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Fir Dwarf Mistletoe

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Fir dwarf mistletoe (*Arceuthobium abietinum* Engelmann ex Munz) is a common and damaging parasite of white fir (*Abies concolor* (Gord. & Glend.) Lindl. ex Hildebr.), grand fir (*Abies grandis* (Dougl. ex D. Don) Lindl.), and California red fir (*A. magnifica* A. Murr.) in the western United States.

There are two forms of fir dwarf mistletoe: one that attacks white and grand fir called white fir dwarf mistletoe (*A. abietinum* Engelmann ex Munz f. sp. *concoloris* Hawksworth & Wiens) and one that attacks red fir called red fir dwarf mistletoe (*A. abietinum* Engelmann ex Munz f. sp. *magnificae* Hawksworth & Wiens).

White fir dwarf mistletoe occurs on grand and white fir in the Cascade Mountains of southern Washington, Oregon, and northern California, the Siskiyou Mountains of southern Oregon and northern California, and in the Sierra Nevada Mountains in California. It has also been reported on white fir in southern Nevada and Utah, in a few locations in Arizona, and on Durango fir (*Abies durangensis* Mart.) from two locations in Chihuahua, Mexico (Figure 1 - map of white fir dwarf mistletoe distribution).

Red fir dwarf mistletoe occurs on California red fir and Shasta red fir (*A. magnifica* var. *shastensis* Lemmon), in the Cascade Mountains of Oregon and northern California, the Siskiyou Mountains of southern Oregon and northern California, and in the Sierra Nevada Mountains in California (Figure 2 - map of red fir dwarf mistletoe distribution).

Fir dwarf mistletoe is common on true firs in the Cascade and Sierra Nevada Mountains. For example, surveys of national forests in Oregon, Washington, and California indicated that over 20 percent of the true fir forests in this region were infested with fir dwarf mistletoe.

Fir dwarf mistletoe parasitizes several tree species in several different genera. White, grand, and red fir are the principal tree species affected by fir dwarf mistletoe. Brewer spruce (*Picea breweriana* Wats.) is severely parasitized in the Siskiyou Mountains of southern Oregon when associated with infected white fir. Subalpine fir (*Abies lasiocarpa* (Hook.) Nutt is occasionally parasitized when growing with infected white fir in northern Arizona and infected red fir in northern California.

Pacific silver fir (*Abies amabilis* (Dougl.) Forbes), western white pine (*Pinus monticola* Dougl. ex D. Don), sugar pine (*P. lambertiana* Dougl.), and lodgepole pine (*P. contorta var. murrayana* (Grev. & Balf.) Engelm.) are rare hosts of this mistletoe.

In the Cascade Mountains of central Oregon, Pacific silver fir and noble fir (*Abies procera* Rehd.) are severely parasitized by mountain hemlock dwarf mistletoe (*Arceuthobium tsugense* (Rosendahl) G.N. Jones ssp. *mertensianae* Hawksw. & Nickrent), but not by the fir dwarf mistletoe. Mountain hemlock dwarf mistletoe plants on true firs are similar in size to those of fir dwarf mistletoe, but mountain hemlock dwarf mistletoe plants are generally greenish or reddish in color and this dwarf mistletoe severely parasitizes mountain hemlock (*Tsuga mertensiana* (Bong.) Carr.) when this host is associated with infected true firs. Fir dwarf mistletoe has not been reported to parasitize mountain hemlock, thus far.

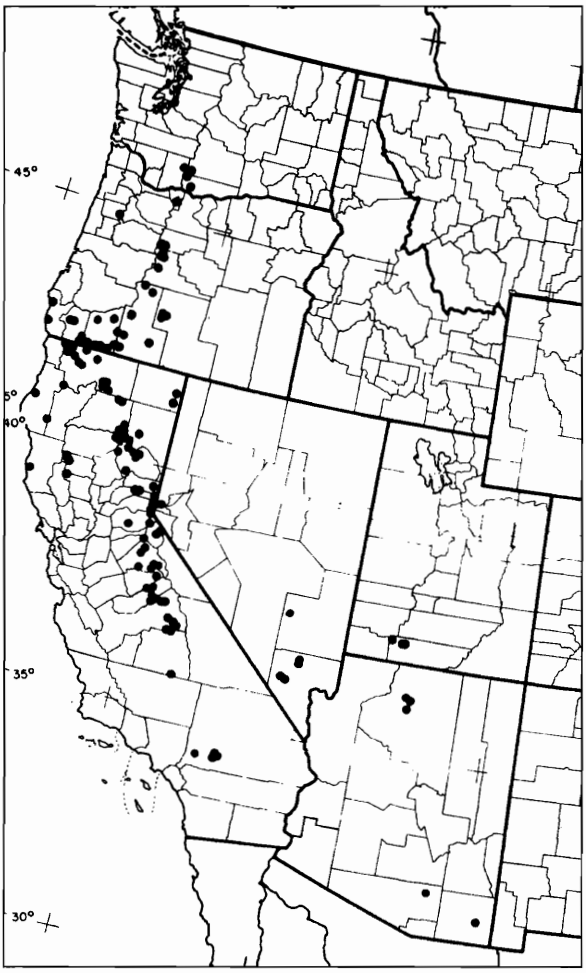

Fig. 1. Distribution of white fir dwarf mistletoe in the western United States.

Life History

Fir dwarf mistletoe is a small, seed-bearing parasitic plant. The external (aerial) shoots are yellow-green to yellow, leafless, and perennial. Their average height is only about 3 inches (8 cm), but they are sometimes as tall as 9 inches (22 cm) (Figure 3).

