as 6,000 acres. With a combined annual production estimated at more than 11 million trees, Oregon, Washington, and Idaho produce more than one-quarter of all Christmas trees grown in the country. While a number of tree varieties are grown throughout the Pacific Northwest, the area is the country's largest producer of Douglas-fir, noble fir, and grand fir.



Pacific Northwest Christmas Tree Production

- Counties with Major Wholesale Christmas Tree Production
- Counties with Minor Wholesale Christmas Tree Production or Predominantly U-Cut Farms

In Oregon, Douglas-fir and true firs, such as noble, grand, Turkish, and Nordmann, make up 99% of its approximately 60,000 acres of trees. Other varieties less commonly grown in Oregon include Colorado blue spruce, concolor fir, Fraser fir, Scots pine, Shasta fir, and western white pine. Major Christmas tree producing counties in Oregon are Benton, Clackamas, Douglas, Lane, Linn, Marion, Polk, Washington, and Yamhill. Other counties with some commercial and U-cut operations include Columbia, Hood River, Jackson, Multnomah, Willamette, and Wasco.

In 2007 approximately 775 Oregon Christmas tree growers cut and sold 7 million trees on 61,850 acres, with a value of \$109.3 million. Douglas-fir accounted for the largest percentage of trees sold in Oregon, but production of this species continues to decline, decreasing from 57% of trees cut and sold in 2001 to 50% in 2007. As Douglas-fir production declines, production of noble fir increases.

In Washington, Douglas-fir and noble fir account for about 90% of the state's production. The major Christmas tree producing counties in Washington are Kitsap,

Lewis, Mason, and Thurston. A number of counties have smaller-acreage farms, including Asotin, Clark, Cowlitz, Grays Harbor, King, Pend Oreille, Okanogan, Pierce, Skagit, Snohomish, Spokane, Walla Walla, Whatcom, and Whitman. In 2007 about 300 Washington growers cut and sold approximately 2 million trees on 25,000 acres, with a value of approximately \$50 million.

In Idaho, grand fir is the primary species produced. Fraser, concolor, and Nordmann firs and Colorado blue spruce are also grown. Various other fir, pine, and spruce are grown, especially on smaller “choose and cut” operations. In 2007 about 50 Idaho growers harvested approximately 46,000 trees from 1,000 acres, with an estimated market value of \$829,000. Most of the Christmas tree production takes place in Bonner County, but Ada, Benewah, Boise, Boundary, Clearwater, Kootenai, Latah, Lemhi, Nez Perce, and Teton Counties also have some commercial and U-cut operations. Most Christmas tree plantations in Idaho are smaller than 20 acres.

Christmas trees grow best with full sun, adequate rain, and well-drained soil on a level or only moderately-sloping area of land. Good soil drainage is particularly critical on high-rainfall sites in western Oregon and Washington and on mountain sites in Idaho. A depth of at least 18 inches of soil is needed for adequate rooting.

Seedlings are generally planted in late winter or early spring, which allows nurseries to lift the seedlings at the trees’ maximum dormancy. In areas east of the Cascade Mountains, seedling growers lift in late fall and refrigerate seedlings for spring planting, which generally takes place from February through May. West of the Cascade Mountains, trees are planted from January to March.

In preparation for planting, sites are often cleared of stumps and competing brush and weeds, and soil is cultivated by ripping, disking, or plowing. Once soil is properly prepared, tree planting may proceed. Hand-planted fields (using shovels and hoes) can be established at any time once the site has been prepared, as long as the ground is not frozen, but machine planting (power augers and tractor-pulled transplanting machines) requires waiting until the soil is dry enough to permit equipment access. During wet springs, this can push planting dates into April or even May, which may limit the crop’s growth and survival. Trees are generally spaced from 3 feet (for table top plantings) to approximately 5½ feet, with a 6-foot row spacing for trees to be grown to a height of 6 feet or taller. On average, there are about 1,400 trees per acre.

Commonly, Christmas trees are a dryland crop, yet a few growers irrigate their trees using overhead or trickle systems. In general, irrigation is used to help trees through the

dry season or to help newly planted trees survive. It usually occurs with a few deep irrigations at 10-day to 2-week intervals in mid-summer.

Traditionally, Christmas tree growers add nitrogen fertilizer toward the end of the plantation cycle to improve needle color and growth on some sites. Research has found that varieties respond differently to this practice.

Culturing is an important practice in Christmas tree production in order to control excessive growth, increase the density of branches and foliage, and correct imperfections in tree shape. In the first couple of years, culturing includes replacing dead and sick trees, removing multiple leaders, and reducing competition of weeds and pests. During the later years of crop maturation, growers focus on basal pruning, leader length regulation, and side shaping/shearing.

It takes from 7 to 12 years to produce a 6-foot tree in the Pacific Northwest, depending on the variety of tree and productivity of the site. After years of work and waiting, a successful harvest uses a minimum amount of time to cut, sort, bale, and get the trees on their way to market while at the same time avoiding damage to the soil.



Wholesale trees are generally tagged for harvest and cut using lightweight chain saws or circular saws mounted on rotary brush cutters. Once trees are cut they are taken to on-farm processing areas for baling and loading. Transport equipment depends upon the size of grower, but tractors, trucks, or even helicopters for greater distances or larger operations are typically used.

For some markets, it is necessary to mechanically shake trees to remove pests, dead needles, and other materials before baling. (Mechanical shakers are available.) Baling

wraps trees tightly with string or mesh netting to protect them during shipping and to increase the number of trees a truck can carry. Some growers use baling contractors, while others have their own balers.



A small percentage of Christmas trees in the Pacific Northwest is grown as “U-cut” for the general public. These growers have different harvest considerations, such as parking, how trees will be cut, customer safety, insurance, pricing, payment collection, and creation of a unique holiday experience for customers.

A harvest may require 2–3 years before all the trees are removed. Once harvest is complete, the site is generally prepared for replanting. If the soil is not compacted or in need of other treatment, some growers simply replant between the stumps. However, growers are finding that stumps can pass along some root diseases to newly planted trees, and the practice, although convenient, is losing favor. Mechanical equipment and contractors are available to remove or grind stumps; however, the process requires drier soil, possibly compelling growers to wait until the summer after harvest. The practice of planting a cover crop after a field has been harvested and before a new crop of trees is planted is becoming more common. This can benefit soil health by improving soil tilth and biological activity.

The Christmas tree industry is facing severe competition from artificial trees and changing consumer tastes. In addition to facing cyclical markets, different regions have experienced both tree surpluses and tree shortages. It is a unique industry wherein a grower must make long-term planting decisions based upon the hope that consumers will purchase trees planted 6 to 10 or more years earlier.

Christmas Tree Export Markets

Approximately 92% of all Pacific Northwest Christmas trees are exported from the region. California is the largest market, receiving 47% of the Pacific Northwest tree harvest in 2007. Mexico received 13% of the 2006 harvest. (Twenty-three percent of all Oregon Douglas-fir trees are shipped to Mexico.) Trees are also shipped to overseas markets, including Japan, China, Hong Kong, the Philippines, Hawai'i, Guam, and Puerto Rico.

Each state's department of agriculture provides inspection and certification services for Christmas tree growers who ship to other states and foreign countries. Most foreign countries require that each shipment of Christmas trees be inspected, found free of pests of regulatory concern, and be accompanied by a Phytosanitary Certificate. Some states have specific quarantines that restrict the importation of Christmas trees. In these cases, the shipments can be inspected and certificates issued indicating that the trees meet the quarantine requirements of the importing state.

One big regulatory challenge faced by the Pacific Northwest Christmas tree industry has been exports to Mexico. Mexican officials are particularly concerned about pests and diseases on Douglas-fir. They strictly enforce tolerance levels for all pests and diseases, especially Douglas-fir twig weevil (*Cylindrocopturus furnissi*) and Douglas-fir needle midge (*Contarinia* spp.). Trees showing symptoms of either of these pests are held for further examination. Those not meeting importation requirements are returned or destroyed. At one point during the 2008 shipping season, as many as 5% of U.S. shipments were turned back at Mexican border crossings. In addition to issues with pests and diseases, in early 2009 a 20% tariff was imposed on all Christmas trees (and a number of other U.S.-grown crops) imported into Mexico from the United States. This will greatly impact Christmas tree growers of the Pacific Northwest. The industry, along with state and federal departments of agriculture, is currently in communication with Mexican regulatory authorities about issues related to Mexican importation of Christmas trees from the Pacific Northwest.

In addition to the shipment rejections by Mexico, Pacific Northwest Christmas tree growers also had shipments rejected in 2008 by regulatory officials in Hawai'i and Guam due to the presence of yellowjackets, slugs, and a variety of other "hitchhiking" pests. Hawai'i, Guam, and Mexico now require that 100% of trees be shaken prior to entry. The shaking process requires that trees be thoroughly agitated prior to baling to remove dead needles, pests, and any other debris from the trees. To prevent reinfestation by insects such as yellowjackets, weevils, etc., trees are loaded onto the

truck as soon as possible after shaking, or protected with netting or screening. Looking forward, regulatory authorities in Mexico are expected to continue to closely scrutinize Christmas trees, especially Douglas-fir, imported from the Pacific Northwest. The industry can also expect that other states and U.S. territories will become increasingly concerned about pests and diseases that could be imported on Christmas trees. The industry's challenge is to produce trees that meet current and future export requirements of other states and foreign countries.

Targeting Pests in Christmas Tree Production

Whenever possible, Christmas tree growers are using an integrated approach to control pests. However, an industry-wide IPM program currently does not exist for Christmas trees in the Pacific Northwest. There are a number of fundamental areas for which more research is needed in order to establish a successful IPM program. For example, in the realm of scouting, more models are needed (e.g., degree-day, weather patterns) to assist growers in determining when to begin scouting for important insects or diseases. Similarly, once pests are found and identified, more information is needed on threshold levels, particularly for insects and mites. Growers are often faced with making a “best guess” and are in need of more precise information in order to make more informed decisions regarding pest management.

Although there is not yet an industry-wide IPM program, Christmas tree growers in Oregon and Washington are developing voluntary certification programs, which include a commitment to IPM practices, to help minimize the need for pesticide applications. Currently there are two programs, both requiring growers to demonstrate knowledge of and commitment to IPM practices. One program, Socially and Environmentally Responsible Farm (SERF) certification, began as a pilot program that was initiated in 2008.

The SERF program is designed not only to follow state- and federally-mandated laws but also to encourage industry policies and practices that benefit both the environment and the well-being of society. SERF certification includes the following areas: Environmental Management, Bio-diversity, Soil Conservation, Integrated Pest Management, Social Health and Safety, and Consumer Relations. Growers may certify their entire land base or only fields from which trees will be sold and shipped.

The Oregon Department of Agriculture (ODA) provides SERF verification and auditing services. The program is available to any Oregon or Washington Christmas tree farm. Site visits and inspections require the grower to demonstrate knowledge across a range of environmental and sustainable practices.

A second program is called the Coalition of Environmentally Conscious Growers (CECG). With this program, a private consulting firm conducts the evaluations and audit activities. As with SERF, pest monitoring and determining acceptable thresholds within an IPM program are components of the CECG program. Similar components are included and emphasized in the two programs.

With both programs, growers are being asked to develop or comply with a series of best management practices (BMPs) in developing environmental programs. They also involve cooperation with local watershed groups. Further development of BMPs for Christmas trees will require considerable research and investigation into many of the needs stated in this PMSP. The strategic effort of this PMSP for Christmas trees will greatly assist in prioritizing this move forward, helping the industry develop a successful plan for IPM.

Christmas Tree Pests Outline

I. Major Pests

a. *Insects and Mites*

- i. Aphids
 - ii. Balsam woolly adelgid
 - iii. Conifer root aphid
 - iv. Douglas-fir needle midge
 - v. Douglas-fir twig weevil
 - vi. Eriophyid needle mite
 - vii. Root weevil
 - viii. Spruce aphid
 - ix. Spruce spider mite
 - x. White pine weevil
- ### b. *Diseases*
- i. Annosus Root Rot
 - ii. Armillaria Root Rot
 - iii. Interior Needle Blight
 - iv. Needle Rusts
 - v. Phytophthora Root Rot
 - vi. Needle Casts (Rhabdocline, Rhizosphaera, Swiss)

c. *Weeds*

II. Major Regulatory Pests

a. *Insects and Mollusks*

- i. Douglas-fir needle midge
- ii. Douglas-fir twig weevil
- iii. European pine shoot moth
- iv. Slugs/Snails
- v. Wasps/Yellowjackets

III. Vertebrate Pests

- i. Birds
- ii. Mice/Voles
- iii. Rabbits/Hares
- iv. Gophers
- v. Deer/Elk

IV. Sporadic and Minor Pests

a. Insects

- i. Cooley spruce gall adelgid
- ii. Douglas-fir tussock moth
- iii. Grand fir twig borer
- iv. June and rain beetles and other scarabs
- v. Silver-spotted tiger moth

b. Diseases

- i. Botrytis blight
- ii. Grovesiella canker
- iii. Phomopsis canker

V. Other Disorders

- i. Current season needle necrosis (unknown cause)
- ii. *P. ramorum*
- iii. Physiological disorders

Major Christmas Tree Pests by Crop Stage

The following outline of the general crop stages involved in Christmas tree production includes each major pest in the stage (or stages) during which the pest would be controlled.

I. Preplanting and site preparation

Annosus root rot, Armillaria root rot, Phytophthora root rot

II. Planting through maturation (includes multiple years of tree growth)

i. Late dormancy (winter/spring)

Douglas-fir twig weevil, Mites (can be controlled with horticultural oils during this stage), Spruce aphid, Rhizosphaera needle cast

ii. Bud break through vegetative growth (spring/summer)

Aphids (including conifer root aphid), Adelgids, Douglas-fir needle midge, Mites, Root weevil, White pine weevil
Interior needle blight, Needle casts, Needle rusts, Phytophthora root rot

iii. Early dormancy (fall/winter)

Spruce aphid

III. Harvest year

i. Late dormancy (winter/spring)

Douglas-fir twig weevil

ii. Bud break and vegetative growth (spring/summer)

Aphids, Adelgids, Douglas-fir needle midge, Mites, Needle rusts, Rhabdocline needle cast

iii. Early dormancy (early fall)

Douglas-fir twig weevil

iv. Tree cutting (late fall)

Annosus root rot

Weed and vertebrate pest control is ongoing, and timing of controls for regulatory and sporadic pests is discussed in each pest's description.

Christmas Tree Field Activities by Crop Stage

The following outline of the general crop stages involved in Christmas tree production includes common field activities that might take place during each stage.

I. Preplanting and site preparation

i. First-time field

- Cultivation to remove grass
- Planting a cover crop (2 years prior to tree planting or replanting)
- Planting field borders for erosion control

ii. Replanted or interplanted field

- Stump excavation
- Field cultivation (breaking up soil)
- Liming
- Soil testing for pH
- Planting field borders for erosion control

II. Planting through maturation

i. Late dormancy (winter/spring)

- Herbicide application
- Fertilizer application
- Monitoring for nutrient management (foliar samples)
- Monitoring for pests
- Replanting
- Shearing
- Basal pruning (early in rotation; only done once)

ii. Bud break through vegetative growth (spring/summer)

- Herbicide, fungicide, and insecticide applications
- Foliar fertilizer applications
- Erosion management (vegetation strips, mulch, straw bales)
- Rodent control
- Irrigation (This is rare, and would occur primarily in seedling fields, during first and second years of rotation.)
- Scouting and monitoring for pests

iii. Early dormancy (fall/winter)

- Soil sampling for nitrogen
- Shearing

III. Harvest year

- i. Late dormancy (winter/spring)*
 - Insecticide, fungicide, and herbicide applications
 - Scouting and monitoring for pests
- ii. Bud break and vegetative growth (spring/summer)*
 - Shearing/culturing
 - Tagging trees for harvest
 - Herbicide, fungicide, and insecticide applications
- iii. Early dormancy (early fall)*
 - Shearing
 - Tagging trees for harvest
 - Insect control
 - Road maintenance
 - Staging equipment
- iv. Tree cutting (late fall)*
 - Tree cutting
 - Covering stumps (true fir) to treat for annosus root rot
 - Shaking
- v. Postharvest*
 - Stack and burn culled trees

Ongoing activities for all years: Culling poor quality and dead trees

Christmas Tree Pests and Management Options

I. Major Pests

Insects and Mites

Aphid

Balsam twig aphid (*Mindarus abietinus* Koch)

Giant conifer aphids (*Cinara* spp.)

The Balsam twig aphid is a transcontinental species that occurs extensively and abundantly in the Pacific Northwest. It has been reported in balsam fir, Fraser fir, grand fir, Siberian fir, subalpine fir, white spruce, Colorado blue spruce, and juniper. These aphids are small (1 to 2 mm long), generally yellow-green, powdery (waxy or woolly), and they may be either winged or wingless. Balsam twig aphids overwinter as small brown eggs that are laid in bark crevices and are covered with white, waxy filaments. Eggs hatch in the spring. This pest has several generations annually. It becomes most abundant in the early summer months and then nearly disappears from firs. Balsam twig aphids feed on new (developing) needles and twigs, causing them to twist. Needle drop, stunting, and twig distortion make Christmas trees valueless for 2 to 3 years following attack.

Giant conifer aphids (also referred to as “bow-legged” aphids) are relatively large (2 to 5 mm long), long-legged, and dark in color without much waxy covering. There are about 175 species, and many occur in the western United States. They infest most true firs, Engelmann spruce, and deodar cedar. These aphids overwinter as eggs on needles and bark. Multiple generations occur on conifers after egg hatch and can be found on trees into the fall. The aphids feed on twigs and branches, but occasionally they are found on trunk and roots.

In general, aphids are among the most damaging of the insects that attack Christmas trees, particularly grand, noble, and Fraser firs. Heavy infestations can yellow foliage and reduce tree growth, primarily on young trees. These aphids also secrete honeydew, which yellows and burns needles and leads to sooty mold. This can cause needle matting, loss, and distortion as well as stunting of growth and death of branches. In rare instances, extremely high numbers of giant conifer aphids may cause reduced terminal growth and some twig dieback. These aphids are tended by *Formica* species ants, which also cause damage by chewing on trees. In addition to attracting ants, the honeydew is also attractive to yellowjackets and other wasps.

Aphids are generally controlled from bud break through early dormancy of maturation and harvest years. The controls listed below could be used at any time during these stages.

