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SUGAR PINE AND WESTERN WHITE PINE DWARF MISTLETOES

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Sugar pine dwarf mistletoe (*Arceuthobium californicum*) and western white pine dwarf mistletoe (*Arceuthobium monticola*) are parasitic flowering plants that cause serious damage in the coniferous forests of the Sierra Nevada, Klamath, and Siskiyou Mountains. Sugar pine dwarf mistletoe primarily damages sugar pine (*Pinus lambertiana*) from southern California (San Diego County) along the west side of the Sierra Nevada Mountains to as far north as Mount Shasta. It also occurs in the northern part of the Coast Range in Lake, Tehama, and Siskiyou Counties (Figure 1). Sugar pine dwarf mistletoe has not been found in the isolated sugar pine populations in Nevada or in the central and southern Coast Range of California. Although sugar pine dwarf mistletoe has been reported in southern Oregon, this report has never been confirmed and it is believed that it does not occur in Oregon.

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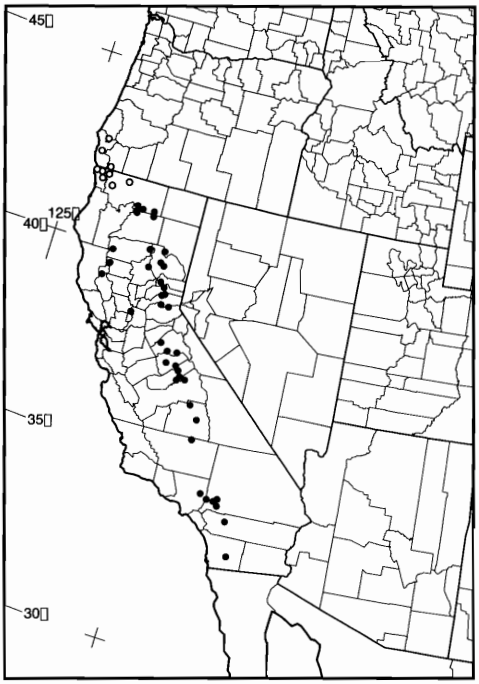

Figure 1. Distribution of sugar pine and western white pine dwarf mistletoes in California and Oregon. Solid circles represent sugar pine dwarf mistletoe and open circles represent western white pine dwarf mistletoe.

Western white pine dwarf mistletoe parasitizes western white pine (*Pinus monticola*) in the Klamath and Siskiyou Mountains of northern California (Siskiyou and Del Norte Counties) into southwestern Oregon (Josephine, Coos, and Curry Counties) (Figure 1). Although western white pine is widely distributed in California, the Pacific Northwest, the Inland Empire, and into western Canada, western white pine dwarf mistletoe is only found within the restricted range described above. Western white pine dwarf mistletoe will also infect sugar pine, but to a much lesser extent than western white pine. It also infects the rare Brewer's spruce (*Picea breweriana*) and rarely occurs on Jeffrey pine (*Pinus jeffreyi*). Although this dwarf mistletoe has a small distribution it is included in this pest leaflet because it was formerly considered to represent populations of sugar pine dwarf mistletoe. However, in 1992 it was classified as a distinct species. Earlier reports of sugar pine dwarf mistletoe in Oregon are probably based on infection of sugar pine by western white pine dwarf mistletoe. A few other dwarf mistletoes also infect western white pine, including mountain hemlock dwarf mistletoe (*A. tsugense* subsp. *mertensianae*) and limber pine

dwarf mistletoe (*A. cyanocarpum*). These dwarf mistletoes are discussed in other Forest Insect and Disease Leaflets (See numbers 135 and 171 at the following Web site: http://www.na.fs.fed.us/pubs/fidl_hp.shtm).

Sugar pine grows as scattered individuals or small groups of trees in the mixed conifer zone and comprises 6.5% of the conifer volume in California. Although sugar pine does not dominate mixed conifer stands, it is one of the most valuable timber species because of its large size, straight bole, and desirable wood characteristics. Forest disease surveys by the USDA Forest Service conducted from 1958 to 1965 in California found that sugar pine dwarf mistletoe was present in approximately 22 percent of the sugar pine stands examined. In addition, more than 10 percent of the trees in these stands were infected. More recently, data from almost 5000 forest inventory plots completed by the USDA Forest Service in California estimated that about 19% of the sugar pine is infected with dwarf mistletoe. Therefore, an estimate that about 20% of the sugar pine in California is infected with sugar pine dwarf mistletoe is probably a reasonable approximation.