Chemical control:

- *Beauveria bassiana* (Mycotrol): Approved for use in organic production. Not widely used due to limited grower experience and questionable efficacy.
- Chlorpyrifos (Lorsban and other brands): Restricted-use pesticide. Main (federal) labels of Lorsban and other brands allow ground application. Oregon and Washington Special Local Need (SLN) registrations (OR-050015 and WA-050012) for Lorsban-4E allow aerial application. Chlorpyrifos is considered effective and is widely used in Oregon and Washington, as it also controls balsam woolly adelgids and cooley spruce gall adelgids. It is not used in Idaho.
- Endosulfan: Restricted-use pesticide. Widely used and considered very effective by growers.
 - (Thionex 3EC): Oregon, Washington, and Idaho SLNs allow aerial application and use in all conifer species for control of the balsam twig aphid (OR-030013, WA-030018, ID-030002).
 - (Thionex 50W): Oregon and Washington SLNs allow aerial application and use in all conifer species for control of the balsam twig aphid (WA-030017, OR-030012).
- Imidacloprid (Admire, Provado): Not widely used. It is slow acting on large populations. Efficacy is better when populations are small.
- Oxydemeton-methyl (MSR): Restricted-use pesticide. Not widely used in areas where buffer zones exist. Also, its long REI limits usefulness, and it is expensive.
- Pymetrozine (Endeavor): Not widely used. This product is newly registered, so grower experience with it is limited. A good product for IPM due to its selectivity with regard to aphids and whiteflies; however, timing is critical for best efficacy.
- Soaps (M-Pede): Approved for use in organic production. Fair efficacy.
- Spirotetramat (Ultror): Newly registered. Limited grower experience. Has potential because it moves systemically both downward and upward and also works on other aphids and adelgids. Might not be cost-effective for foliar aphids.

Biological control (naturally-occurring; helpful but only partial efficacy):

- Lacewings.
- Ladybird beetles.
- Parasitic wasps and flies.
- Syrphid fly larvae.

Cultural control:

- Monitor aphid populations carefully. (Some growers scout for signs of honeydew close to the ground.) Treat only when needed, as natural predators and parasitic organisms are important controls. Scouting should include signs of natural enemies and parasitized aphids (mummies). Mummies are usually very conspicuous, since they vary in color and shape from the rest of the colony.

Critical Needs for Aphid Management in Christmas Trees

Research:

- Identify products approved for use in organic production, such as Ecotrol (essential oils).
- Determine the efficacy and habitat needs of released beneficials and learn how to manage them.
- Identify and evaluate “soft” chemistries for protection of beneficials and parasites.
- Identify and evaluate effective adjuvants used in combination with existing chemical controls.
- Properly identify the aphids that occur on Christmas trees and the types of damage they cause.
- Develop economic threshold information for aphids.

Regulatory:

Have EPA, WSDA, ODA, and ISDA come to a consensus on the regulatory terms referring to Christmas trees, especially as they relate to pesticide registrations and labels.

Ask agrichemical companies to express application rate on pesticide labels in concentration rather than in rate per acre.

Education:

- Educate growers on the usefulness of target-specific pymetrozine (Endeavor) in IPM programs.
- Develop better educational programs and materials for growers about resistance management for new and existing chemistries.
- Educate growers regarding proper identification of aphid species that occur in Christmas trees and the damage they cause once these have been determined.
- Educate growers on economic threshold information for aphids once it has been determined.

Balsam woolly adelgid (*Adelges piceae*)

Adult balsam woolly adelgids are very small, dark purple to black, and wingless. They are very difficult to observe until egg-laying begins, when they are then covered with a thick mass of waxy, wool-like material that protects the adult and her eggs. Amber-colored crawlers hatch from the eggs. Crawlers are the only mobile stage, and this is the most susceptible stage for control measures. Long-range dispersal is accomplished mainly by wind or contact with birds or other animals. Adult balsam woolly adelgids can have two to four generations per year.

Balsam woolly adelgids appear as cottony or grayish “spots” or masses on trunks and the undersides of branches and twigs. When sucking tree sap they produce a toxin that causes swelling (“gouting”) of branch nodes and tips. Trunks, branches, or twigs may be covered with white, waxy secretions in heavy infestations. Growth is retarded and twigs are distorted, often appearing in the shape of a “bird’s claw.” Tree crowns often experience “top curl” or leaders growing off-center. Persistent crown infestations can kill a tree over a number of years. They are especially damaging to balsam, canaan, and Fraser fir, but they also damage noble and other true firs. Occasionally, they can cause significant damage to entire plantations. Turkish and Nordmann firs have resistance.

This pest is generally controlled during Stage II after bud break and also Stage III after bud break.

The controls listed below are applied to the crawler stage (small and without waxy covering) at or around bud break.

Chemical control:

- Chlorpyrifos (Lorsban and other brands): Restricted-use pesticide. Main (federal) labels of Lorsban and other brands allow ground application only. Oregon and Washington SLNs (OR-050015 and WA-050012) for Lorsban 4E allow aerial application. Chlorpyrifos is widely used for this pest in Oregon and Washington, and it is also effective for aphids and cooley spruce gall adelgids. It is not used in Idaho. Timing is critical for effective control.
- Endosulfan: Restricted-use pesticide. Widely used when balsam woolly adelgid is the target pest. Considered very effective by growers.
 - (Thionex 3EC): Oregon, Washington, and Idaho SLNs allow aerial application and use in all conifer species (OR-030013, WA-030018, ID-030002).
 - (Thionex 50W): Oregon and Washington SLNs allow aerial application and use in all conifer species (WA-030017, OR-030012).

- Horticultural oils: Not used by growers due to phytotoxicity and discoloration concerns.
- Imidacloprid (Admire, Provado): Not widely used by growers. Efficacy is unknown.
- Oxydemeton-methyl (MSR): Restricted-use pesticide. Not widely used in areas where buffer zones exist. Its long REI limits usefulness, and it is expensive. Efficacy unknown for this pest.
- Spirotetramat (Ultror): A newly-registered product with limited grower experience. Has potential because it moves systemically downward and upward and also works on other aphids and adelgids.

Biological control (limited efficacy against this adelgid):

- Lacewings.
- Ladybird beetles.
- Predacious beetles and midges.

Cultural control:

- Scouting on a regular basis helps identify outbreaks early.
- Tree removal for large infestations.

Critical Needs for Balsam Woolly Adelgid Management in Christmas Trees

Research:

- Identify effective options for adelgid control.
- Evaluate the efficacy of imidacloprid (Admire, Provado) and dinotefuran (Safari). Include research on the cost-effectiveness of control with Safari.
- Develop resistant cultivars of Fraser fir.
- Identify and evaluate “soft” chemistries for protection of beneficials and parasites.
- Develop economic threshold information for this pest.

Regulatory:

- Have EPA, WSDA, ODA, and ISDA come to a consensus on the regulatory terms referring to Christmas trees, especially as they relate to pesticide registrations and labels.

Education:

- Educate new growers regarding the severity of adelgid damage.
- Educate growers regarding specific management practices for adelgid control when growing Fraser fir.
- Educate growers on economic threshold information once it has been developed.

Conifer root aphid (*Prociphilus Americanus*)

Conifer root aphids are light yellow to white aphids that produce waxy material. Winged migrational forms fly in fall. The conifer root aphid feeds on the roots of conifers. These wax-covered colonies may be visited by ants collecting honeydew. Fraser fir and noble fir are particularly susceptible.

Conifer root aphids can cause yellowing and stunting, fading of foliage, reduced growth, and death of leader and branch tips. These aphids have multiple generations per year, and while a portion remain on the fir host year round, many alternate between true fir species and Oregon ash.

This is a widespread problem, and damage can be serious during the first half of the Christmas tree rotation. This pest is generally controlled for during the first few years when trees are small, from bud break through vegetative growth.

Chemical control:

- Imidacloprid (Admire, Provado): This chemical is currently widely used, and although root aphids are not listed on the label, it is critical for root aphid control. However, use as a drench for the conifer root aphid is still experimental.
- Spirotetramat (Ultror): Newly-registered product with limited grower experience. However, this product has demonstrated excellent efficacy in research trials for conifer root aphid control, because it moves systemically downward and upward and also works on other aphids and adelgids.

Biological control:

- None is effective.

Cultural control:

- Avoid poor seedling transplant practices, such as j-root or “pancake” rooting, as this seems to render them more susceptible.
- Use water and fertility practices that promote vigorous tree growth.

- Stump removal can be effective in decreasing ant populations, as stumps are good nesting sites for ants that tend the aphids and move them around. By eliminating rotten stumps, the number of ants will be reduced, which could provide some control of the root aphid.

Critical Needs for Conifer Root Aphid Management in Christmas Trees

Research Needs:

- Determine whether weeds can exacerbate conifer root aphid populations.
- Conduct more research regarding this pest and its life history and biology.
- Continue research on identifying and developing effective management of this pest.
- Determine whether there is a correlation between stressed trees and geographic location and increased root aphid problems.
- Develop economic thresholds for this pest.
- Identify and evaluate “soft” chemistries for protection of beneficials and parasites.

Regulatory:

- Maintain registration of spirotetramat (Ultror) and imidacloprid (Admire) to control this pest.

Education:

- Educate growers regarding pest life cycle and biology.
- Educate growers on effective management of this pest.
- Educate growers on economic threshold information once it has been developed.

Douglas-fir needle midge (*Contarinia* spp.)

Needle midge larvae bore into young needles. A single needle may harbor one to three white or orange larvae. When they are full grown in the fall, the larvae drop from the needles and spend the winter in the soil beneath infested trees. Larvae pupate during March and April. Adults begin to emerge during early April and early May, depending on location and weather. Prolonged rainy periods during hatches may limit infestations.

The adult insect is a small orange midge (fly). Females are larger than males and have an ovipositor, or tail, for egg-laying (visible with a hand lens). There is only one generation per year.

Needle midge larvae mine needles, causing feeding damage, and can feed on needles throughout summer. Needle infestations often appear as a purple to brownish node above which the needles can be bent and distorted. Needles can also become discolored—first yellow, and then purple to brown during the fall. The nodes or swollen feeding area can be seen near the base, near the tip, or somewhere on the middle of the needle. Severe infestations can cause intolerable needle loss, and trees may take several years to recover.

It is extremely important to react quickly with management soon after the first adults are seen in traps. Infestations can be devastating in partially harvested fields. Because the number of host trees has decreased, the adults concentrate on the remaining trees.

This pest drives pesticide use due to export issues with Mexico, which has zero tolerance for the pest. It is generally controlled during Stage II after bud break, and also Stage III after bud break. However, during Stage II, control is only used during the last few years of the rotation. Because of the export issues mentioned above, control is critical during the harvest year.

Chemical control:

Currently, effective chemical control is only possible during a very short time during which the adult female is laying eggs.

- Acephate (Orthene and other formulations): This chemical is sometimes used by growers, but it can be toxic to natural predators of the needle midge.
- Chlorpyrifos (Lorsban and other brands): Restricted-use pesticide. Main (federal) labels of Lorsban and other brands allow ground application. Oregon and Washington SLNs (OR-050015 and WA-050012) for Lorsban-4E allow aerial application. Chlorpyrifos is widely used in Oregon and Washington. It is not used in Idaho.
- Endosulfan: Restricted-use pesticide. Widely used and considered very effective by growers.
 - (Thionex 3EC): Oregon, Washington, and Idaho SLNs allow aerial application and use in all conifer species (OR-030013, WA 030018, ID-030002).
 - (Thionex 50W): Oregon and Washington SLNs allow aerial application and use in all conifer species (WA-030017, OR-030012).

Biological control:

- None known.

Cultural control:

- Late budding cultivars generally avoid damage.
- Scouting and monitoring are important for controlling this pest, especially during the second half of the rotation.
- Needle midge traps are used to determine adult emergence, which helps determine most effective timing for chemical controls.
- Shearing may reduce some of the damage with a light infestation, but potentially not enough to meet inspection/quarantine restrictions. (Shearing alone is not effective in a heavily-infested field.)

Critical Needs for Douglas-fir Needle Midge Management in Christmas Trees

Research:

- Determine the efficacy of imidacloprid (Admire).
- Develop a degree-day model for midge emergence.
- Identify all insect species that cause galls in Douglas-fir.
- Survey growers regarding successful management practices for this pest.
- Research the potential for larvae present at harvest to survive until trees arrive at export destination (e.g., Mexico).
- Develop new strategies for control that may prevent midge larvae emergence from soil.
- Determine life cycle and biology of larvae and pupae.
- Identify and evaluate “soft” chemistries for protection of beneficials and parasites.
- Develop economic threshold information for this pest.
- Identify and encourage natural predators of the Douglas-fir needle midge.

Regulatory:

Determine the various inspection methods used by different state agencies (e.g., individual trees versus whole fields) and strive for consistency.

Determine the population structure of needle midge in the Pacific Northwest as well as target export countries to determine whether species are the same.

Education:

- Educate growers regarding the most effective timing of chemical applications.
- Educate growers on monitoring practices and proper interpretation of trap counts.
- Educate growers on practices that improve adherence to export standards.

- Educate growers on the danger of regulatory pests shutting down export markets.
- Educate growers on economic threshold information once it has been developed.

Douglas-fir twig weevil (*Cylindrocopturus furnissi*)

Adult Douglas-fir twig weevils are about 1/10 inch in size. These insects are small, bronze- or dark-brown-colored weevils with white mottling, sometimes with pink or orange spots. The larvae are white to yellowish, legless, C-shaped grubs.

Adults emerge from Douglas-fir twigs beginning in early- to mid-June and continuing through early August. Adults feed on tender twigs for about a month before preparing small punctures in the bark of 1- to 3-year-old twigs into which eggs are deposited. Eggs hatch after a few days, and larvae bore through the outer bark into the underlying inner bark and cambial region. Larvae form internal feeding galleries in the region between the bark and wood of the branch. Feeding continues from late summer through the following spring. Maturing larvae may tunnel through the wood into the pith region. Larvae of all sizes overwinter in infested branches. After a period of spring feeding, larvae pupate during May and June. Some adults may overwinter on the tree and resume egg laying in the spring. One generation occurs each year.

The appearance of stem damage from larval feeding varies with the degree of infestation. Lightly infested trees have scattered areas of necrotic bark of a reddish-brown color that contrasts with healthy stem tissue. Heavily infested trees often have a swollen appearance in the vicinity of larval wounds. Weevil numbers increase dramatically during drought years on sites where trees suffer from prolonged periods of stress. The symptoms of infestation include dieback of lateral branches and resin exudation on the outer bark. On sapling-sized trees, weevil damage is concentrated on branches with 2-year-old growth. Damage to seedlings and young trees more frequently occurs on the main stem and resembles winter damage. Sometimes small trees may be killed.

This pest is generally controlled for in Stage II during late dormancy, and also in Stage III during late and early dormancy.

Chemical control:

- Chlorpyrifos (Lorsban and other brands): Restricted-use pesticide. Main (federal) labels of Lorsban and other brands allow ground application. Oregon and Washington SLNs (OR-050015 and WA-050012) for Lorsban 4E allow aerial

application. Chlorpyrifos is widely used in Oregon and Washington. It is not used in Idaho. **This is the only registered chemical control for this pest.**

Biological control:

- None known.

Cultural control:

- Avoid planting in wet or droughty areas.
- Maintain vigorous tree growth.
- Remove and burn infested twigs to eliminate the weevil from the plantation. (This is especially important for trees being shipped to Mexico.)
- Scouting and monitoring are important.

Critical Needs for Douglas-fir Twig Weevil Management in Christmas Trees

Research:

- Identify and evaluate new chemistries, and evaluate the potential of existing chemistries, such as imidacloprid (Admire, Provado) and bifenthrin (Brigade, Discipline, Fanfare), for control of this pest.
- Determine best timing for chemical applications.
- Determine the persistence and survival of “hitchhiking” larvae on exported trees.
- Identify and evaluate “soft” chemistries for protection of beneficials and parasites.
- Develop economic threshold information for this pest.

Regulatory:

Evaluate the accuracy of inspection methods, since twig weevil damage tends to look similar to a wide variety of other conditions affecting Christmas trees.

Education:

- Educate growers regarding the export tolerance levels for this pest.
- Educate growers on best timing for chemical applications to control Douglas-fir twig weevil.
- Educate growers on economic threshold information once it has been developed.

Eriophyid needle mite (*Epitrimerus* spp. and others)

Eriophyid mites are very tiny (less than 0.12 inches), white, worm- or cone-shaped

arachnids with four legs. A hand lens is necessary to verify their presence. Some species are found along stem and needle bases, and others are leaf vagrants feeding along the length of the needles.

With their stylet-like mouthparts, eriophyid mites suck out plant juices while transferring a substance, both of which contribute to deformation of plant growth. Infested foliage takes on an olive-green color. These mites can cause stunting of new growth, yellowing to browning of needles, and curling of older needles. Older needles may drop prematurely.

This pest is generally controlled for in Stage II after bud break and also Stage III after bud break. Most of the control for this pest during Stage II would take place during the second half of rotation.

Chemical control:

Most effective control is achieved when applications are made when evidence of mites is first noticed. Delaying application reduces effectiveness of control.

- Endosulfan: Restricted-use pesticide. Widely used and considered very effective by growers.
 - (Thionex 3EC): Oregon, Washington, and Idaho SLNs allow aerial application and use in all conifer species (OR-030013, WA 030018, ID-030002).
 - (Thionex 50W): Oregon and Washington SLNs allow aerial application and use in all conifer species (WA-030017, OR-030012).
- Horticultural oils: Not used by growers due to phytotoxicity and discoloration issues.
- Spirodiclofen (Envidor): Newly-registered product. Not widely used due to little grower experience.

Note: Avoid overuse of broad-spectrum pesticides, which can create or exacerbate a mite problem.

Biological control:

- Predacious mites.

Cultural control:

- Scouting and monitoring are critical so that treatment application can be made when mites are first noticed.

Critical Needs for Eriophyid Needle Mite Management in Christmas Trees

Research:

- Determine the biology, ecology, and life cycle of this pest.
- Determine efficacy and use pattern of spiroticlofen (Envidor).
- Identify different species of mites that may appear in Christmas trees.
- Identify and evaluate efficacy of biological controls.
- Determine the potential for reduced phytotoxicity with the use of mineral oils (e.g., Stylet) and essential oils (such as Ecotrol).
- Determine the most effective scouting methods for early detection.
- Identify and evaluate “soft” chemistries for protection of beneficials and parasites.
- Develop economic threshold information for this pest.

Regulatory:

None.

Education:

- Educate growers on effective scouting methods for early detection.
- Educate growers on life history and biology of this mite.
- Educate growers on economic threshold information once it has been developed.

Root weevil

Strawberry root weevil (*Otiorhynchus ovatus*)
and others

Root weevil larvae are cream-colored, C-shaped, legless grubs. *O. ovatus* larvae are about 1/5 inch long. Other species may be twice as long.

Strawberry root weevil larvae pupate in the soil in early spring. New adults emerge in late spring to early summer. Adults feed on needles. Feeding is visible as characteristic notching and results in sparse foliage. Adults deposit eggs in the soil near the base of the tree. The flightless adults are active at night and often hide during the day in plant debris and organic matter under the trees. Larvae feed on roots, sometimes severely damaging or even killing the young trees by girdling their roots in the spring.

This pest is generally controlled from bud break through vegetative growth during the first few years of tree growth.

Note: Treatment applications targeted at aphids may also be controlling adult weevils at the same time.

Chemical control (for adult root weevil):

- Acephate (Orthene and other brands): This chemical is sometimes used by growers and is considered effective, but it can be toxic to predators.
- Bifenthrin (Brigade, Discipline, Fanfare): Restricted-use pesticide. Oregon and Washington have SLNs for Brigade and Discipline (OR-070015, 050005; WA-070016, 050005). Bifenthrin is effective, but use in Christmas trees is limited. It is used only in rotation with other chemicals due to its negative impact on predators and other beneficials. It is used judiciously to protect beneficials.

Biological control (for root weevil larvae):

- Entomophagus nematodes: Soil temperature needs to be warm. Available but not practical and not used due to high cost and poor efficacy.
- Parasitic wasps: Naturally-occurring. Provides some control.

Cultural control:

- Increased scouting and monitoring can help early detection and better time treatments.
- Good site preparation prior to planting (i.e., fallow the field and remove all plant debris by plowing, discing, and habitat removal).

Critical Needs for Root Weevil Management in Christmas Trees

Research:

- Identify and evaluate “soft” chemistries for protection of beneficials and parasites.
- Develop economic threshold for root weevil larvae, with special attention to age of tree.
- Identify species occurring in Christmas trees, and determine their life cycle and biology to aid in determining timing of treatments.
- Identify and evaluate the efficacy of alternative treatments and biocontrols (e.g., predacious nematodes and fungi).

Regulatory:

- None.

Education:

- Educate growers on how to use economic threshold information.
- Educate growers on proper scouting for this pest.

Spruce aphid

The spruce aphid is a small, olive green to very dark, pear-shaped aphid. The head end can be yellowish green, with reddish eyes. Eggs are yellow to reddish to dark brown or black and can be very difficult to see during scouting.

The spruce aphid is also known as the winter aphid because of its peak growth in numbers during the winter; however, very cold winter temperatures might reduce damage. Populations start to build in October through March, with peak numbers in late winter and early spring. There are several generations annually.

This aphid attacks various species of spruce, but can also (rarely) occur on other conifers, such as pine or Douglas-fir. Aphids feed on older needles and do not move to the new growth immediately. During feeding by aphids, needles may turn discolored and eventually yellow or brown. Most aphids are found on the lower end of branches, in towards the trunk, and are usually concentrated low on the tree, but high infestations can occur everywhere. Needles die back and finally drop off the twig.

This pest is not a problem for growers in Oregon and Washington and is not often managed by growers, but the following chemistries are registered and might be used to manage the pest in Idaho at any time the aphids are present.

Chemical control:

- Chlorpyrifos (Lorsban and other brands): Restricted-use pesticide. Main (federal) labels of Lorsban and other brands allow ground application. Oregon and Washington SLNs (OR-050015 and WA-050012) for Lorsban- 4E allow aerial application. Chlorpyrifos is considered effective and is widely used in Oregon and Washington. It is not used in Idaho.
- Imidacloprid (Admire, Provado): Not widely used.
- Oxydemeton-methyl (MSR): A restricted-use pesticide. This is the most often-used chemical for this pest, but the new (long) REI may preclude use.
- Permethrin (Ambush and others): This pyrethroid has fair efficacy for spruce aphid control, but it can lead to a spruce spider mite outbreak due to its toxicity to predator mites.

- Pymetrozine (Endeavor): Not widely used. New registration with limited grower experience. A good product for IPM due to its selectivity to aphids; however, timing is critical for best efficacy.

Biological control (only partially effective):

- Lacewings.
- Ladybird beetles.
- Predacious beetles and midges.

Cultural control:

- Scout early and often, including for signs of natural enemies and parasitized aphids (mummies). Mummies are usually very conspicuous, as they vary in color and shape from the rest of the colony.

Critical Needs for Spruce Aphid Management in Christmas Trees

Research:

- Determine efficacy of products, such as Admire, as an alternative to MSR.
- Identify and evaluate “soft” chemistries for protection of beneficials and parasites.
- Develop economic threshold information for this pest.

Regulatory:

Shorten the REI for MSR.

Education:

- Educate growers on economic threshold information once it has been developed.

Spruce spider mite (*Oligonychus ununguis*)

These arthropods are small, dark green to dark brown mites with eight legs that overwinter as red-orange eggs. The eggs hatch in the spring. Three or more generations will develop in a season at 2- to 3-week intervals. Usually reproduction declines in hot, dry summer weather, and activity increases again later in the summer as cooler weather begins again.

Like other spider mites, the spruce spider mite produces webbing that collects dust and debris, resulting in a dusty or grayish appearance of the foliage. Mite feeding stipples

and bronzes the needles, beginning at the base. They can cause serious defoliation, making trees unmarketable. Spruce spider mites prefer feeding on older needles or scales, and symptoms are seen only on the previous year's foliage. These mites favor Fraser fir but feed on many species of conifer and can easily be carried to another host plant by wind or animals. Dusty roads and stressed trees seem to be areas where first infestations occur. Also, as trees mature, the density provides a better environment for the mites to gain a foothold.

This pest is a problem for most growers and in most tree species. All the chemicals listed below (except horticultural oils, which can be used during late dormancy) would be used in Stage II or Stage III from bud break through vegetative growth.

Chemical control:

- Abamectin (Avid and other brands): A restricted-use pesticide. Not widely used by growers. Expensive and controls only adults. Use is limited, also, because abamectin is a broad-spectrum pesticide that can negatively impact predatory mite populations.
- Bifenazate (Floramite): A restricted-use pesticide. Widely used by growers. An effective miticide. Preferred because it is soft on beneficials. However, coverage is an issue, as good coverage is necessary for good efficacy.
- Bifenthrin (Brigade, Discipline, Fanfare): A restricted-use pesticide. Oregon and Washington have SLNs for Brigade and Discipline (OR-070015, 050005; WA-070016, 050005). Generally, bifenthrin is used judiciously, and only in rotation with other chemicals, because it controls only adult mites and because of its potential negative impact on predators and other beneficials.
- Chlorpyrifos (Lorsban and other brands): Restricted-use pesticide. Main (federal) labels of Lorsban and other brands allow ground application only. Oregon and Washington SLNs (OR-050015 and WA-050012) for Lorsban 4E allow aerial application. Not used in Idaho, but widely used by growers in Oregon and Washington. However, chlorpyrifos may have resistance issues for this pest. Chlorpyrifos generally only provides suppression of mite populations, but some growers report good control.
- Clofentezine (Apollo): A restricted-use pesticide. Not widely used by growers.
- Etoxazole (TetraSan): Very effective and soft on beneficials, but not widely used by growers because it is very expensive.
- Fenbutatin-oxide (Promite, Vendex): A restricted-use pesticide. Not widely used. Slow-acting and can cause resistance issues.
- Hexythiazox (Onager 1E): Widely used by growers. However, only works against nymphs and current season eggs. Often used in combination with other miticides that control adults. It has a long residual, which is desirable.

- Horticultural oils: Used on Fraser fir. Applied during late dormancy. Not used on other species due to discoloration issues.
- Insecticidal soap (M-Pede): Thorough coverage important. Not widely used by growers, as efficacy is marginal.
- Oxydemeton-methyl (MSR): Restricted-use pesticide. Widely used and effective for controlling this pest, but 18-day PHI may limit usefulness.
- Propargite (Omite): Oregon and Washington SLNs (OR-030022 and WA-910017). Widely used by growers, but long REI limits usefulness.
- Spirodiclofen (Envidor): Newly-registered product. Not widely used due to little grower experience.

Biological control:

- Predacious mites (naturally-occurring): Fairly effective.
- Ladybird beetles (naturally-occurring): Fairly effective.

Cultural control:

- Improve air flow and circulation in plantation.
- Reduce dust using tree barriers.
- Plant resistant species of trees (such as Nordmann and Turkish).
- Scouting and monitoring.
- Tree shaking at harvest.

Critical Needs for Spruce Spider Mite Management in Christmas Trees

Research:

- Determine the most effective application methods.
- Determine the optimum gallonage and most effective sprayer technology for controlling this pest.
- Develop a Fraser fir cultivar resistant to mite damage.
- Identify and evaluate products, such as Ecotrol, that are approved for organic production.
- Study resistance to better understand shifts in mite sensitivity to pesticides.
- Develop a better understanding of the effects of currently-registered chemicals on predatory mites.
- Identify and evaluate “soft” chemistries for protection of beneficials and parasites.
- Develop economic threshold information for this pest.

Regulatory:

Seek Idaho registration for propargite (Omite).

Education:

- Educate growers on resistant tree species.
- Educate growers on identification of predatory mites and other beneficials.
- Educate growers on monitoring for pest resistance.
- Educate growers on economic threshold information once it has been developed.

White pine weevil (*Pissodes strobi*)

This weevil is small (roughly ¼ inch long), brown, and with a “snout” typical of other weevils. Wing covers are marked with irregular patches of brown and white scales. The larva is a legless, white grub with a dark head capsule and is about the same length as the adults.

There is only one generation a year, but some adult weevils survive for up to 4 years. Adults fly or crawl to new hosts in the spring of the year. The female lays eggs in one-year-old tree terminals in May and June, and larvae feed on the tissues beneath the bark well into August. During August and September a new generation of weevils emerges from the dead terminal. The adults overwinter in the duff beneath trees or on the lateral branches.

The larvae tunnel and girdle the terminal, resulting in dead tops. Weevil feeding can also cause growth reduction, stem deformation, increased susceptibility to wood decay organisms, and tree mortality. Tree mortality is rare and only occurs in small trees (less than 4 feet tall) growing very vigorously in full sunlight.

The first evidence of attack in spring is the tiny glistening droplets of resin exuding from feeding punctures made by adults on the previous year’s growth, just below the terminal buds. However, damage is often first noticed in the summer when the terminal suddenly yellows and eventually loses its needles and turns brown. This is due to girdled stems caused by larval feeding. Feeding by larvae often causes the new terminals to appear to be wilting. Normally, tree dieback does not extend beyond the previous year’s terminal growth.

This pest is an important pest of spruce and pine (commonly grown in Idaho and eastern Washington and Oregon) and only occasionally a pest of Douglas-fir.

This pest would generally be controlled for during Stage II after bud break. However, controls are usually mechanical (see “cultural control” section) for this pest. Chemical controls are not common.

Chemical control:

Apply to the tops to control egg-laying weevils as weather warms in spring. Several applications 3 to 4 weeks apart may be necessary.

- Bifenthrin (Brigade, Discipline, Fanfare): Restricted-use pesticide. Oregon and Washington have SLNs for Brigade and Discipline (OR-070015, 050005; WA-070016, 050005). Widely used and considered effective by growers.
- Chlorpyrifos (Lorsban and others): Restricted-use pesticide. Main (federal) labels of Lorsban and other brands allow ground application only. Oregon and Washington SLNs (OR-050015 and WA-050012) for Lorsban 4E allow aerial application. Widely used in Oregon and Washington. Not used in Idaho.
- Diflubenzuron (Dimilin): Restricted-use pesticide. Efficacy unknown. Not widely used by growers.
- Oxydemeton-methyl (MSR): Restricted-use pesticide. Widely used and effective, but has a long REI and is expensive, which limits usefulness.
- Phosmet (Imidan): Efficacy unknown. Not widely used by growers.

Biological control:

- None known.

Cultural control:

- Mechanical practices, such as cutting and removing tree tops that show damage.
- Scouting and monitoring.
- Tests of weevil-resistant planting stock are being conducted at several locations in western Oregon. The use of weevil-resistant planting stock shows promise and may be widely used in the future.

Critical Needs for White Pine Weevil Management in Christmas Trees

Research:

- Develop a degree-day model to understand the life cycle and predict emergence and outbreak.
- Investigate whether the white pine weevil is a “hitchhiker” pest in Douglas-fir.
- Identify and evaluate “soft” chemistries for protection of beneficials and parasites.
- Develop economic threshold information for this pest.

Regulatory:

None.

Education:

- Educate growers on economic threshold information once it has been developed.

Diseases

Annosus Root Rot

Annosus root rot is a common disease in Pacific Northwest forests and has become a significant problem in some Christmas tree production areas. This disease is caused by *Heterobasidion annosum*, a fungus. In forests, this pathogen can live several decades as a saprophyte in stumps and roots. Infection is mainly from airborne spores produced by conks (visible fruiting bodies) on or in old stump hollows. Spores infect freshly cut stump surfaces or trunk wounds. Cut stumps are susceptible only for a short period of time. Infection spreads from stumps to roots of healthy seedlings or trees that contact infected wood. Root infections may lead to root decay, which spreads up into the stem of the tree. The pathogen colonizes the woody portion of the stem and eventually kills the tree. It produces a dark staining of the older wood in the cut trunk of the tree, which is an important diagnostic symptom for this disease.

This disease has caused significant losses in noble and Fraser fir Christmas tree plantations in the Pacific Northwest. Limited, if any, disease occurs during the first rotation in Christmas tree plantations. Newly planted seedlings are at greatest risk of becoming infected when they are planted between stumps that become infected after harvest or next to stumps of old infected trees. The risk of this disease increases when plantations are planted for a second or third rotation to Christmas trees. Pockets of this disease increase in plantations where the disease goes unnoticed and/or untreated.

In the later stages of root infection, affected trees often show limited symptoms prior to dying. Aboveground symptoms can include yellowing of foliage, reduced terminal growth, and branch flagging. These are general symptoms and can be confused with any other root rot problem. Infected roots may be covered by mycelium of the pathogen, but most often no mycelium or conks are present. Decayed wood may be laminated or stringy with black flecks. Trees can begin to die a few years after planting. Diseased trees may occur in pockets in the field. There may be no aboveground symptoms before Christmas tree harvest. However, a dark staining of the older wood may be evident on the cut surface. If trees are harvested prior to symptom development, the colonization of the stem by the pathogen can significantly reduce the postharvest quality of trees.

This disease is primarily a problem in Oregon and Washington and is not common in Idaho. It would be controlled in Stage I and also Stage III at tree cutting.

Chemical control:

- Borax (Sporax): Sprinkle or shake on freshly cut stumps to completely cover all exposed wood surfaces. Widely used to prevent stumps of previous harvest from becoming infected.

Biological control:

- None used.

Cultural control:

- Urea in an aqueous solution of 20% or higher has been effective in accelerating stump decay on pine, but results are more variable on spruce and other tree species.
- Avoid wounding tree roots and trunks.
- Plant species that are not susceptible to the disease. Nordmann fir appears to be resistant to this disease.
- Monitor for staining in the older wood of recently cut trees that may indicate a problem in one or more fields.
- Remove and destroy infected trees and root systems if possible.
- Excavating stumps between rotations (and removing them from the plantation, especially when the disease has been found within the plantation) can help prevent the spread of this disease.
- The use of soil to cover freshly cut stumps has been suggested but has only worked in two of three tests.

Critical Needs for Annosus Root Rot Management in Christmas Trees

Research:

- Evaluate the effectiveness of applications of *Trichoderma* spp. and other biological control agents in protecting cut stumps from infection.
- Determine the effectiveness of applications of fungicides in protecting freshly cut stumps from infection.
- Conduct more research on the biology and life cycle of Annosus root rot.
- Develop economic threshold information using stump discoloration as an indicator of problems or potential problems.

Regulatory:

- Obtain registration of *Phlebiopsis gigantea* (formerly *Peniophora gigantea*), which is used to manage this disease in European forests, as a stump treatment in the United States.

Education:

- Educate growers on the life cycle and biology of this disease.
- Educate growers on scouting techniques that can help them to develop a strategy of appropriate management practices for the next Christmas tree crop.

Armillaria Root Rot

Armillaria ostoyae is the species associated with most conifer mortality in the Pacific Northwest. This fungus occurs on the roots of many forest tree species and agronomic hosts. The host range includes more than 500 species of woody plants. Douglas-fir, grand fir, and white fir are susceptible and can be severely damaged. Other conifers are mildly susceptible, but some damage may occur.

This disease is associated with stress conditions. Factors such as poorly planted seedlings or use of low-quality planting stock often contribute to disease development.

The fungus can live many years as a saprophyte in soil and on infected stumps, roots, and other organic matter. It breaks down the lignin and cellulose in plant tissue. This fungus may form mushrooms at the base of infected trees in fall and winter. Mushrooms are honey-colored or light tan, with a stalk 4 to 6 inches or more in height and a cap 2 to 4 inches across, often dotted with brown scales. Even when infected trees are cut, infected roots that remain below ground can serve as a source of inoculum for Christmas tree seedlings planted in the same location.

This disease is characterized by thin and/or chlorotic foliage, abundant resin flow or leaching of brown liquid at tree bases, and tree death. Diagnostic mycelial fans can be observed beneath the bark of the root crown of infected plants. Use a pocketknife to remove thin layers of bark from the lower trunk or root collar area where resin may be observed oozing from the bark. Mycelial fans are thick, white layers of fungus that adhere to the root bark and/or the wood beneath the bark. *Armillaria ostoyae* also makes black, shoestring-like structures called rhizomorphs, which are occasionally found within or on the bark and/or extending into surrounding soil. Rhizomorphs may look like roots on the outside but have an entirely different structure when cut open in cross-section. Verification is often difficult to an untrained eye.

This disease is controlled mainly through stump excavation during Stage I.

Chemical control:

- None known.

Biological control:

- None known.

Cultural control:

- A balanced fertilizer regime might help to reduce host susceptibility and the spread of *Armillaria* root rot, especially if there are deficiencies in potassium and sulfur.
- Excavation of infected stumps and roots can be partially effective where terrain, soil type, and economics permit. Burn or let stumps air dry.
- Proper site and species selection.
- Scouting and monitoring can help with early detection.

Critical Needs for *Armillaria* Root Rot Management in Christmas Trees

Research:

- None.

Regulatory:

- None.

Education:

- Educate growers on scouting methods for this disease, stressing that this pest can be a problem in newly-established fields and can be confused with other root rots.

Interior Needle Blight

The cause of this disease is unknown; however, it is thought to be due to the fungus *Mycosphaerella* sp. Several other fungi are found less frequently, including *Phaeocryptopus nudus*, *Phyllosticta abietina*, and *Rhizosphaera pini*. It is unknown whether one or more of these fungi are the primary cause of this disease. The result is a potentially serious needle cast of noble fir and, to a lesser extent, grand fir.