Life History

Dwarf mistletoes are small, seed-bearing parasitic plants. The external (aerial) shoots of sugar pine dwarf mistletoe are yellow to yellow-green and have their leaves reduced in size to small scales. The shoots are perennial and usually about 3-4 inches (7-10 cm) long (Figure 2). The shoots of western white pine dwarf mistletoe

Figure 2. Female plants of sugar pine dwarf mistletoe.

Figure 3. Female plants of western white pine dwarf mistletoe. The fruits on this plant are nearly mature.

are typically dark brown and about 2-4 inches (5-10 cm) long (Figure 3). Aerial shoots arise from a network of root-like strands embedded in host branches. This network, called the endophytic system, consists of two parts: 1) cortical strands growing longitudinally in the bark, and 2) sinkers growing radially in the wood. The endophytic system absorbs nutrients and water from infected branches, and will usually continue to live as long as infected host tissue remains alive. Dwarf mistletoes are dependent upon their host tree for water, minerals, and carbohydrates. Although the aerial shoots do contain some chlorophyll which allows them to produce small quantities of carbohydrates through photosynthesis, the principal function of aerial shoots is reproduction.

The aerial shoots produce male and female flowers on separate plants. Flowers and fruits are both small and inconspicuous structures. Flowering primarily occurs during July for sugar pine dwarf mistletoe and starts in July but continues well into August for western white pine dwarf mistletoe. Insects and wind are both involved in pollination.

Fruits complete their development 13 to 15 months after pollination (Figure 3). The mature fruits contain one seed averaging about 0.1 inch (3 mm) in length. Seed dispersal is one of the most interesting characteristics of dwarf mistletoes. Seeds are dis-

charged explosively from the small fruits in September for sugar pine dwarf mistletoe, but for western white pine dwarf mistletoe seed dispersal extends from early October through early November. Dispersed seeds may travel 30 to 40 feet (10-13 m), but most land within 10-15 feet (3-5 m) of the disseminating shoot. A sticky seed coating called viscin enables seeds to stick to most objects they strike. Needles are the most common receiving surface. Viscin, when first moistened by rains, acts as a lubricant. Seeds slide down and either fall off needles or become lodged on bark at the base of needles. They are fastened in place when the viscin dries and they over winter in a dormant condition. They are often destroyed by insects and fungi, or dislodged by hard rains or heavy snowfall, so only a small proportion of the seeds dispersed actually survive and give rise to new plants.

Seeds that survive the winter adhered to host tissue germinate in early spring. A structure called a radicle emerges from the germinating seed and grows along the bark surface until an obstruction, usually a needle base, is encountered. The radicle then forms a mound of tissue called a holdfast which develops an infection peg that penetrates the host branch. The mistletoe's endophytic system then develops in the bark and wood of the infected branch. Infection occurs most readily in branches less than five years old because their bark is more easily penetrated than older branches. Once the mistletoe is established within a branch, it may continue to grow into and along the branch. If the infection occurs within six inches of the main bole of the tree, the endophytic system may eventually reach the bole and aerial shoots will form on the main stem. But sometimes large bole swellings may develop because the bole was infected directly by a seed when the main stem was very young.

Aerial shoots typically appear 2 to 3 years after initial infection. Infections that have not yet produced aerial shoots are called latent infections. The typical length of time needed for female plants to complete their life cycle from initial establishment to dissemination of the first seed crop is 4 to 5 years. Many successive crops of aerial shoots may be produced from the established endophytic system.

Symptoms and Signs of Infection

The first symptom of dwarf mistletoe infection is the appearance of slight swellings at infection sites. Swellings become visible 1 to 2 years after infection occurs. Usually mistletoe shoots emerge from the area of swollen tissue. Older swellings become less obvious and produce fewer shoots. Often on older swollen branches only the remnants of shoots, called basal cups, remain after the shoots have fallen off the branches.

On severely infected trees the most obvious symptoms of dwarf mistletoe infection are witches' brooms (Figure 4). Witches' brooms are variously shaped masses of abnormal branch and twig growth. Often the branches

Figure 4. Witches' brooms associated with severe infection by sugar pine dwarf mistletoe on sugar pine. The dead tree on the left was also infected with sugar pine dwarf mistletoe and was killed by mountain pine beetles.

in these brooms have several mistletoe plants on them. In severely infected pines, witches' brooms often encompass most of the tree's foliage and represent a significant drain on the tree's vigor.

Severely infested sugar pine and western white pine stands typically have many trees with stunted growth, witches' brooms, dying or dead tops and branches, and dead trees. Unmanaged stands eventually contain numerous dying and dead trees usually bearing remnants of dwarf mistletoe induced witches' brooms (Figure 5).