Needles on lower, interior branches become brown but remain firmly attached in late summer and early fall. Research indicates that it takes approximately 2 years from the time of infection until symptoms develop. Diseased trees are noticeably affected and are unmarketable that season. Needles are abscised and fall off by the following spring. Small, black, fruiting bodies (pycnidia, pseudothecia, or perithecia, depending on the

fungus) develop on the undersurfaces of needles in spring when they begin to abscise.

This disease is a problem for most growers, but is not as much of a problem at higher elevations. Chemical controls are applied during Stage II after bud break, starting 4 years from expected harvest. Controls are generally not needed during the harvest year.

Chemical control:

- Chlorothalonil (Bravo Weather Stik and others). **This is the only effective product for controlling this disease**, but applying chlorothalonil-based products may cause chlorotic or necrotic needle flecking.

Biological control:

- None known.

Cultural control:

- Do not interplant the next rotation before the current rotation of trees has been completely harvested.
- Practices that increase air circulation and needle drying will be partially effective.
- Proper site selection that encourages vigorous growth is important, especially when planting at higher elevations.

Critical Needs for Interior Needle Blight Management in Christmas Trees

Research:

- Determine the etiology and biology of the pathogen responsible for this blight.
- Determine whether cultural management practices, such as wider row spacing and in-row spacing, can help control this problem.
- Evaluate the efficacy of copper products (e.g., Kocide).
- Screen sources of noble fir for resistance to this disease
- Develop diagnostic tools for growers to distinguish this disease from abiotic disorders.

Regulatory:

- None.

Education:

- Educate growers on how to identify and mitigate the negative effects of this disease.

Needle Rusts (*Melampsora*, *Pucciniastrum*, and *Uredinopsis*)

There are several needle rusts that occur on Christmas trees in the Pacific Northwest. Needle rust pathogens often have complex life cycles, involving several different spore stages and an alternate host. Rusts vary in intensity from year to year. Cool, moist springs favor disease development. Depending on location, infection generally occurs during May and June.

The fungus *Melampsora occidentalis* is the most common cause of needle rust on Douglas-fir in the Pacific Northwest. The alternate hosts are black cottonwood and other poplars. The two spore stages are found on the current-year needles, and three other spore stages occur on the alternate host.

This rust overwinters as telia on fallen poplar leaves. In the spring, spores are wind-disseminated to developing needles on emerging Douglas-fir shoots. Within a couple of weeks of infection, slightly chlorotic areas develop on the needles. Under severe disease pressure, reddish brown sunken cankers form on the current-season growth. These cankers can girdle the stems, resulting in dieback.

Yellow to orange pustules appear on infected needles during spring. The spores produced by these pustules spread the disease to nearby poplar leaves. In summer, golden, yellow, or orange powdery pustules (uredia) appear on the cottonwood leaf undersurface. Spores produced by the uredia infect additional poplar leaves throughout the summer. In late summer and autumn, small, slightly raised areas or crusts appear on the poplar leaves. At first orange-yellow, they change to dark brown or black. These are the telia, thus completing the lifecycle of this pathogen.

Uredinopsis pteridis commonly occurs on a number of true firs. Grand, white, and Shasta fir are highly susceptible to this pathogen. The alternate host for this rust is bracken fern. The most characteristic symptom associated with this disease consists of chlorotic to yellowish blotches on the upper surfaces of infected needles. Symptoms may appear on new growth as well as several-year-old needles. White, tube-like fruiting structures (aecia) appear on the lower needle surface. Aecia of *U. pteridis* can mature on current-year needles in fall or winter but usually develop on 1-year-old and older needles in spring. *Uredinopsis* aeciospores are white or colorless. Severe infections will result in needle drop.

Wind-blown aeciospores are carried to young bracken fern fronds. Symptoms on fern are chlorotic markings on the upper surface and white pustules (uredia) on the lower surface. Uredinia produce spores that reinfest the fern throughout the summer. Telia

develop on the fern during late summer and fall and overwinter in dead fronds. The telia germinate in spring and produce spores that infect newly emerging conifer needles, completing the life cycle of this pathogen.

Needle rust caused by *Pucciniastrum goeppertianum* is more common in Washington than Oregon. *P. goeppertianum* will infect a number of true firs, especially Shasta, grand, silver, balsam, and subalpine firs. The alternate hosts are *Vaccinium* sp., including huckleberry, blueberry, and cranberry.

Infected needles may develop slight chlorotic areas, but the most conspicuous sign of infection is the white, tube-like fruiting structures (aecia) on the lower surfaces of infected needles. These structures can appear on current-year needles in late summer or on previous years' needles in early summer. These fruiting structures produce spores, which are yellow and spread the disease to nearby *Vaccinium* hosts. Once the alternate host is infected, the rust grows within the stem, resulting in the formation of a witches' broom of thickened stems with few or no leaves. Telia form in a reddish brown layer around stems each year and produce spores that spread the disease back to the conifer host. Unlike with other needle rusts on conifers in the Pacific Northwest, no known uredinial stage occurs on the alternate host.

This pest is commonly controlled for in Stage II (Planting and Maturation), during bud break, and Stage III (Harvest Year), also during bud break.

Chemical control:

Note: Chemical controls are best used as protectants, before infection has occurred.

- Azoxystrobin (Heritage, Quadris): Used in conjunction with a non-silicone-based wetter-sticker. This chemical is not widely used by growers, as its efficacy is unknown in Christmas trees.
- Chlorothalonil (Bravo Weather Stik and others): Fair efficacy for controlling needle rusts.
- Mancozeb-based products (Dithane and other formulations): This product is somewhat efficacious but is not widely used.
- Triadimefon (Bayleton): This product is very efficacious and widely used by growers.
- Ziram (Ziram): This product has some efficacy but is not widely used by growers, since other products, such as Bayleton, are more effective.

Biological control:

- None known.

Cultural control:

- Remove and destroy the alternate host for at least 1,000 feet around plantations.
- Remove infected trees.

Critical Needs for Needle Rust Management in Christmas Trees

Research:

- Determine efficacy and phytotoxicity of propiconazole and azoxystrobin.

Regulatory:

- Register propiconazole if found to be safe and efficacious.

Education:

- Educate growers about the importance of protectant applications of fungicides in controlling these diseases.

Phytophthora Root Rot

This disease is caused by *Phytophthora* spp., a water mold. *Phytophthora* is generally a problem on poorly drained sites or areas where flooding has occurred in a plantation. Most trees die within the first 3 to 4 years of planting. Shasta, noble, white, and Fraser fir are very susceptible.

One to several roots become infected and die. The fungus continues to invade the root crown or collar, causing the cambium and phloem to become a red-brown or butterscotch color. Seedlings often die, while older trees may develop necrotic cankers, which are also dark red to dark brown. Stem cankers are narrow, long, and may spiral up the tree starting from the infected root and root crown area. Bark splits and pitch may accompany necrotic cankers. Lower branches may wilt and die, with needles turning dark red. Use a pocket knife to determine where the canker is coming from in order to distinguish it from *Grovesiella* canker.

This pest is a problem for true fir species (primarily noble), and it limits where this species can be grown. It is generally controlled in Stage I and also in Stage II after bud break.

Chemical control:

- Mefenoxam (Subdue MAXX and others): Not widely used. Efficacy is poor, and it is not cost-effective.
- Phosphorous acid (Fosphite and other brands): Foliar spray at 14- to 21-day intervals. Not used due to poor efficacy.

Biological control:

- None known.

Cultural control:

- Avoid planting in poorly drained soil or areas prone to flooding.
- Choose plant species that are well adapted to local site and soil conditions.
- Plant disease-free seedlings.
- Do not track or move soil from infected sites to other areas of the plantation.
- Improve soil drainage.
- Know the site well prior to planting, and avoid planting in areas with previous or potential *Phytophthora* issues.
- Plant less susceptible tree species, such as Nordmann fir.

Critical Needs for Phytophthora Root Rot Management in Christmas Trees

Research:

- Identify and evaluate viable chemistries or other management options for control of *Phytophthora* root rot.
- Determine whether improved soil drainage, raised beds, and/or applications of gypsum are efficacious methods for helping to control this disease.
- Identify the sources of inoculum that lead to disease development.
- Identify sources of true firs that are resistant to root rot.

Regulatory:

- Establish an inspection program to test nursery stock for *Phytophthora*.

Education:

- Educate growers regarding proper identification of this disease.
- Educate growers on the importance of proper site selection.

Rhabdocline Needle Cast

This disease, which is a problem in Douglas-fir trees, is caused by two fungi, *Rhabdocline pseudotsugae* and *R. weirii*. They perpetuate themselves from year to year in needles on the tree. The extensive loss of needles on susceptible trees renders them unmarketable.

The first evidence of the disease appears in the autumn or early winter as minute yellow spots on upper and lower surfaces of current-year needles. Usually the spots are more abundant near the needle's apex. Spots become larger and darker during winter. By spring, many spots coalesce and become deep red-brown (i.e., "mottled"). Fruiting bodies (apothecia) of the fungus appear on each side of the midrib on the needle's lower surface. The needle's epidermis lifts up as a patch, exposing an orange to orange-brown fungus structure. Spores are released during spring concurrently with the emergence of new shoots. Needles are shed from February through late June in the Pacific Northwest.

On coastal types of Douglas-fir, which are commonly grown in Oregon and Washington, this is a minor needle cast compared with Swiss needle cast. In Idaho, which grows inter-mountain types of Douglas-fir, this disease is a major problem, and Swiss needle cast is minor. Treatments for Swiss needle cast can also control Rhabdocline needle cast, but timing on both is critical. This pest is controlled in Stage II at bud break and also in Stage III at bud break.

Chemical control:

- Azoxystrobin (Heritage, Quadris): Only marginally effective under high disease pressure.
- Chlorothalonil (Bravo Weather Stik and others): Most widely used for this disease and considered efficacious by growers. Excellent control under a variety of conditions. Aerial applications work well.
- Copper-based products (Kocide and other brands): Only marginally effective under high disease pressure. Not widely used by growers to control this disease, as other products are more efficacious.
- Mancozeb-based products (Dithane and other brands): Research has demonstrated good efficacy, but this chemical is not used by growers.
- Sulfur: Some research has shown that high rates of micronized sulfur can reduce the level of this disease. However, the use of sulfur is not recommended until additional information relating to its effectiveness and consumer acceptance of sulfur-treated trees is obtained. Sulfur is not widely used in Christmas trees for needle cast disease.

Biological control:

- None.

Cultural control:

- Avoid planting in low-lying areas with air circulation.
- Plant inter-mountain seed sources that are resistant to this disease.
- Control weeds around the bases of trees.
- Remove and destroy infected trees.
- Space plants for good air circulation.

Critical Needs for Rhabdocline Needle Cast Management in Christmas Trees

Research:

- Establish and maintain a vigorous evaluation program to find alternative products for control of this needle cast so that growers will have another product with which to alternate with Bravo Weather Stik (which is effective in controlling all needle casts).
- Identify sources of resistant inter-mountain types of Douglas-fir.

Regulatory:

- None.

Education:

- Educate growers on identification and best management practices for controlling needle casts.

Rhizosphaera Needle Cast

Rhizosphaera kalkhoffii is the most prevalent cause of this disease, although several other fungi (such as *R. pini*, *Lophodermium* sp., and *Lirula* sp.) can cause needle cast diseases on spruce. The fungus overwinters in infected needles attached to the tree or on the ground. Rain-splashed spores spread to current-season needles. Shearing crews can also spread spores if foliage is wet. Young trees may die if weather favors the disease several years in a row.

At first, current-season needles mottle yellow late in the summer. They soon turn brown or, on blue spruce, purplish brown. Brown needles are shed the next spring and summer. The fungus produces a fruiting body (pycnidium), which emerges from

stomata. These small, black pycnidia are in rows on the underside of the needle. The disease is first visible on lower branches and gradually moves up the tree.

This disease is a pest mainly in Idaho and primarily in spruce trees. Colorado blue spruce and Engelmann spruce are highly susceptible. White spruce has intermediate susceptibility. Norway spruce is relatively resistant. Other conifer hosts include pine, Douglas-fir, true fir, and western hemlock. This needle cast is not regularly controlled for in Washington or Oregon.

This pest is generally controlled in Stage II in both late dormancy and at bud break.

Chemical control:

- Chlorothalonil (Bravo Weather Stik and others): Widely used and considered efficacious. Excellent control under a variety of conditions.
- Copper-based products (Kocide and other brands): Not widely used by growers, because other products are more efficacious.
- Mancozeb-based products (Dithane and other brands): Research has shown fair efficacy, but this chemical is not used by growers.

Biological control:

- None.

Cultural control:

- Avoid shearing and other operations if foliage is wet.

Critical Needs for Rhizosphaera Needle Cast Management in Christmas Trees

Research:

- Establish and maintain a vigorous evaluation program to find alternative products for control of this needle cast so that growers will have another product with which to alternate with Bravo Weather Stik (which is effective in controlling all needle casts).

Regulatory:

- None.

Education:

- Educate growers on the importance of monitoring and proper identification of this needle cast.

Swiss Needle Cast

Phaeocryptopus gaeumannii is a common fungus found on trees of all ages. It is an important disease on Douglas-fir, its only known host, where needle quantity and quality determine marketability. The disease is native to the Pacific Northwest and is a serious problem in western Oregon and Washington. It is a minor problem in Idaho.

Hazard zone research has shown that variables associated with increased moisture (such as fog, rainfall, and altitude), warm conditions (such as temperature during the winter), and lack of excessive heat in the summer correlate with higher disease severity.

Spores produced in spring infect through the pores of young needles on rapidly expanding shoots. Cool, rainy weather in spring is conducive to disease development. Symptoms and fruiting bodies of the fungus (pseudothecia) are not produced until the next spring. Production of pseudothecia is related to winter mean daily temperature and spring cumulative leaf wetness.

Infected needles usually turn off-color (light green to yellow to brown) and are prematurely cast in early spring. Needles may yellow only at the tips or be generally speckled yellow over the entire length. Current-year needles generally do not show symptoms. Some trees will retain infected needles and show no symptoms.

The most visible diagnostic signs are rows of black pseudothecia (pinpoint-sized fruiting structures) on each side of the midrib on the lower needle surface. A hand lens is helpful in distinguishing these structures from sooty mold. Pseudothecia are most prevalent on needles 1 year old and older. Severely infected trees have only current-year needles. When Christmas trees are displayed indoors, infected trees dry out twice as fast as healthy ones.

This disease is generally controlled in Stage II at bud break.

Chemical control:

Note: Fungicides are not needed the first few years a Christmas tree is in the ground. Treatments usually begin 3 years before harvest.

- Azoxystrobin (Heritage, Quadris): Generally ineffective.
- Chlorothalonil (Bravo Weather Stik and others): Widely used and efficacious. Excellent control under a variety of conditions, including aerial application.
- Copper-based products (Kocide and other brands): Not widely used by growers, because other products are more efficacious.

- Mancozeb-based products (Dithane and other brands): Research has shown fair efficacy with ground applications, but this chemical is not used by growers.
- Sulfur: Some research has shown that high rates of micronized sulfur can reduce the level of this disease on Douglas-fir needles. However, the use of sulfur is not recommended until additional information relating to its effectiveness and consumer acceptance of sulfur-treated trees is obtained. Sulfur is not widely used in Christmas trees.
- Thiophanate-methyl (Topsin): Tank-mix or alternate with other fungicides. Limited efficacy data exists. This chemical is not used by growers.

Biological control:

- None.

Cultural control:

- Avoid planting in low-lying areas with poor air circulation.
- Control weeds around the bases of trees.
- Space plants for good air circulation.
- Scouting and monitoring are important to notice the disease early.

Critical Needs for Swiss Needle Cast Management in Christmas Trees

Research:

- Conduct genetic screening to identify families of Douglas-fir with higher resistance levels.
- Develop an ongoing evaluation program to find alternative products for control of this needle cast so that growers will have another product with which they can alternate with Bravo Weather Stik (which is effective in controlling all needle casts).

Regulatory:

- Maintain the registration for chlorothalonil.

Education:

- Educate growers and buyers regarding the best use of chlorothalonil and other fungicides.
- Educate growers on importance of monitoring and proper identification of the disease.

Weeds

The following weeds are commonly found on Christmas tree plantations in Oregon, Washington, and Idaho. However, not all of the weeds are necessarily found on any one plantation.

Broadleaf Weeds

Bindweed, field
Clovers
Dandelion, false
Dock, curly
Filaree
Goatweed (St. John's wort)
Groundsel, common
Hawksbeard
Hawkweed
Knotweed
Lambsquarters
Lettuce, prickly
Marestail
Mullein
Mustards
Oxeye daisy
Pigweed
Plantain
Queen Anne's lace
Ragwort, tansy
Sowthistle, annual
Sowthiste, perennial
Spotted catsear
Thistle, bull
Thistle, Canada
Willow herb
Vetch

Grass Weeds

Barnyard grass
Bentgrass
Bluegrass, annual
Brome grasses
Fescues, fine
Fescues, tall
Orchardgrass
Quackgrass
Ryegrass, annual
Ryegrass, perennial
Velvetgrass
Witch grass

Woody Species

Blackberry (evergreen, Himalaya, trailing)
Cherry
Cottonwood
Maple
Maple, vine
Oak
Poison oak
Red alder
Salal
Scotch broom
Willow

Other

Fern, bracken
Horsetail, field

Weed management is a delicate balance between soil protection and weed competition. Excessive weed growth in Christmas trees reduces tree vigor, increases occurrence of vertebrate pests, and can reduce the quality of the harvested trees if plant debris is lodged among branches. However, completely eliminating all vegetation increases runoff, soil erosion, and soil compaction and can diminish quality if tree branches get muddy during harvest. Consequently, vegetation management in Christmas trees requires weed control practices combined with careful management of the ground cover to maintain tree growth, quality, and ease of harvest while reducing soil erosion and compaction.

It is possible to control competition and get the benefits of partial vegetative cover by controlling only the weeds within the tree row or around each tree. Some growers plant less competitive, more desirable ground vegetation between tree rows. As trees become better rooted and approach harvest age, weed competition is less of an issue. Instead, a living cover on the soil surface is ideal to facilitate harvest. Growers can grow a cover crop between tree rows during the entire rotation, or during the soil preparation phase only, before planting, or on strategically located strips across the field and along its edges, keeping all cover crops short to avoid attracting rodents. Soil that is tilled, or heavily disked and left unplanted, should be seeded with a fast-growing winter grass or cereal grain that can hold soil in place in wet weather and help reduce erosion.

Methods to control vegetation between the tree rows include light tillage, mowing, and herbicide applications. However, it's important to remember that weed infestations are dynamic and change depending on previous cultural and weed control practices. For example, routine cultivation, mowing, or use of the same or similar herbicides will result in a weed shift to species that tolerate these practices. Best practices include a combination of a variety of weed control practices or treatments.

I: Preplant and site preparation

Main Problem Weeds: bentgrass, false dandelion, fescues, field bindweed, marestail, quackgrass, ryegrasses

Chemical control: (Many of the soil residual products that can be used post-planting can also be used in site preparation, but most growers wait until after planting to apply these products.)

- **Atrazine:** A restricted-use pesticide. A preemergence herbicide used for control of annual broadleaf and grass weeds prior to transplanting, after transplanting, or in established conifers.

- Glyphosate (Roundup and other brands): A nonselective, systemic herbicide used to control vegetation that might compete with trees and impede preplant cultivation. Additional surfactant or mixing ammonium sulfate as label instructs may improve control of slightly stressed weeds. Various rates may be used, depending on the weed species to be controlled.

Biological control:

- Some biological controls (such as cinnabar moth, released) are used in perimeter areas.

Cultural control:

- Cultivation (plowing, disking, tilling) will control many established weeds. A good cultivation program is often a summer fallow program, including plowing and two to three discings over the summer prior to planting the following winter.
- Plant a cover crop to help suppress annual weeds.

II. Planting through Maturation

All herbaceous weeds, as well as blackberry species and Scotch broom, are a problem throughout this stage. In later years, hardwood tree seedlings, such as cottonwood, red alder, and willow, can be a problem. Woody plants will begin to occupy plantations in this stage and need to be controlled immediately and frequently during this stage. If weed species are controlled well during the first half of the rotation, weeds will become shaded out by the trees in the later years of this stage before harvest.

Weed control differs between new plantings and established plantings during this stage of Christmas tree growth. Certain herbicides are more appropriate for use in an established planting and may not be recommended for use in a newly established plantation. Established plantings are those that have completed 1 year of growth in their transplanted location. Care needs to be taken when applying herbicides to, or over the top of, newly planted tree seedlings. Waiting to apply until rain has settled the soil around root systems of trees is often recommended. One-half inch of rain is usually sufficient. Damage can occur on newly planted trees, so lower rates may be recommended.

Chemical controls:

- 2,4-D (LV4 and Amine): These are the only two 2,4-D products registered for use in Christmas trees. Over-the-top applications can be made as a rescue treatment,

but there are risks associated with this application. Only one formulation of 2,4-D carries this over-the-top label. Caution: do not apply over the tops of pine or true firs.

- Asulam (Asulox): Used for bracken fern control. (This is the only product that controls bracken fern around actively growing trees.) Rate lower than the labeled rate is usually effective and advised. Caution: do not graze treated areas. This product is widely used.
- Atrazine: Restricted-use pesticide. This chemical can cause resistance issues so is generally best when used in a rotation with other herbicides. Atrazine is widely used but mostly in combination with other products like oxyfluorfen. Atrazine is very commonly used in new plantings.
- Atrazine + 2,4-D isooctyl ester (Shotgun): Restricted-use pesticide. (Atrazine is the component that is restricted-use.) High rates are used for quackgrass control. This product is often used as a directed spray between and around trees. In Idaho it is not recommended to apply to trees that are less than 3 years old. This product is not widely used by growers and is not for use in new plantings.
- Clethodim (Envoy Plus): For use around or over the top of actively growing Douglas-fir, true fir, and pines. Clethodim is applied postemergence to actively growing annual or perennial grasses. This product is widely used but expensive. Can be used on both new and established plantings.
- Clopyralid (Stinger): This product is applied broadcast or in bands during active weed growth. Canada thistle is the target weed. To avoid needle curling, do not apply during first year after transplanting. Can be applied over the tops of trees in the Pacific Northwest but cannot be used on Scots pine. Tree injury may occur with addition of surfactant or crop oil (which are not used unless testing or previous experience shows injury is tolerable). This product is widely used by growers on established plantings only.
- Fluazifop (Fusilade DX): Results are often erratic on grasses stressed from lack of vigor, drought, high temperature, or low fertility. This product is more effective than other products on quackgrass when applied over the top, but mature grasses and quackgrass may require more than one application. Annual bluegrass and all fine fescues resist treatment. This product is not widely used because of poor control on fine fescues.
- Flumioxazin (SureGuard): Preemergence and/or postemergence herbicide for control of selected grass and broadleaf weeds. Postemergence weed control is limited to very small weeds. All over-the-top applications of SureGuard are applied prior to spring bud break or delayed until conifers have hardened off. Do not apply to conifers within 2 years of seedling emergence.
- Glufosinate (Finale): Applied to actively growing weeds. Do not let spray or drift contact living tissue or green, thin, or uncalloused bark, as injury may occur. This

product cannot be used broadcast over the top of Christmas trees. Glufosinate is not widely used except by some growers to spot spray for horsetail.

- Glyphosate (Roundup and other brands): Prevent crop injury by selecting application equipment to direct spray toward base of plants, or use selective applicators. Additional surfactant or mixing ammonium sulfate as label instructs may improve control of slightly stressed weeds. Avoid contact of spray or mist with foliage or green bark of desirable plants. To avoid weed resistance, rotate herbicides and weed control practices. Some glyphosate formulations have an over-the-top supplemental label during dormancy. Commonly used for spot spraying during the summer.
- Hexazinone (Velpar L and DF): Registered for use in new plantings and commonly used in established plantings. Variable tree injury has been observed with use on new plantings. (Testing on a small area is recommended.) Later applications (e.g., in early April) may be more effective than March applications, due to greater leaching from spring rains. High labeled rate is more effective on trailing blackberries. Repeated use of triazine compounds can promote problem weeds like false dandelion and rattail fescue. Douglas-fir is more vulnerable to this herbicide. A reduced rate is used during the first year of tree growth.
- Hexazinone + sulfometuron (Westar): Broadcast treatments are made to dormant trees only. If trees have broken dormancy, directed applications are required to avoid contact with new growth. This product is used in Douglas-fir, Fraser fir, grand fir, noble fir, Nordmann fir, and Turkish fir plantings. For maximum safety to grand and noble fir, use large transplant stock and apply at a lower rate, or use after trees have been established at least one growing season. In newly transplanted fields, rain or irrigation should have settled soil prior to use. This product is widely used by growers and can be used on new or established plantings.
- Isoxaben (Gallery or Gallery T&V): This preemergence herbicide is applied from late summer to early fall, in early spring, or immediately after cultivating. This product is not widely used due to its high cost. For use on established plantings.
- Isoxaben + trifluralin (Snapshot 2.5 TG): This product is not used, because the application method is too expensive.
- Oryzalin (Surflan and other brands): Used in pine and true firs (but not Douglas-fir) after transplanting once soil has settled around the tree roots. However, this product is not widely used due to its high cost.
- Oryzalin + benefin (XL 2G): This preemergence herbicide controls winter or summer annual grasses and broadleaves. It cannot be used on Douglas-fir or in new plantings of any species. This product, as with other granulars, is not used because of the high cost.

- Oxyfluorfen (Goal 2XL, GoalTender, Galigan, and other brands): Oxyfluorfen can be applied over trees or as a directed spray throughout the year, except when buds and new shoot growth are tender and not yet hardened off. It has a short soil residual and controls small, emerged broadleaf weeds. Perennial and emerged annual grasses are not controlled, although fine fescues may be suppressed. The XL formulation is the preferred formulation and is widely used by growers. Oxyfluorfen can be used on both new and established plantings.
- Pendimethalin (Pendulum and other formulations): Apply at planting or before weed seeds germinate. Soil should be loose and free of all established weeds. This product is not widely used as a stand-alone product, as other herbicides are more effective.
- Prodiamine (Barricade and other brands): This preemergence herbicide is used judiciously, as injury may occur on trees with new and actively-growing shoots. This product is not widely used, as it is expensive and other products are more effective.
- Pronamide (Kerb): A restricted-use pesticide. Oregon and Washington SLNs (OR-040029 and WA-060002) for Kerb 50W allow aerial application. Mostly preemergence activity with some postemergence control of small broadleaf and annual grass weeds. Pronamide is used only on established plantings (not recommended on trees less than 1 year old). Pronamide is not widely used by growers, because it is very specific to certain grass weeds (such as quackgrass).
- Sethoxydim (Segment): This postemergence grass herbicide can be used to control annual and perennial grasses after bud break during active tree growth. It is not widely used by growers, as other products, such as Envoy, are more effective on specific grass problems (e.g., annual bluegrass and fine fescues). Sethoxydim can be used on new or established plantings.
- Triclopyr (Garlon 3A): This product is widely used by growers, most commonly to control woody species, especially blackberries. Triclopyr is used with caution as a directed spray, as spray solutions can injure needles and branches.

Biological control:

Note: Both of these biologicals are used as a supplement to other control measures, as populations are cyclical.

- Tansy flea beetle releases for tansy ragwort control
- Release of cinnabar moth for tansy ragwort control.

Cultural control:

- Mowing/cultivation between rows (only in young plantations due to the risk of root damage in established plantings).
- Manual brush (woody plants) removal.
- Establishment of a cover crop between tree rows.

III. Harvest Year

Weeds in the harvest year are generally not a problem. By this time cultural, biological, and chemical applications should have been effective, and weeds should be shaded out by the mature Christmas trees.

However, if weed control is needed during the harvest year, the control measures used would be the same as those listed in Stage II (Planting through Maturation). Contact herbicides are preferable to soil-applied herbicides during this stage. In addition to the cultural controls mentioned in Stage II, tree shaking at harvest is a common practice.

Critical Needs for Weed Management in Christmas Trees

Research:

- Identify biological controls for weeds, particularly thistles.
- Determine how to best use currently registered products (optimum timing, efficacious rotation of products, etc.) for better control of false dandelion.
- Identify and evaluate new management strategies (chemical and cultural) to control maretail, wild carrot (Queen Anne’s Lace), witchgrass, and St. John’s wort.
- Identify and evaluate predator-friendly ground-applied systemic insecticides to protect the Klamath beetle, which is an important biological control for St. John’s wort (“Klamath weed”).
- Identify and evaluate effective equipment sanitation practices to prevent or reduce weed movement between fields.
- Develop weed management methods and strategies to minimize herbicide impact on surface and groundwater.
- Continue research on identifying low maintenance ground covers for weed and sediment control that also provide habitat for beneficials and are economically viable to maintain.
- Determine efficacy and economics of using rimsulfuron (Matrix) for grass and broadleaf weed control.
- Identify and evaluate organic-approved weed control methods.
- Develop economic thresholds for problem weeds.

Regulatory:

Have EPA, WSDA, ODA, and ISDA come to a consensus on the regulatory terms referring to Christmas trees, especially as they relate to pesticide registrations and labels (e.g., SureGuard label).

Education:

- Educate growers on best practices for equipment sanitation to reduce weed movement between fields.
- Educate growers on most effective way of using available weed control tools with respect to both efficacy and affordability.
- Educate growers on effective and economical ground covers.

II. Major Regulatory Pests

Insects and Mollusks

Douglas-fir needle midge (*Contarinia* spp.)

This pest was discussed previously in the section entitled Major Pests. In addition to causing quality issues in Christmas trees, the Douglas-fir needle midge is also a regulatory pest. Please see this pest's entry in the Major Pests section for the pest description and explanation of controls.

Douglas-fir twig weevil (*Cylindrocopturus furnissi*)

This pest was discussed previously in the section entitled Major Pests. In addition to causing quality issues in Christmas trees, the Douglas-fir twig weevil is also a regulatory pest. Please see this pest's entry in the Major Pests section for the pest description and explanation of controls.

European Pine Shoot Moth (*Rhyacionia buoliana*)

This moth is established in western Washington and can also be found in Idaho, but it is still relatively rare in Oregon. Damage is done by larvae that bore into shoot and bud tissue. Larvae stunt and deform stems, especially terminals. Attacks frequently occur in young trees.

Adults emerge in early summer. The exact date depends on spring temperatures. Warm spring temperatures permit an earlier emergence, whereas a relatively cool spring delays the emergence flight. Pheromone traps and degree-day models are available to monitor for adults.

Female moths lay eggs on host pines that may be scattered over a large area. This moth is a relatively strong flier and can disperse its eggs widely. Eggs hatch in 1 to 2 weeks, at which time the new larvae begin feeding. Needles are mined first, then buds. Larvae spend the winter under a resin/silk shelter or in buds.

The following spring, larvae migrate upward and feed on new buds or expanding shoots. Developing shoots are killed. Pupation (the change from larva to adult) occurs in shoots and takes 2 to 3 weeks in late spring. There is only one generation per year.

This pest is not a quality problem and is not treated chemically by growers. However, it is a regulatory pest and is inspected using traps.

Chemical control

- This pest is not treated chemically by growers.

Biological control:

- Many natural parasites and predators exist. Care is taken not to disrupt them through careless or ill-timed pesticide applications.

Cultural control:

- Shearing can help with the problem.

Slugs and Snails

Gray garden slug (*Deroceras reticulatum*)

Marsh slug (*Deroceras laeve*)

Brown banded slug (*Arion circumscriptus*)

Brown garden snail (*Helix aspersa*)

and others (species composition not well researched)

Slugs and snails are considered contaminants at harvest and need to be removed from trees before shipping, especially to certain areas. The species name of the brown garden snail, *aspersa*, means “bespeckled” and refers to the mixture of grayish-yellow and brown coloration of the shell, which can be 1 to 1¼ inches in diameter when snails are full grown. The snail itself is light to dark gray and when fully extended is about 2 inches long. Slugs are closely related to snails but have no external shell. The gray garden slug and the marsh slug vary in color from gray to brown to almost black. The brown banded slug is tan with brown stripes on its sides. All three species can reach about 1 to 1½ inches in length when mature. They are active above ground both day and night, whenever the relative humidity in their immediate environment reaches 100%, the temperature is above 38°F, and the wind is negligible. They are most active at night.

Slug and snail populations can be determined and monitored with the use of bait stations. (Scratch out an area in the field, about ½ by 1 foot in size, and bait it with a molluscicide in the evening to attract slugs and snails to the station. Visiting the stations the following morning will reveal relative populations in the field.)

Slugs and snails are regulatory pests and need to be managed throughout the harvest year beginning in the spring at bud break and continuing through tree cutting.

Chemical control:

- None registered for use in Christmas trees.

Biological control:

- None known.

Cultural control:

- Some growers use copper impregnated tarps to store trees on after shaking and baling.
- Keep time between tree cutting and processing as short as possible.
- Removing natural ground covers (e.g., weeds, etc.) will help suppress slug and snail populations.
- Tree shaking at harvest might remove some slugs. (This process is explained under the Wasps/Yellowjackets section.)

Critical Needs for Slug and Snail Management in Christmas Trees

Research:

- Determine whether groundcovers between rows contribute to slug and snail infestations.
- Investigate when and how pests are entering trees and the viability of shaking as a removal tool.
- Investigate best practices regarding storage, including timing and other protocols, to prevent slug and snail infestations.

Regulatory:

Seek registration of metaldehyde or iron phosphate for slug and snail control on plantations before harvest.

Education:

- Educate growers regarding proper shaking and storage protocols once these are developed.

Wasps/Yellowjackets

German yellowjacket (*Vespula germanica*) queens

Western yellowjacket (*V. pensylvanica*) queens

Common yellowjacket (*V. vulgaris*) queens

Baldfaced “hornet” (*Dolichovespula maculata*) queens

European paper wasp (*Polistes dominulus*) queens

Yellowjacket queens are about $\frac{3}{4}$ inch long, and all species are black and yellow striped except the baldfaced hornet, which is black and white. European paper wasp queens are black and yellow striped and about $\frac{1}{2}$ inch long.

Hornets and many species of yellowjackets (*Vespula* species) frequently visit trees in late summer to collect honeydew produced by aphids and other insects. Trees and shrubs are commonly used as nesting areas. Nests are constructed of paper-like materials produced from ground-up bark and wood mixed with saliva.

All wasps are beneficial in their natural habitats and are critically important in natural biocontrol, as they feed on other insects, including caterpillars, flies, and beetle larvae. However, they are a contaminant in trees at harvest and must be removed before trees are shipped to certain markets, such as Hawaii. They can also present a worker safety issue during the years when the trees are growing on the plantation.

When this pest is posing a worker safety issue, it is controlled from early spring through October. Otherwise, as a regulatory pest, it is controlled in the harvest year. This pest is generally not treated with chemicals unless a serious problem arises.

Chemical control:

- Spot spray, when needed, with a pyrethroid product, such as bifenthrin (Brigade, Discipline, Fanfare), esfenvalerate (Asana), or permethrin (Ambush).

Biological control:

- None known.

Cultural control:

- Scouting and monitoring.
- Tree shaking at harvest: For export to some areas, such as Hawaii, tree shaking is required at harvest to remove wasps and other insects. If any yellowjacket queens are found during the shaking process, the entire lot of trees is considered “infested,” and these trees cannot be shipped to Hawaii.

Shaking can be done by hand in the presence of an inspector by striking the butt of individual, unbound trees onto a solid surface with sufficient force to dislodge any “hitchhiking” insects and other contaminants. The trees must be shaken using a minimum of three or more strikes, or until most of the dead needles have been removed. Shaking can also be done with a mechanical shaker (e.g., a motor- or PTO-driven shaking unit). Each unbound tree should be mechanically shaken for a period of time sufficient to dislodge any “hitchhiking” insects and other contaminants, and/or until most of the dead needle fall is eliminated.

Critical Needs for Wasp and Yellowjacket Management in Christmas Trees

Research:

- Develop a better understanding of the effects of tree shaking on the translocation of water and the possible increased drying speed of tree.
- Research the relative effectiveness of various shaking methods (with special attention to dry trees versus wet trees, etc.).
- Determine whether preharvest pesticide applications are effective in managing yellowjacket populations.
- Determine whether yellowjacket contamination of harvested trees occurs in the field or after trees have been shaken and loaded for transport. Also determine the same for paper wasp queens.

Regulatory:

Seek clarification from regulatory agencies on which species are contaminants.

Education:

- Educate growers on the fact that contamination (on trees and in shipping containers) by yellowjackets and other wasps can likely occur after shaking.

III. Vertebrate Pests in Christmas Tree Production

Birds

Broken tree tops are the most common bird damage. Breakage occurs in the May to July period when the new tops are just elongating, before they become rigid enough to support bird perching. Tall trees are particularly sensitive, as the birds look for high vantage points. Most growers expect and accept some bird damage and do not specifically follow control practices.

Management of birds:

- One suggestion includes placing poles or perches throughout the fields at a height above the trees.
- Noise cannons, predator calls, and colored balloons have all been suggested, but little evidence is available to support their use.

Mice/Voles

These rodents damage trees by feeding on the tree bark and tree roots to get at the cambium or sap. The damage appears as small feeding marks around the stem of seedlings, just above ground level. Close inspection can reveal individual, small teeth marks. Damage can occur year-round, but winter or spring damage is most common. Damage can be more severe in winter, especially under snow cover.