Spread and Intensification

Several interrelated factors influence tree-to-tree spread of dwarf mistletoes. These include size class, stand structure, species composition of stands, tree spacing, and infection position. In single storied stands, horizontal spread is estimated to be 1.5 to 2 feet (0.5-0.6 m) per year. Spread in multistoried stands is more rapid because understory trees are bombarded by dwarf mistletoe seeds from infected overstory trees. Presence of non-susceptible tree species can slow the spread of dwarf mistletoes. Spread rates in very dense stands are less than in more open stands because dwarf mistletoe seed production is usually reduced due to limited light and lowered host vigor. In addition, many seeds are intercepted before they travel far. Dwarf mistletoe seeds from shoots located high in tree crowns tend to travel farther than those from shoots in lower portions of crowns.

Nearly all dwarf mistletoe spread is local and results from explosive discharge of seeds. In some cases, wind influences the distance and direction of seed travel. Birds and other animals are responsible for some long-distance spread when seeds stick to them and later are rubbed off onto susceptible trees.

The 6-class dwarf mistletoe rating (DMR) system is useful for quantifying intensity of infection in trees and stands. In this system, the live crown of the tree is visually divided into thirds

Figure 5. Dead, mature sugar pines severely infected with sugar pine dwarf mistletoe and killed by mountain pine beetle in the Sierra Nevada Mountains. Note the numerous, large witches' brooms scattered throughout the crown of this dead tree.

and each third rated as: 0 = no visible infection, 1 = light infection (less than half of the branches in the crown third have dwarf mistletoe infections), or 2 = severe infection (more than half of the branches in the crown third have infections). The three ratings are then added to obtain a tree rating. The tree ratings of all live trees (including uninfected ones) are then averaged to obtain a stand or plot rating. The 6-class DMR system has been used since the late 1950s and is the standard protocol in the U.S., Canada, and Mexico for assessing severity of dwarf mistletoe infection on individual trees and within stands.

As a rough rule-of-thumb, intensification of dwarf mistletoes averages about one DMR class per decade for individual trees, but varies with tree size, stand position, and overstory infection. Infection intensifies most rapidly in sapling or pole-size trees under severely-infected larger trees.

Impacts

Infection by dwarf mistletoes causes increased tree mortality, reduced growth rates and loss of vigor, lowered timber quality, reduced cone and seed production, and increased susceptibility to other damaging agents. These detrimental effects result from the dwarf mistletoe plants taking food and water from the host, thus reducing the amount available for the tree's normal growth, protective, and reproductive processes. The effect of dwarf mistletoe on growth increases with severity of infection and is especially acute in severely infected trees (DMR 5 or 6). Tree volume growth can be reduced by as much as 60% in severely infected trees. Once infected trees reach a DMR of 6 they can be expected to die within 10 years and often they die in less than 5 years. Mature pines weakened by dwarf mistletoe infection are frequently attacked and killed by bark beetles, particularly mountain pine beetle and western pine beetle (Figure 5). In addition, the wood quality of mature sugar pines is often reduced due to the development of large knots when persistent witches' brooms occur on severely infected trees. Infections of the main stems of sugar pines may also result in pitchy, cross-grained wood of low grade.

Other forest values are affected adversely by dwarf mistletoes. Witches' brooms and dead branches can increase the hazard potential in recreation sites because they may cause trees and branches to break and fall. Dead and dying trees detract from visual quality. Potential for wildfires is increased because of dead branches, increased tree mortality, and the accumulation of dead branches around the bases of infected trees.

Dwarf mistletoe infection also can have beneficial effects. Flowers, shoots, and fruits are food for insects, birds, and mammals. Witches' brooms are used by birds and mammals for nesting, foraging, resting, and cover. Tree mortality caused by dwarf mistletoes, either directly or by predisposing trees to other agents, provides snags as habitat for cavity nesting birds and, eventually, coarse woody debris on the forest floor.

Management

In forest ecosystems, dwarf mistletoes have value as individual, biological species and act as disturbance agents, influencing both the structure and function of forest communities. Management of dwarf mistletoes must recognize their value as functional components of forest ecosystems. In areas where timber production or developed recreation is the primary goal, direct control of dwarf mistletoes may be warranted. In other areas, where wildlife or esthetic values are more important, allowing dwarf mistletoe populations to remain or increase may be appropriate.

The objective of any control effort should be to reduce the amount of dwarf mistletoe to levels that are relatively harmless to the pines. Trees with a DMR of less than 4 do not suffer severe growth loss. Complete elimination of the dwarf mistletoe is unnecessary and very difficult, if not impossible to accomplish.

For most dwarf mistletoes, the only practical control over large forested areas is through cultural treatments. Profitable production of sugar pine timber in many local areas often depends on dwarf mistletoe control. Because the parasite can cause large reductions in yield, control should be considered in all timber-producing sugar pine stands where dwarf mistletoe is present. Western white pine is not a commercially important timber species within the range of western white pine dwarf mistletoe.