Management of mice and voles:

- The most common solution to voles and mice involves eliminating weeds around the seedlings. This removes a source of cover that can protect the mice from natural predators, such as hawks, owls, snakes, and skunks. Weed control along tree rows is particularly important in situations where plantings are made near fields with existing rodent populations.
- Barriers to trunk feeding (e.g., metal or plastic cages).
- If needed, ground broadcast or hand spot baiting can be effective with the use of certain brands of zinc phosphide or chlorophacinone (Rozol Vole Bait). Chlorophacinone is newly registered, so there is little grower experience with this product. Diphacinone (Ramik Brown) can also be used for ground baiting or hand spot baiting, but it is allowed only in Washington and Idaho.

Rabbits/Hares

Branch feeding from rabbits can be identified by the 45 degree cut they make while feeding. Damage can be severe on young trees but is seldom a problem on older trees. Damage may extend up to 2 feet from the ground, since rabbits are capable of feeding while standing on their hind legs. Occasionally, rabbits strip the bark and girdle stems on young trees. Feeding damage is generally more severe in winter when preferred food sources are rare.

Management of rabbits and hares:

- Weed control is the leading remedy for damage from rabbits. It removes the protective cover that rabbits prefer.
- Plantskydd (soluble powder and granular formulations): this odor-based repellent works well as a browse deterrent for rabbits and hares. It is approved for organic production.

Gophers

These rodents are capable of damaging most Christmas tree species, especially pine. Gophers build semicircular mounds and feed on roots. (Moles, which build circular mounds, do not feed on roots.) Gophers are seldom seen above ground. They are largely solitary.

Trees near gopher mounds or burrows may be progressively dying. Leaning trees are easily pulled out of the ground due to gopher root feeding. After digging up trees, growers find that roots may be minimal to nonexistent.

Management of gophers:

- Weed control: Remove any flesh-rooted weeds such as wild carrot and dandelion.
- Strychnine can be used as a down-the-hole treatment and is very effective.
- For small-scale problems, trapping is the preferred control measure.
- In more severe situations, sulfur fuming with propane torches can provide effective control.

Deer/Elk

Antler rubbing or polishing and foliage feeding are typical types of damage associated with deer and elk. Antler rubbing occurs on trees with open internodal spaces, such as true firs. Typical damage involves broken or missing branches on one side of the tree. Often bark is scraped off, producing a long-lasting injury. Damage is most severe along edges of a field adjacent to timber stands. Foliage feeding damage may occur throughout the year, but it is more intense at or near bud break. (Deer are more common foliage feeders than elk.) Feeding is common during harsh winters when snow covers other food sources. Deer and elk often select Douglas-fir for feeding in the spring. Winter and spring damage to Fraser and Nordmann firs is common.

Damage typically involves leaders and upper branches, usually confined to current-season foliage. Browsed branches may have a ragged appearance, as animals tend to bite and pull rather than sharply cut off the tissue. Occasionally, deer and elk may pull seedlings out of the ground. Elk tend to do other damage not associated with browsing activities. They pull up young seedlings and can cause physical damage by rubbing and trampling of older trees.

Management of deer and elk:

- Fencing (electric or woven wire) can be effective on deer, but elk can break physical barriers and become trapped inside where they are free to damage trees. Fencing is expensive and often impractical.
- Repellents: Numerous products are available for repelling deer and elk (Deer Away, Tree Guard, Plantskydd, and other products). Home remedies are also used but rarely effective. Repellents tend to be less effective on elk (except for Plantskydd, which works well on elk populations if they are not concentrated in specific areas).
- Individual tree protection: Bud caps, tree tubes, and individual tree cages may minimize deer feeding successfully in forest settings. However, they have limited utility in Christmas tree fields, since they restrict development of lateral buds and require maintenance while in place.
- Damaged trees should not be removed, since animals tend to revisit the same damaged trees.
- Trained dogs to run off deer and elk may be used.
- Herd-size reduction may be a practical solution in some cases by means of special hunts arranged by fish and game departments.

Critical Needs for Vertebrate Pest Management in Christmas Trees

Research:

- Identify effective controls to mitigate bird damage on tree tops.
- Identify nonchemical means for controlling vertebrate pests.

Regulatory:

- None.

Education:

- Educate growers on proper identification of vertebrate pest damage.
- Growers should be trained regarding animal behavior in order to most effectively use the known and available management strategies.

IV. Sporadic and Minor Pests

These pests may not appear very often. Some can be very serious if and when they do appear, while others may cause only limited damage.

Insects

Cooley spruce gall adelgid (*Adelges cooleyi*)

On spruce trees, immature females overwinter underneath young branches. In spring, females mature and lay several hundred eggs near developing buds. Eggs hatch at bud break, and young nymphs (crawlers) migrate to new spring growth. They feed at the base of growing needles, causing the formation of cone-like galls at the tip of branches during June and July. Initially, galls are green or purple and have needles projecting from the surface. The insects develop within chambers inside the galls and gradually increase in size. By mid-summer the galls dry out and release winged adelgids. Most winged forms migrate to Douglas-fir trees. Abandoned galls are brown and may persist on trees for years.

On Douglas-fir, adelgids appear as “pepper” flecks (crawlers) on needles in late spring, and/or small cottony tufts (“stem mothers,” a waxy secretion of adults) on the underside of needles before bud break. The newly hatched crawlers migrate to the buds and attach themselves to the expanding new growth. They may produce a second generation around mid-June.

These insects cause yellowing and distortion of needles and may contribute to premature needle drop. No galls are produced on Douglas-fir. Late in summer, some of the adelgids develop wings and fly back to spruce and produce the overwintering population. Others are wingless and remain on Douglas-fir trees, where they produce other overwintering forms.

This is not a major pest for Christmas tree growers and is rarely controlled specifically. It is often controlled with midge control.

Chemical control:

- Chlorpyrifos (Lorsban and other brands): Restricted-use pesticide. Main (federal) labels of Lorsban and other brands allow ground application. Oregon and Washington SLNs (OR-050015 and WA-050012) for Lorsban-4E allow aerial

application. Chlorpyrifos is widely used in Oregon and Washington, as it is also effective for balsam woolly adelgids and aphids. It is not used in Idaho. Timing is critical for effective control.

- Endosulfan: Restricted-use pesticide. Considered very effective for cooley spruce gall adelgid but used mainly when balsam woolly adelgid is the target pest.
 - (Thionex 3EC): Oregon, Washington, and Idaho SLNs allow aerial application and use in all conifer species (OR-030013, WA 030018, ID-030002).
 - (Thionex 50W): Oregon and Washington SLNs allow aerial application and use in all conifer species (WA-030017, OR-030012).
- Horticultural oils: Not widely used by growers due to phytotoxicity concerns.
- Imidacloprid (Admire, Provado): Not widely used by growers. Efficacy is unknown.
- Oxydemeton-methyl (MSR): Restricted-use pesticide. Not widely used in areas where buffer zones exist. Its long REI limits usefulness, and it is expensive.
- Spirotetramat (Ultror): A newly-registered product with limited grower experience. Has potential because it moves systemically downward and upward and also works on other aphids and adelgids.

Note: Chemical treatments are most effective when applied during crawler stage, usually when new growth is expanding in spring (50–80% bud break).

Biological control:

- Lacewings: Naturally-occurring. Provide some control.
- Ladybird beetles.

Cultural control:

- Scouting is a very important control for these adelgids, as controlling them early is essential.

Critical Needs for Cooley Spruce Gall Adelgid Management in Christmas Trees

Research:

- Identify and evaluate “soft” chemistries for protection of beneficials and parasites.
- Develop economic threshold information for this pest.
- Develop resistant species of Douglas-fir.

Regulatory:

None.

Education:

- Educate growers on economic threshold information once it is developed.

Douglas-fir Tussock Moth (*Orgyia pseudotsugata*)

The adult male tussock moth is a gray-brown to black-brown moth with feathery antennae. The female has tiny rudimentary wings, small thread-like antennae, and a large grayish abdomen. Egg masses are grayish, as they are mixed with black hairs from the female's abdomen. Larvae (caterpillars) go through several stages of development. They hatch as tiny, black-headed caterpillars. The caterpillars are very colorful, with two hair-like tufts projecting from the head and a similar one at the rear. There are four light-colored brushes on the front half of the caterpillars' back. There are also numerous red spots along the sides and on the top rear half. Mature caterpillars are about 1-3/16 inch long. All stages of development are hairy.

The flightless female lays eggs on her cocoon any time from August through October. Eggs overwinter in a mass and hatch from late May to late June. Larvae initially feed on the underside of new needles, and then they switch to older needles and next year's buds. Young larvae may be dispersed to other trees by "ballooning." Fully developed larvae spin a cocoon and pupate from mid-August through September, emerging to mate and die soon thereafter. Only one generation occurs each year.

Damaged needles may appear ragged. Heavy populations defoliate branches. Defoliation by the tussock moth may kill or top-kill trees, weaken trees that can then be eventually killed by bark beetles, or retard tree growth for several years. Larval body hairs irritate the skin of some people.

The Douglas-fir tussock moth is an important defoliator of true firs and Douglas-fir in western North America. Outbreaks of the Douglas-fir tussock moth appear to develop almost explosively, and then they usually subside abruptly after a year or two. Douglas-fir, white fir, and grand fir are all equally susceptible hosts.

Chemical control:

- Acephate (Orthene and other brands): This chemical is sometimes used by growers, but it can be toxic to beneficials.

- Permethrin (Ambush and others): This pyrethroid is considered highly effective on Lepidoptera larvae, but it can lead to a spruce spider mite outbreak due to its toxicity to predator mites.
- Spinosad (Success, Entrust): Not used by growers. Efficacy is not well known.
- Tebufenozide (Confirm): This product is highly specific to Lepidoptera larvae. It is an insect growth regulator that requires contact or ingestion by the target insect larvae and works best on young larvae.

Biological control:

- Parasitic wasps: Naturally-occurring wasps help reduce populations.
- Diseases: Frequently, when caterpillar populations explode, their numbers are reduced naturally by polyhedralnuclear viruses. Occasionally, fungi and some bacteria work on them as well. Several of these entities have been commercially formulated, but they are not widely used by growers.

Cultural control:

- None known.

Critical Needs for Douglas-fir Tussock Moth Management in Christmas Trees

Research:

- Identify and evaluate “softer” chemistries that will control the tussock moth and not be harmful to naturally-occurring beneficials and parasites.
- Develop economic threshold information for this pest.
- Research the efficacy of spinosad against tussock moth.

Regulatory:

Seek *Bacillus thuringiensis* (Bt) registration for Christmas trees for controlling this pest.

Education:

- Educate growers on the importance of scouting for this pest, which appears sporadically but can be very damaging.
- Educate growers on economic threshold information once it is developed.

Grand Fir Twig Borer (*Argyresthia* sp.)

This is a small, grey-brown moth that emerges in late April to early May and lays eggs shortly thereafter on new twigs. The whitish larva feeds inside the base of the twig, causing needles to turn yellow and die. Prior to pupation, the larva enlarges or chews a new exit tunnel, then pupates inside the twig base.

This pest has a limited distribution area, occurring mostly in central western Washington.

Chemical control:

- Esfenvalerate (Asana and other brands): A restricted-use pesticide. Best timing for control is pre-bud break.

Biological control:

- Parasitic wasps (naturally-occurring).

Cultural control:

- Remove and burn infested trees.
- Scouting and monitoring, which include enclosing infected twigs to see when the moth emerges, are important.

Critical Needs for Grand Fir Twig Borer Management in Christmas Trees

Research:

- Conduct research and surveys to determine whether this pest is an emerging, widespread problem.
- Identify where this pest is present (other than central western Washington).
- Identify and evaluate “softer” chemistries that are effective in controlling the twig borer and are not harmful to beneficials and parasites.
- Develop economic threshold information for this pest.

Regulatory:

None.

Education:

- Educate growers that this may be an emerging pest and provide information on identification, biology, and life cycle.
- Educate growers on economic threshold information once it is developed.

June Beetles, Rain Beetles, and other scarabs

(*Polyphylla decemlineata*, *Pleocoma* spp., *Aphodius* spp.)

These pests appear as small to large, C-shaped, white beetle larvae with six legs and a brown head and are commonly known as “white grubs.”

The adult *Polyphylla* is about 1 inch long, with white stripes on brown wing covers. *Pleocoma* is about the same size, but all brown, while *Aphodius* spp. are smaller, at about ¼ inch, and variously colored brown, black, or brown and black.

Depending mainly upon climatic factors, the life cycle of June beetles requires 3 or 4 years for completion. Grubs and adults overwinter in the soil, and in late June and early July, adults emerge on warm evenings, mate, and return to the soil. These flights are repeated daily for 2 to 3 weeks. Eggs are small, slightly oval, and creamy white. They are deposited in the soil and hatch after 2 to 6 weeks. For the remainder of the growing season, and for the following two growing seasons, larvae feed on organic matter and roots near the soil surface. Pupation occurs early- to mid-summer in the third year of development in cells just below the soil surface.

White grubs feed on roots of many conifers and can cause needle yellowing and tree stunting. Damage can be detected when seedlings turn brick-red and die as a result of larvae shearing off (girdling) the plant roots. Larvae cause greatest damage in their second year of development.

This pest presents a sporadic problem, and more research is needed for treatment methods.

Chemical control:

- Thiamethoxam (Flagship): Efficacy unknown.
- Imidacloprid (Admire, Provado): Efficacy unknown.

Biological control:

- Parasitic wasps.

Cultural control:

- Attract and collect. (Females are collected and put in a container to attract males.)

Critical Needs for Scarab Beetle Management in Christmas Trees

Research:

- Identify and evaluate biological control, including nematodes, for the larval stage of June and rain beetles and other scarabs.
- Investigate pheromone control options for scarab beetles.

Regulatory:

- None.

Education:

- Educate growers on how to properly investigate and identify below-ground root damage caused by these pests.

Silver-spotted tiger moth (*Lophocampa argentata*)

Silver-spotted tiger moth larvae are about 1½ inches in length and are covered with a combination of dense black, reddish brown, and yellowish hairs. Tiger moth larvae hibernate in dense clusters on twigs and become active on warm winter days. Larvae mature in June. The young larvae are small, hairy, and brownish in color. The mature larvae have tufts of yellow and brown hair and sometimes dorsal tufts of black hair. Adult moths are yellowish brown with distinct silvery-white spots on their forewings.

The damage to trees is caused by the caterpillars (larvae), which feed in webs on needles. Early in their development, the caterpillars congregate in a tent-like construction of silk. They overwinter in these “tents” on twigs, feeding well into and throughout winter, depending on warm temperatures. Caterpillars pupate on the tree or the ground in June. Adults emerge and lay eggs on the tree foliage from July to August. The eggs hatch in late summer and early fall.

The young caterpillars are among the first insects to start feeding on Douglas-fir in the spring. Although commonly seen in the late winter and spring months, these insects feed gregariously, and damage may occur in late fall or early spring. Tiger moth defoliation usually occurs on a few scattered trees, and infestations generally do not spread. Larval feeding is concentrated in the vicinity of the webbing, so only a few branches are stripped of needles. The buds at the tips of the branches are unaffected by the defoliation and flush normally during April and May. The flushing of new foliage greatly improves the appearance of trees, and the new needles are not eaten by larvae.

Silver-spotted tiger moth is the most common defoliator of Douglas-fir in western Oregon. In addition to Douglas-fir, pine, spruce, and true fir also are subject to attack. Tiger moth infestations only persist for 1 or 2 years and do not cause branches to die.

This pest is not actively managed by growers. Individual tree and spot treatments are almost always adequate for effective control.

Chemical control:

- Acephate (Orthene and other formulations): This chemical is sometimes used by growers, but it can be toxic to predators.
- *Bacillus thuringiensis* (Bt): Effective, but not used by growers.
- Permethrin (Ambush and others): This pyrethroid is considered highly effective on Lepidoptera, but it can lead to a spruce spider mite outbreak due to its toxicity to predator mites.
- Spinosad (Success, Entrust): Not used by growers. Efficacy not well known.
- Tebufenozide (Confirm): This product is highly specific to Lepidoptera larvae. It is an insect growth regulator that requires contact or ingestion by the target insect larva.

Biological control:

- Parasites: naturally-occurring. Provide some control.

Cultural control:

- Inspect plantations often, as early intervention can prevent catastrophic loss to individual trees and can reduce treatment costs.
- Removal of infested twigs (e.g., webbed “tents”).
- Tree shaking at harvest might remove some moths.

Critical Needs for Silver-Spotted Tiger Moth Management in Christmas Trees

Research:

- Need a diazinon-type product for silver-spotted tiger moth (something easy to apply and fast-acting, when needed).
- Evaluate the efficacy of spinosad against tussock and tiger moths.
- Identify and evaluate “soft” chemistries for protection of beneficials and parasites.
- Develop economic threshold information for this pest.

Regulatory:

- Seek Bt registration for silver-spotted tiger moth.

Education:

- Educate growers on how to identify this pest.
- Educate growers on economic threshold information once it is developed.

Diseases

Botrytis Blight

Botrytis cinerea is a fungus that is most commonly encountered on conifer hosts as a damping off or seedling blight. However, environmental conditions occasionally allow this fungus to incite shoot blight in Christmas tree plantations. Seedling trees held in cold storage also can undergo losses due to infections by this fungus.

All conifer species grown for Christmas tree production, especially Douglas-fir, can be hosts for this fungus. *Botrytis cinerea* also functions as a saprophyte, colonizing dead and dying plant materials. In some situations, it is considered only a weak pathogen, and infections are limited to wounded or stressed plants.

Initial infection appears as water-soaked, tan-colored lesions on newly-expanded needles and shoots. As the lesions enlarge, the diseased tissue becomes brown. Shoots wither and die if lesions enlarge to girdle the expanding shoots. When humid conditions exist, a gray-brown mycelium, looking like a sparse web, develops on diseased tissues, and clusters of gray spores form on short stalks arising from the surface. If these are disturbed, clouds of powdery spores can be seen floating from the diseased shoots and needles.

The fungus may continue to build up or maintain its population by colonizing dead and dying plant tissues or plants weakened by frost or freeze injury. Spores spread either by wind or by water splashing onto susceptible host tissue. Rapid changes in humidity also can trigger release of spores into the atmosphere. During periods of wet, cool weather, spores germinate and directly penetrate plant tissues. As weather warms and dries, disease activity ceases.

In Christmas tree plantations, *B. cinerea* infections most commonly could be confused with late frost injury, Phomopsis canker, Douglas-fir twig weevil, Phytophthora shoot blight, and some types of environmental stress and chemical damage.

This pest is only a sporadic problem and is not a big problem for most growers. If control is necessary, it is generally controlled in Stage II at bud break.

Chemical control:

- Chlorothalonil (Bravo Weather Stik and others): Widely used to control other needle casts and considered efficacious. Excellent control under a variety of conditions.

Note: controls for Swiss Needle Cast (see pest entry for Swiss Needle Cast to see the list of controls) will often control this pest.

Biological control:

- None known.

Cultural control:

- Improve air circulation.
- Remove infected shoots.
- Since this disease most commonly attacks Douglas-fir, with most of the damage on the tips of newly-elongating shoots in the spring, light to moderate damage is often removed during the shearing process.
- Scouting and monitoring can aid in early detection.

Critical Needs for Botrytis Blight Management in Christmas Trees

Research:

- None.

Regulatory:

- None.

Education:

- Educate growers on identification of this disease and management options.

Grovesiella Canker

The fungus *Grovesiella abieticola* can cause sunken, dead areas (cankers) and branch dieback on true fir. The fungus is found growing primarily on lower branches and stems. Young trees are attacked most often. White fir and Shasta fir are more susceptible than noble fir or grand fir.

The life cycle of this disease is not well understood. Mature fruiting bodies can be found

any time of year, even up to a year later on dead branches removed from infected trees. The number of branches with cankers will continue to increase if cankers are not removed from infected trees.

Cankers develop on branches or stems older than 1 year. Generally the branch above the canker is swollen or enlarged and tapers as it gets further away from the infection. Twigs also may die back. Occasionally the entire seedling or tree is killed when the canker completely girdles the stem. Tops of larger trees may survive up to a year after being completely girdled, making early detection difficult. Small ($\frac{1}{2}$ to 1 mm in diameter), gray-black fruiting bodies (apothecia) of the fungus may be found on the canker's surface. No wood staining accompanies infection.

The disease can be confused with *Phytophthora* root rot or shoot blight because flagging branches can be low to the ground. Sporulation may occur on infected host material on the ground, with airborne spores spreading the disease to nearby trees.

This disease can be found in Oregon, Washington, or Idaho, but it is only a sporadic problem. It is generally controlled by removing infected branches or trees in Stage II after bud break and also in Stage III during early dormancy in the fall.

Chemical control:

Some fungicides have been effective in limiting pathogen growth in the laboratory, but there is no evidence for effective chemical control in the field.

Biological control:

- None known.

Cultural control:

- Removing and immediately destroying cankered branches from infected trees, or destroying the entire tree, can help prevent the spread of infection.
- Regular scouting aids in detecting cankers early.
- Do not interplant the next rotation before the current rotation of trees has been completely harvested.

Critical Needs for *Grovesiella* Canker Management in Christmas Trees

Research:

- Identify and evaluate management options for this pathogen.

- Develop a better understanding of the biology and life cycle of this pathogen, including the time and location of infection and the time between infection and canker development.

Regulatory:

- None.

Education:

- Educate growers on identification of this disease.

Phomopsis Stem Canker

Dermea pseudotsugae (asexual: *Faveostroma boycei*) and *Diaporthe lokoyae* (asexual: *Phomopsis lokoyea*) are fungi that cause this disease. Cankers are most often found on trees that are not vigorous or are weak from drought or winter injury, typically 1 to 2 years after the stress. Infections occur on new shoots from windblown spores. Mechanical injuries such as hail damage can also create sites for new infections. *D. pseudotsugae* has generally been found on young Douglas-fir and grand fir trees.

The sunken cankers are elliptical and vary in size. Larger cankers can be up to 30 inches long and develop during the dormant season. Branches and stems can be attacked. When the canker has girdled the stem or branch, the portion above the canker is killed. Tiny black pycnidia appear on sunken cankers in the bark.

This is a sporadic pest and is not managed chemically by growers. Cultural controls would be used in Stage II after bud break and during Stage III at tree cutting.

Chemical control:

- None known.

Biological control:

- None known.

Cultural control:

- Use cultural practices that favor good plant growth.
- Pruning out the canker below the infected area helps reduce inoculum levels.
- Proper site and seed source selection is important.
- Scouting and monitoring can aid in early detection.

Critical Needs for Phomopsis Management in Christmas Trees

Research:

- None.

Regulatory:

- None.

Education:

- Educate growers on identification of this disease.

V. Other Disorders

Current Season Needle Necrosis (etiology unknown)

Current season needle necrosis (CSNN) is a poorly understood problem that can limit where susceptible Christmas tree species can be grown. In the Pacific Northwest, this disorder is most commonly seen on noble and grand fir grown at low elevation sites. A similar but much less common problem has also been observed on Nordmann and Turkish fir.

Initial symptoms of CSNN usually appear during shoot elongation in the spring and consist of discolored, tan bands on newly-developed needles. In some cases, the areas of discoloration expand and involve the tip of the needle or the entire needle. These affected portions of the needle turn a reddish brown by mid-summer, and on some species, such as grand fir, needles with extensive symptoms are generally shed. The onset of symptoms seems to be associated with periods of cool, moist weather followed by high temperatures during shoot elongation.

The etiology of CSNN is unknown. Research in the Pacific Northwest suggests that CSNN is associated with low calcium levels in developing needles, which predisposes the needles to damage when they are exposed to heat stress. However, ongoing research in Europe has potentially implicated the fungus *Kabatina abietis* as the cause of this disorder. Susceptibility to this problem appears to be under strong genetic control.

Currently there are no known effective ways to minimize the damage caused by CSNN.

Critical Needs for Current Season Needle Necrosis Management in Christmas Trees

Research:

- Determine the cause of CSNN, site factors that affect its development, and how to effectively control it.
- Develop a better understanding of the role of calcium in CSNN, and determine whether it can help improve the problem.
- Research the efficacy of other controls for this problem, such as coppers or other products.
- Develop economic thresholds and survey of economic impact.
- Identify potential sources of noble and grand fir that are resistant to CSNN.

Regulatory:

- None.

Education:

- Educate growers regarding proper identification of CSNN.
- Educate growers about the importance of site selection.

Sudden Oak Death (*Phytophthora ramorum*)

Historically, Christmas tree growers in the Pacific Northwest have taken a proactive approach to dealing with the threat posed to the industry by *P. ramorum*, a regulated, fungal-like pathogen that is sporadically detected in Pacific Northwest ornamental nurseries. This has included working closely with all appropriate regulatory agencies, including USDA, ODA, and WSDA, to develop voluntary inspection programs to provide for *P. ramorum*-free certification by the appropriate agency.

It is anticipated that as efforts to limit the spread of this disease and to control or eliminate this threat to the Pacific Northwest nursery and Christmas tree industry continue, growers will work actively with all agencies involved to develop management practices and inspection protocols that will satisfy both domestic and international customers.

Critical Needs for Sudden Oak Death Management in Christmas Trees

Research:

- Develop a better understanding regarding the risk that this pathogen could become established in Pacific Northwest Christmas tree plantations.
- Research the efficacy of potential controls to protect conifer nursery stock from this pathogen.

Regulatory:

- Continue to work actively with all agencies to develop management practices and inspection protocols that will prevent the spread of this pathogen into Christmas tree plantations.

Education:

- Educate growers regarding proper identification of sudden oak death.

Physiological Disorders

There are a few important physiological and abiotic disorders that can damage Christmas trees. While these disorders can present a major challenge for growers, they are not discussed in detail in this document. They are not caused by pests, and there are no pest management strategies that can be used to control them.

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Activity Tables for Christmas Trees

Notes:

1. An activity may occur at any time during the designated time period but generally not continually during that time period.
2. Each "x" in the table, whether large or small, represents 1 week of the month.
3. A large "X" represents the time of the year when the majority of the work is done by most growers. A small "x" represents times when an activity may be taking place on some farms, as time and work crew availability allow. (Small growers may complete the tasks at the desired times [large "X"s], while large growers generally require additional time [small "x"s] to accomplish all the activities.)
4. Workers are removed from fields during and after pesticide applications in accordance with applicable pesticide labels regarding restricted-entry intervals (REIs).

~ Cultural Activities ~

Activity	J	F	M	A	M	J	J	A	S	O	N	D
Basal pruning		XXXX	XXXX						XXXX	XXXX		
Culturing	xxxx	xxxx	xxxx			xx	XXXX	XXXX	XXXX	xxxx		
Cut and remove cull trees from the field	XXXX	XXXX										
Erosion control					XXXX			XX	XXXX			
Foliar fertilization					X	XXXX						
Harvest										x	XXXX	XXX
Irrigation						xx	xx					
Liming (preplant)		XX						XXXX	XXXX			
Plant cover crops								XXXX	XXXX	XX		
Plant tree seedlings		XXXX	XXXX	XXXX	xx				xx	xx		
Prepare fields for planting	XXXX	XXXX	xxxx	xxxx	xxxx	xxxx	xxxx	XXXX	XXXX	xxxx		
Prepare for harvest (tagging, grading, and positioning equipment)							xxxx	XXXX	XXXX	XXXX		
Soil fertilization		X	XXXX	XXXX								

~ Pest Management Activities ~

Activity	J	F	M	A	M	J	J	A	S	O	N	D
Deer repellent application				X	XXXX						XX	
Fungicide application					XXXX	XXXX				X	XXXX	XX
Insecticide and miticide application		xxxx	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX			
Rodent control					XXXX	XXXX	XXXX					
Scouting and monitoring	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX
Tree shaking for pests at harvest										x	XXXX	XXX
Weed management (including herbicide application)			XXXX	XXXX	xxxx	xxxx	XXXX		XXXX	XXXX		

Seasonal Pest Occurrence for Christmas Trees

Notes:

1. x = times when pest management strategies are applied to control these pests, not all times when pest is present.
2. Each "x" in the table, whether large or small, represents 1 week of the month.
3. A large "X" represents the time of the year when the majority of pest control is done by most growers. A small "x" represents times when pest control may be taking place on some farms, as time and work crew availability allows. (Small growers may do this at the desired times [large "X"s], while large growers generally require additional time [small "x"s] to accomplish all pest control activities.)
4. Workers are removed from fields during and after pesticide applications in accordance with applicable pesticide labels regarding restricted-entry intervals (REIs).

Insects	J	F	M	A	M	J	J	A	S	O	N	D	
Aphid				XX	XXXX	XXXX	XXXX	XXXX					
Balsam woolly adelgid					XXXX	XX							
Conifer root aphid		xxxx	xxxx	XXXX	XXXX	XXXX	XXXX						
Douglas-fir needle midge				XX	X								
Douglas-fir twig weevil (based on trap catch)							XXXX	XX					
Eriophyid mite			XXXX		XX	XXXX							
Root weevil				XXXX		XX	XXXX						
Spruce aphid	XXXX	XX								XXXX	XXXX		
Spruce spider mite		XXXX	XXXX		XX	XXXX							
White pine weevil				XX	XXXX								
Diseases	J	F	M	A	M	J	J	A	S	O	N	D	
Annosus root disease			XXXX	XXXX	XXXX	XXX					X	XXXX	XX
Armillaria root rot		XX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX			
Interior needle blight					XX	XXXX	X						
Needle rust (<i>melampsora</i> , <i>pucciniastrum</i> , and <i>uredinopsis</i>)				XX	XXXX	XX							
Phytophthora root rot									XXXX	XXXX			
Rhabdocline needle cast				XX	XXXX	XX							
Rhizosphaera needle cast				XX	XXXX	XX							
Swiss needle cast					XXXX								
Weeds	J	F	M	A	M	J	J	A	S	O	N	D	
Broadleaves													
<i>Annual</i>	xxxx	xxXX	XXXX	XXXX			xxxx	xxxx					
<i>Perennial</i>	xxxx	xxXX	XXXX	XXXX		XXXX	xxxx	xxxx	XXXX	XXXX			
Grasses													
<i>Annual</i>	xxxx	xxXX	XXXX	XXXX			xxxx	xxxx					
<i>Perennial</i>	xxxx	xxXX	XXXX	XXXX			xxxx	xxxx	XXXX	XXXX			
<i>Woody Species</i>	XXXX	XXXX							XXXX	XXXX			

Efficacy Ratings for INSECT and MITE Management Tools in Christmas Trees

Rating scale: **E** = excellent (90–100% control); **G** = good (80–90% control); **F** = fair (70–80% control); **P** = poor (< 70% control); **?** = efficacy unknown in Christmas tree management system—more research needed; **NU** = not used for this pest—chemistry or practice known to be ineffective; * = used but not a stand-alone management tool.

Note: Pesticides or practices with two ratings (e.g., F–G) are dependent on pest pressure (e.g., fair if high pest pressure; good if low pest pressure), or it may be due to regional differences.

MANAGEMENT TOOLS	Aphid	Balsam woolly adelgid	Conifer root aphid	Douglas-fir needle midge	Douglas-fir twig weevil	Eriophyid needle mite	Root weevil	Spruce aphid	Spruce spider mite	White pine weevil	COMMENTS
Registered Chemistries											
Abamectin (Avid and others)	NU	NU	NU	NU	NU	NU	NU	NU	G	NU	
Acephate (Orthene and others)	NU	NU	NU	G	NU	NU	E	NU	NU	NU	Can be toxic to predators
<i>Beauvaria bassiana</i>	?	NU	NU	NU	NU	NU	NU	NU	NU	NU	
Bifenazate (Floramite)	NU	NU	NU	NU	NU	NU	NU	NU	F-G	NU	
Bifenthrin (Brigade and others)	NU	NU	NU	NU	NU	NU	E^	NU	G	E	OR, WA SLNs ^Can be toxic to predators
Chlorpyrifos (Lorsban and others)	E	E	NU	G	E	NU	P	G	G	G	OR, WA SLNs; not used in Idaho
Clofentezine (Apollo)	NU	NU	NU	NU	NU	NU	NU	NU	G	NU	Not widely used
Diffubenzuron (Dimilin)	NU	NU	NU	NU	NU	NU	NU	NU	NU	?	
Endosulfan (Thionex)	G	E	NU	E	NU	E	NU	NU	NU	NU	OR, WA, ID SLNs
Etoxazole (TetraSan)	NU	NU	NU	NU	NU	NU	NU	NU	E	NU	Not widely used; expensive
Fenbutatin-oxide (Promite, Vendex)	NU	NU	NU	NU	NU	NU	NU	NU	G	NU	Not widely used
Hexythiazox (Savey and others)	NU	NU	NU	NU	NU	NU	NU	NU	E	NU	
Horticultural oils	NU	NU	NU	NU	NU	NU	NU	NU	F	NU	Phytotoxicity and discoloration concerns
Imidacloprid (Admire, Provado)	G-E^	?	E	NU	NU	NU	NU	G	NU	NU	^More effective on small populations
Insecticidal soap (M-Pede)	F	NU	NU	NU	NU	NU	NU	NU	P-F	NU	
Oxydemeton-methyl (MSR)	E^	?	NU	F	NU	NU	NU	E	F	G^	^Expensive; not widely used
Permethrin (Ambush and others)	NU	NU	NU	NU	NU	NU	NU	F	NU	NU	Can be toxic to predators
Phosmet (Imidan)	NU	NU	NU	NU	NU	NU	NU	NU	NU	?	

EFFICACY RATINGS FOR INSECT AND MITE MANAGEMENT TOOLS IN CHRISTMAS TREES

MANAGEMENT TOOLS	Aphid	Balsam woolly adelgid	Conifer root aphid	Douglas-fir needle midge	Douglas-fir twig weevil	Eriophyid needle mite	Root weevil	Spruce aphid	Spruce spider mite	White pine weevil	COMMENTS
Propargite (Omite)	NU	NU	NU	NU	NU	NU	NU	NU	E	NU	OR, WA SLNs
Pymetrozine (Endeavor)	E	NU	NU	NU	NU	NU	NU	E	NU	NU	Newly registered; limited grower experience
Spirodiclofen (Envidor)	NU	NU	NU	NU	NU	G	NU	NU	G	NU	Newly registered; limited grower experience
Spirotetramat (Ultror)	G	G	G	NU	NU	NU	NU	NU	NU	NU	Newly registered; limited grower experience
Unregistered / New Chemistries											
None currently under consideration											
Biological											
Entomophagus nematodes	?	?	?	?	?	?	P	?	?	?	
Fungal and bacterial disease formulations	?	?	?	?	?	?	?	NU	?	?	
Lacewings	G	P-F	?	?	NU	?	?	F	?	NU	
Ladybird beetles	G	P-F	?	?	NU	?	?	P-F	F	NU	
Parasitic wasps	G	?	?	?	?	?	F	?	NU	?	
Parasitic flies	G	?	?	?	?	NU	?	?	NU	NU	
Predacious beetles and midges	?	F	?	?	?	?	?	P-F	NU	NU	
Predacious mites	?	?	?	?	NU	F-G	NU	?	F-G	NU	
Syrphid fly larvae	G	?	?	?	NU	?	?	?	NU	NU	
Cultural / Nonchemical											
Attention to nutrient needs	?	?	?	?	?	?	?	?	?	?	
Buffer against forested perimeters	?	?	?	?	?	?	?	?	?	NU	
Improve airflow and circulation	NU	?	?	?	?	?	?	?	*	NU	
Maintain vigorous tree growth	?	?	F	?	G	?	?	?	?	?	
Plant resistant species/stock	?	?	?	?	?	?	?	?	G	?	
Remove and burn infested twigs	?	?	?	?	G	?	?	?	?	G	
Removal of insects	NU	NU	NU	NU	NU	NU	NU	NU	NU	G	

EFFICACY RATINGS FOR INSECT AND MITE MANAGEMENT TOOLS IN CHRISTMAS TREES

MANAGEMENT TOOLS	Aphid	Balsam woolly adelgid	Conifer root aphid	Douglas-fir needle midge	Douglas-fir twig weevil	Eriophyid needle mite	Root weevil	Spruce aphid	Spruce spider mite	White pine weevil	COMMENTS
Removal of natural ground covers	?	?	?	?	?	?	?	?	?	?	
Scouting and monitoring	G	E	G	E	F	G	G	E	E	F	
Shearing	?	?	?	F*	?	?	?	?	?	?	
Skirting/ragging	?	?	?	?	?	?	?	?	?	?	
Tree shaking at harvest	?	?	?	?	?	?	?	?	F	?	

Efficacy Ratings for DISEASE Management Tools in Christmas Trees

Rating scale: **E** = excellent (90–100% control); **G** = good (80–90% control); **F** = fair (70–80% control); **P** = poor (< 70% control); **?** = efficacy unknown in Christmas tree management system, more research needed; **NU** = not used for this pest (chemistry or practice known to be ineffective); ***** = used but not a stand-alone management tool.

Note: Fungicides or practices with two ratings (e.g., F–G) are dependent on disease pressure (e.g., fair if high disease pressure; good if low disease pressure), or it may be due to regional differences.