Shelterwood/Seed Tree Treatments

Shelterwood and seed tree harvests may be good even-age management methods to apply in dwarf mistletoe-infested pine stands. Trees selected to provide shelter or seeds should be uninfected or only lightly infected (DMR 1 or 2). Moderately and severely infected trees, in addition to being a source of dwarf mistletoe seeds, produce poorer crops of tree seeds. Infected shelterwood or seed trees should be removed as soon as susceptible reproduction becomes established. As a general rule for most dwarf mistletoes it is desirable to remove the infected overstory before the young stand is 3 feet (1 m) tall or 10 years old.

Favor Non-host Species

In mixed-species stands that contain sugar pine or western white pine infected by dwarf mistletoe, silvicultural treatments should favor other tree species. Non-hosts left between infected and non-infected pines prevent or slow the spread and intensification of the parasite. All other tree species occurring in mixed conifer forests within the range of these dwarf mistletoes can be retained other than their principal hosts: sugar pine or western white pine.

Thinning and Sanitation

Thinning or sanitation by removal of infected trees can be an effective treatment in lightly infested stands. Lightly infested is defined as those stands in which there are acceptable numbers of desirable dwarf mistletoe-free or lightly infected (DMR = 1 to 2) trees. Pines with one-half or more of their crowns infected by dwarf mistletoe (DMR = 3 to 6) may decline rapidly about 10 years after they are exposed to full sunlight by thinning. Because of their rapid decline, moderately infected trees should not be left when stands are being sanitized unless they can be expected to reach merchantable size within 15 years. Reexamination of stands 5 years after sanitation is desirable to determine if additional sanitation is needed.

Moderately and severely infested stands should not be sanitized because many trees with latent infections will be missed, and once these trees are released from competition, the number of dwarf mistletoe plants will increase rapidly within their crowns.

In stands where the management of hiding and thermal cover for wildlife is a principal consideration infected trees with large witches' brooms should be treated by girdling rather than felling. If this is not an appropriate option because of stocking considerations or fire hazard, then these trees should be retained and the area managed as wildlife habitat.

Chemical Control

The chemical Florel® (active ingredient = ethephon) is registered by the Environmental Protection Agency for control of dwarf mistletoes. This compound, when sprayed directly on dwarf mistletoe shoots, releases ethylene which causes premature shoot abscission. If applied at the proper time, Florel ® will cause the aerial shoots to fall off of infected host branches before fruits mature and seeds are dispersed, thereby preventing spread of these dwarf mistletoes. However, the endophytic system inside of the infected branches remains alive, and it will produce new aerial shoots in 1-4 years after the infected trees have been treated. Therefore, periodic retreatments will be needed to prevent further seed production and spread of the mistletoes. Because treatments with Florel ® are relatively expensive depending on the size and number of trees that need to be treated, the severity of infection on each tree, and the cost of the product, it is usually only practical to treat infected trees in recreation areas or near homes. Aerial applications have not proven effective.

Management in Recreation Areas

In recreational forests, sanitation treatments that favor non-susceptible hosts or remove infected overstory trees may be appropriate. Branch pruning and tree removal can reduce the impact of dwarf mistletoe and improve the health and longevity of stands. Candidates for branch pruning are trees with infections only in the lower half of their crown. In addition to prolonging tree life, pruning can reduce the danger of trees or branches breaking and causing accidents. Furthermore, for some high-value trees that have large witches' brooms in their lower crown, the removal of the witches' brooms can improve their vigor. These trees may have to be re-pruned occasionally to remove developing witches' brooms. Another consideration in recreation areas or near homes is that pines with dwarf mistletoe infections in their main stems may contain decayed wood and therefore have a high potential to fail. These trees should be examined carefully and when decay is found or expected, they should be removed or their potential to cause personal injury or structural damage to buildings mitigated.

Follow-up Treatments

Regardless of the treatment applied in dwarf mistletoe-infested pine stands, it is recommended that the treated areas be reexamined every 3-5 years. This is necessary because the initial treatment will probably not have removed all of the infected trees for a variety of reasons. Latent infections which were difficult to observe during the initial treatment will usually be more evident 3-5 years later. Re-examinations may determine that further treatment is needed in the stand to remove additional dwarf mistletoe-infected pines that were missed during earlier treatments. In addition, dwarf mistletoe severity may have increased dramatically in some trees that were retained in earlier treatments.

Assistance

Additional information concerning the identification and management of sugar pine and western white pine dwarf mistletoes can be obtained by contacting a County Cooperative Extension Agent, a local state forestry office, or the nearest USDA Forest Service, Forest Health Protection (FHP) Service Area office.

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