MANAGEMENT TOOLS	Annosus root disease	Armillaria root rot	Interior needle blight	Needle rusts (<i>Uredinopsis</i> , <i>Melampsora</i> , <i>Pucciniastrum</i>)	Phytophthora root rot	Rhabdocline needle cast	Rhizosphaera needle cast	Swiss needle cast	COMMENTS
Registered Chemistries									
Azoxystrobin (Hertiage, Quadris)	NU	NU	?	?	NU	F	?	P-F	
Borax (Sporax)	E	NU	NU	NU	NU	NU	NU	NU	
Chlorothalonil (Bravo Weather Stik and others)	NU	NU	G-E	F	NU	E	E	E	
Copper-based products (Kocide, others)	NU	NU	?	?	NU	F [^]	F [^]	P-F [^]	[^] Not widely used
Mancozeb-based products (Dithane and others)	NU	NU	?	F	NU	F-G [^]	F [^]	F-G [^]	[^] Not widely used
Mefenoxam (Subdue MAXX and others)	NU	NU	NU	NU	P	NU	NU	NU	OR, WA SLNs
Phosphorous acid (Fosphite, others)	NU	NU	NU	NU	P	NU	NU	NU	
Sulfur	NU	NU	?	NU	NU	F-G [^]	?	F-G [^]	[^] Not widely used
Thiophanate-methyl (Topsin)	NU	NU	?	NU	NU	?	?	?	Not widely used
Triadimefon (Bayleton)	NU	NU	NU	G-E	NU	NU	NU	NU	
Ziram	NU	NU	?	P-F	NU	?	?	?	
Unregistered and New chemistries									
None currently under consideration.									
Biological									
None currently used.									
Cultural / Nonchemical									
Avoid nutrient and water stress	P	F	NU	NU	NU	NU	NU	NU	
Avoid wounding tree trunks and roots	*	NU	NU	NU	NU	NU	NU	NU	
Complete harvest before planting next rotation	NU	NU	F	NU	NU	NU	*	*	
Excavate stumps between rotations	E	F	NU	NU	NU	NU	NU	NU	
Improve air circulation	NU	NU	*	P	NU	*	*	G	Improve spacing for Botrytis

EFFICACY RATINGS FOR DISEASE MANAGEMENT TOOLS IN CHRISTMAS TREES

MANAGEMENT TOOLS	Annosus root disease	Armillaria root rot	Interior needle blight	Needle rusts (<i>Uredinopsis</i> , <i>Melampsora</i> , <i>Pucciniastrum</i>)	Phytophthora root rot	Rhabdocline needle cast	Rhizosphaera needle cast	Swiss needle cast	COMMENTS
Improve soil drainage	NU	NU	NU	NU	E	NU	NU	NU	
Proper site selection	NU	G	G	NU	G	NU	NU	*	
Prune out galls/cankers	NU	NU	NU	NU	NU	NU	NU	NU	
Remove and destroy infected trees and branches	G [^]	NU	NU	NU	NU	NU	NU	NU	[^] Not effective unless roots and stumps are also removed
Remove alternate hosts	NU	NU	NU	G	NU	NU	NU	NU	
Resistant species selection	G	F	?	?	G	G	NU	?	
Scouting and monitoring	G*	G*	G*	G*	G*	G*	G*	G*	
Shearing	NU	NU	NU	NU	NU	NU	NU	NU	
Urea	G-E	NU	NU	NU	NU	NU	NU	NU	
Weed control around base of trees	NU	NU	*	NU	NU	*	*	*	

Efficacy Ratings for WEED Management Tools in Christmas Trees

Rating scale: **E** = excellent (90–100% control); **G** = good (80–90% control); **F** = fair (70–80% control); **P** = poor (<70% control); **?** = efficacy unknown in Christmas tree management system; - more research needed; **NU** = not used for this pest; * = used but not a standalone management tool.

In “**Type**” row, **S** = soil-active against pre-emerged weeds; **F** = foliar-active against emerged weeds.

Note: Weed size or stage of growth is an important consideration with most post-emergence herbicides.

	Registered Chemistries																				Cultural Controls		COMMENTS		
	2,4-D LV4	Asulam (Asulox)	Atrazine	Atrazine + 2,4-D isooctyl ester (Shotgun)	Clethodim (Envoy and others)	Clopyralid (Stinger)	Fluazifop (Fusilade)	Flumioxazin (SureGuard)	Glufosinate (Finale)	Glyphosate (Roundup and others)	Hexazinone (Velpar)	Hexazinone + sulfometuron (Westar)	Isoxaben (Gallery)	Isoxaben + trifluralin (Snapshot)	Oryzalin (Surflan and others)	Oryzalin + benefin (XL 2G)	Oxyfluorfen (Goal)	Pendimethalin (Pendulum)	Prodiamine (Barricade and others)	Pronamide (Kerb) [OR and WA SLNs]	Sethoxydim (Segment)	Triclopyr (Garlon and others)		Cultivation	Mowing
Type	F	F	S	S	F	F	F	S	F	F	S	S	S	S	S	F	F	S	S	S	F	F			
Broadleaf Weeds																									
Bindweed, field	F	NU	P	G	NU	F-G	NU	F-G	P	G	P	G	?	?	?	?	NU	?	?	NU	NU	F-G			
Clovers	G	NU	F	G	NU	E	NU	F	F	G	F	E	?	?	P	P	F	?	?	P	NU	F			
Dandelion	G	NU	P	G	NU	G	NU	G	F	E	F	E	?	?	P	P	E	?	?	P	NU	G			
Dandelion, false	G	NU	P	F-G	NU	G	NU	G	F	E	F	E	?	?	P	P	E	?	?	P	NU	G			
Dock, curly	F	F	P	F	NU	P	NU	G	P	G	F	F	P	P	P	P	G [^]	P	P	P ^{^^}	NU	G			[^] Seedling ^{^^} Mature
Filaree	F	P	F	G	NU	P	NU	G	F	F	G	G	P	P	P	G	G	P	P	P	NU	G			

EFFICACY RATINGS FOR WEED MANAGEMENT TOOLS IN CHRISTMAS TREES

	Registered Chemistries																				Cultural Controls		COMMENTS	
	2,4-D LV4	Asulam (Asulox)	Atrazine	Atrazine + 2,4-D isooctyl ester (Shotgun)	Clethodim (Envoy and others)	Clopyralid (Stinger)	Fluazifop (Fusilade)	Flumioxazin (SureGuard)	Glufosinate (Finale)	Glyphosate (Roundup and others)	Hexazinone (Velpar)	Hexazinone + sulfometuron (Westar)	Isoxaben (Gallery)	Isoxaben + trifluralin (Snapshot)	Oryzalin (Surflan and others)	Oryzalin + benefin (XL 2G)	Oxyfluorfen (Goal)	Pendimethalin (Pendulum)	Proflaminate (Barricade and others)	Pronamide (Kerb) [OR and WA SLNs]	Sethoxydim (Segment)	Triclopyr (Garlon and others)		Cultivation
Type	F	F	S	S	F	F	F	S	F	F	S	S	S	S	S	F	F	S	S	S	F	F		
Goatweed (St. John's wort)	G	NU	P	F	NU	NU	NU	P	G	G^	P	F	P	P	P	F	NU	P	P	NU	E			^After goatweed is vegetative
Groundsel, common	G	NU	G	G	NU	E	NU	E	F	E	F	G	G	G	F	?	E	P	G	G	NU	E		
Hawksbeard	G	NU	F	E	NU	E	NU	G	G	G	G	G	F	G	F	F	G	P	G	P	NU	E		
Knotweed (prostrate)	G	NU	G	G	NU	P	NU	F	F	F	G	G	F	F	F	G	F	F	F	F	NU	E		
Lambsquarters	G	NU	E	E	NU	F	NU	G	G	E	G	G	G	G	G	E	P	F	F	NU	E			
Lettuce, prickly	G	NU	G	G	NU	E	NU	G	G	G	G	G	G	G	P	F	G	F	G	P	NU	E		
Marestail	G	NU	P	F	NU	P	NU	G	F	G	G	G	?	?	P	?	F	P	P	?	NU	G		
Mullein	F	NU	P	P	NU	NU	NU	F	F	F	F	F	F	F	F	F	P	P	P	F	NU	F		
Mustards	G	NU	G	G	NU	F	NU	G	G	G	G	G	F	F	P	P	F	F	F	F	NU	G		
Oxeye daisy	F	?	P	F	NU	F	NU	F	P	F	?	G	G	?	?	?	?	P	?	P	NU	P		
Pigweed	G	?	G	E	NU	G	NU	G	G	E	?	F	G	?	G	G	E	F	?	F	NU	G		
Plantain	G	P	P	F	NU	P	NU	E	F	G	?	F	E	?	P	P	G	?	?	P	NU	E		

EFFICACY RATINGS FOR WEED MANAGEMENT TOOLS IN CHRISTMAS TREES

	Registered Chemistries																				Cultural Controls		COMMENTS		
	2,4-D LV4	Asulam (Asulox)	Atrazine	Atrazine + 2,4-D isooctyl ester (Shotgun)	Clethodim (Envoy and others)	Clopyralid (Stinger)	Fluazifop (Fusilade)	Flumioxazin (SureGuard)	Glufosinate (Finale)	Glyphosate (Roundup and others)	Hexazinone (Velpar)	Hexazinone + sulfometuron (Westar)	Isoxaben (Gallery)	Isoxaben + trifluralin (Snapshot)	Oryzalin (Surflan and others)	Oryzalin + benefin (XL 2G)	Oxyfluorfen (Goal)	Pendimethalin (Pendulum)	Prodiamine (Barricade and others)	Pronamide (Kerb) [OR and WA SLNs]	Sethoxydim (Segment)	Triclopyr (Garlon and others)		Cultivation	Mowing
Type	F	F	S	S	F	F	F	S	F	F	S	S	S	S	S	F	F	S	S	S	F	F			
Queen Anne's lace	F	?	P	F	NU	P	NU	F^	F	G	?	F^	F	?	P	P	?	?	?	P	NU	P			^Seedling
Ragwort, tansy	F	F	-	?	NU	F	NU	E	F	G	?	F	E	?	P	P	?	?	?	P	NU	E			
Sowthistle, annual	G		F	G	NU	E	NU	E	P	G	G	G	E	?	P	F	?	?	?	P	NU	E			
Sowthistle, perennial	G	P	P	G	NU	G	NU	E	P	G	F	F	E	?	P	P	?	?	?	P	NU	G			
Spotted catsear	E	P	F	G	NU	G	NU	G	F	G	P	F	P	?	?	?	?	?	?	P	NU	F			
Thistle, bull	G	P	P	F	NU	E	NU	E	F	G	?	F	F	?	F	F	G	?	?	P	NU	G			
Thistle, Canada	F	P	P	F	NU	E	NU	P	P	F	P	P	P	?	P	P	F	?	?	P	NU	G			
Willow herb	?	NU	F	G	NU	P	NU	E	F	F	?	G	?	?	?	?	G	F	F	G	NU	G			
Vetch	P	NU	F	G	NU	E	NU	E	F	G	?	?	?	?	?	?	F	P	P	P	NU	G			
Barnyardgrass	P	NU	P	P	G	NU	G	G	F	G	G	G	NU	NU	G	G	P	P	?	F	G	P			
Bentgrass	P	NU	P	P	F	NU	F	P	P	G	G	G	NU	NU	P	P	NU	P	P	S	F	P			

EFFICACY RATINGS FOR WEED MANAGEMENT TOOLS IN CHRISTMAS TREES

	Registered Chemistries																				Cultural Controls		COMMENTS		
	2,4-D LV4	Asulam (Asulox)	Atrazine	Atrazine + 2,4-D isooctyl ester (Shotgun)	Clethodim (Envoy and others)	Clopyralid (Stinger)	Fluazifop (Fusilade)	Flumioxazin (SureGuard)	Glufosinate (Finale)	Glyphosate (Roundup and others)	Hexazinone (Velpar)	Hexazinone + sulfometuron (Westar)	Isoxaben (Gallery)	Isoxaben + trifluralin (Snapshot)	Oryzalin (Surflan and others)	Oryzalin + benefin (XL 2G)	Oxyfluorfen (Goal)	Pendimethalin (Pendulum)	Proflaminate (Barricade and others)	Pronamide (Kerb) [OR and WA SLNs]	Sethoxydim (Segment)	Triclopyr (Garlon and others)		Cultivation	Mowing
Type	F	F	S	S	F	F	F	S	F	F	S	S	S	S	S	F	F	S	S	S	F	F			
Grass Weeds																									
Bluegrass, annual	P	NU	P	P	E	NU	E	G	G	G	G	G	NU	NU	G	G	G	G	G	S	E	P			
Bromegrasses	P	NU	P	P	G	NU	G	NU	G	G	G	G	NU	NU	G	G	G	F	P	S	G	P			
Fescues, fine	P	NU	P	P	F	NU	F	NU	F	F	P^	F	NU	NU	?	?	NU	P	?	G	F	P			^Rattail
Fescues, tall	P	NU	P	P	F	NU	F	NU	F	F	F	G	NU	NU	F	F	G	F	?	G	F	P			
Orchardgrass	P	NU	P	P	G	NU	G	NU	F	G	F	F	NU	NU	P	P	NU	F	?	G	G	P			
Quackgrass	P	NU	P	P	F	NU	F	NU	P	F	G	G	NU	NU	P	P	NU	P	P^	G	F	P			^Ties up in heavy clay
Ryegrass, annual	NU	NU	G	P	G	NU	G	NU	F	G	G	G	NU	NU	G	NU	G	F-G	G	G	G	NU	F	G	
Ryegrass, perennial	NU	NU	P	P	G	NU	G	NU	F	E	F	F	NU	NU	P	NU	F	P	F	G	G	NU	P	F	
Velvetgrass	NU	NU	P	P	G	NU	G	NU	F	E	G	G	NU	NU	P	NU	F	F	P	G	G	NU	P	F	
Witch grass	NU	NU	P	P	G	NU	G	NU	F	E	F	F	NU	NU	F	NU	FG	F	F-G	P	G	NU	E	F	

EFFICACY RATINGS FOR WEED MANAGEMENT TOOLS IN CHRISTMAS TREES

	Registered Chemistries																				Cultural Controls		COMMENTS		
	2,4-D LV4	Asulam (Asulox)	Atrazine	Atrazine + 2,4-D isooctyl ester (Shotgun)	Clethodim (Envoy and others)	Clopyralid (Stinger)	Fluazifop (Fusilade)	Flumioxazin (SureGuard)	Glufosinate (Finale)	Glyphosate (Roundup and others)	Hexazinone (Velpar)	Hexazinone + sulfometuron (Westar)	Isoxaben (Gallery)	Isoxaben + trifluralin (Snapshot)	Oryzalin (Surflan and others)	Oryzalin + benefin (XL 2G)	Oxyfluorfen (Goal)	Pendimethalin (Pendulum)	Proflaminate (Barricade and others)	Pronamide (Kerb) [OR and WA SLNs]	Sethoxydim (Segment)	Triclopyr (Garlon and others)		Cultivation	Mowing
Type	F	F	S	S	F	F	F	S	F	F	S	S	S	S	S	F	F	S	S	S	F	F			
Woody Species																									
Alder	G-E	P	P	F	NU	NU	NU	NU	NU	P	NU	NU	NU	NU	NU	P	NU	NU	NU	NU	NU	G	NU	NU	
Blackberry, evergreen	G	P	P	F	NU	NU	NU	NU	NU	G^	G	P	NU	NU	P	P	P	NU	NU	NU	NU	G	NU	NU	^Fall application
Blackberry, Himalaya	G	P	P	F	NU	NU	NU	NU	NU	G^	G	P	NU	NU	P	P	P	NU	NU	NU	NU	G	NU	NU	^Fall application
Blackberry, trailing	G	P	P	F	NU	NU	NU	NU	NU	G^	?	?	NU	NU	?	?	P	NU	NU	NU	NU	G			^Fall application
Cherry	G	NU	NU	NU	NU	NU	NU	NU	NU	NU	NU	NU	NU	NU	NU	NU	NU	NU	NU	NU	NU	E			
Cottonwood	G	NU	NU	NU	NU	NU	NU	NU	NU	F	F	F	F	F	F	F	F	F	F	F	F	G			
Maple	F	NU	NU	NU	NU	NU	NU	NU	NU	F	F	F	F	F	F	F	F	F	F	F	F	G			
Maple, vine	G	NU	NU	NU	NU	NU	NU	NU	NU	F	NU	NU	NU	NU	NU	NU	NU	NU	NU	NU	NU	G			
Oak	F	NU	NU	NU	NU	NU	NU	NU	NU	?	?	?	NU	NU	?	?	P	?	?	P	NU	F			
Poison oak	F	NU	NU	NU	NU	NU	NU	NU	NU	G-E	NU	NU	NU	NU	NU	NU	NU	NU	NU	NU	NU	G			

EFFICACY RATINGS FOR WEED MANAGEMENT TOOLS IN CHRISTMAS TREES

	Registered Chemistries																					Cultural Controls		COMMENTS
	2,4-D LV4	Asulam (Asulox)	Atrazine	Atrazine + 2,4-D isooctyl ester (Shotgun)	Clethodim (Envoy and others)	Clopyralid (Stinger)	Fluazifop (Fusilade)	Flumioxazin (SureGuard)	Glufosinate (Finale)	Glyphosate (Roundup and others)	Hexazinone (Velpar)	Hexazinone + sulfometuron (Westar)	Isoxaben (Gallery)	Isoxaben + trifluralin (Snapshot)	Oryzalin (Surflan and others)	Oryzalin + benefin (XL 2G)	Oxyfluorfen (Goal)	Pendimethalin (Pendulum)	Proflaminate (Barricade and others)	Pronamide (Kerb) [OR and WA SLNs]	Sethoxydim (Segment)	Triclopyr (Garlon and others)	Cultivation	
Type	F	F	S	S	F	F	F	S	F	F	S	S	S	S	S	F	F	S	S	S	F	F		
Salal	NU	NU	NU	NU	NU	NU	NU	NU	NU	NU	NU	NU	NU	NU	NU	NU	NU	NU	NU	NU	NU	F		
Scotch broom	G	NU	NU	NU	NU	NU	NU	NU	NU	G	NU	NU	NU	NU	NU	NU	NU	NU	NU	NU	NU	G		
Willow	G	NU	NU	NU	NU	NU	NU	NU	NU	G	NU	NU	NU	NU	NU	NU	NU	NU	NU	NU	NU	G		
Other Weeds																								
Fern, bracken	NU	G	NU	NU	NU	NU	NU	NU	NU	F	NU	NU	NU	NU	NU	NU	NU	NU	NU	NU	NU	F		
Horsetail, field	NU	NU	NU	NU	NU	NU	NU	NU	NU	NU	NU	NU	NU	NU	NU	NU	NU	NU	NU	NU	NU	NU		