Aerial shoots arise from a network of root-like absorbing strands imbedded in host tissues. This network, called the endophytic system, consists of cortical strands growing within the bark and sinkers within the wood. The endophytic system obtains nutrients and water from the host tree. The endophytic system lives as long as adjacent host tissues are alive.

The mistletoe is dependent upon its host trees for water and nutrients, although the aerial shoots contain chlorophyll that allows them to produce small amounts of carbohydrates. The major function of aerial shoots is reproduction. Male and female flowers are small and produced on separate plants. Flowering takes place in August and September. Insects and wind are both involved in pollination.

Fruits complete their develop ment 13 to 14 months after pollination. Mature fruit contain one

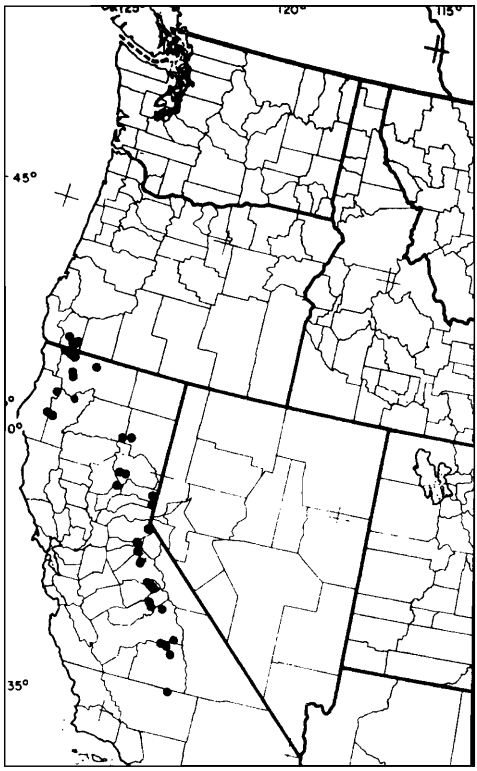

Fig. 2. Distribution of red fir dwarf mistletoe in the western United States.

seed averaging about 0.1 inch (3 mm.) in length. Seed dispersal is one of the most interesting characteristics of dwarf mistletoes. Seeds are discharged explosively from ripe fruits in September and October. They 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 hygroscopic seed coating called "viscin" enables seeds to stick to most objects they strike.

Foliage is 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. Seeds are fastened in place when the viscin dries and they overwinter in a dormant state. Seeds are often destroyed by insects and fungi or dislodged by rains and snow, so only a small proportion of the seeds dispersed actually survive and give rise to new plants.

Seeds germinate in early spring. Radicles grow along the bark surface until an obstruction, usually a needle base, is encountered. The radicles then form mounds of tissue called holdfasts. Host tissue is then penetrated by infection pegs that develop from the holdfasts during the summer. The mistletoe's endophytic system then develops in the cortex and wood of the host. Infection occurs most readily in 1-year old twigs because their bark is more easily penetrated than older twigs.

Aerial shoots typically appear 2 to 3 years after initial infection. Infections that have not yet produced aerial shoots are termed 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. Witches' brooms occasionally are associated with old infections. Witches' brooms are variously shaped masses of abnormal branch and twig growth. Dwarf mistletoe brooms are readily distinguished from the tight, ball-shaped, brooms caused by the rust fungus, *Melampsorella caryophyllacearum* Schroet., that infects true firs.

Often the most conspicuous symptom of fir dwarf mistletoe are flags (Figure 4). Flags are dead branches that are caused by canker-forming fungi, most commonly, *Cytospora abietis* Sacc., that invade dwarf mistletoe swellings and kill the host branches during the dormant season. In

the spring, the foliage on dead branches turns reddish-brown, and forms flags that persist throughout the year.

Bole swellings result from infection of the main stem of firs. Bole swellings are more common on the oldest, most severely infected trees and may break open and allow decay to develop. Trees may break at open bole infections and thus pose serious hazards in developed recreation sites.

Severely infested fir stands typically have many trees with stunted growth, witches' brooms, dying or dead tops and branches, and dead trees. Dieback occurs as nutrients and water needed by growing tree tops are diverted to infections that are usually concentrated in the lower or mid crowns. Foliage near infections becomes sparse and off-color as they are infected by canker fungi, and gradually the branches die. Eventually height growth slows, and such trees may subsequently be attacked and killed by fir engravers (*Scolytus ventralis* LeConte). These stands eventually contain numerous dying and dead trees, usually bearing remnants of dwarf mistletoe infections.

Spread and Intensification

Several interrelated factors influence tree-to-tree spread of fir dwarf mistletoe. These include size class, stand structure, species composition of stands, tree spacing, and infection position. In single storied stands, 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-host tree species can slow the spread of fir dwarf mistletoe. 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 lower host vigor, and many seeds are trapped before they travel far. Dwarf mistletoe seeds from plants high in crowns tend to travel farther than those in lower portions of crowns.

Nearly all spread is local and results from explosive discharge of seeds. Wind exerts a minor influence on 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 true fir trees and stands. For this system, the live crown of the tree is visually divided into thirds and each third rated as: 0 = no visible infection, 1 = light infection (less than half of the number of branches in the crown third have dwarf mistletoe infections), or 2 = heavy infection (more than half of the number of branches in the crown third have infections). Bole infections are rated as 2. 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.

As a rough rule-of-thumb, intensification of fir dwarf mistletoe 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 of fir by dwarf mistletoe causes increased mortality, reduced growth rates and loss of vigor, lowered timber quality, reduced cone and seed production, and increased susceptibility to other damaging agents. These damaging 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 effects 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 40% in severely infected trees.

Fir live crown ratio has an important effect on the consequences of fir dwarf mistletoe. The effect of dwarf mistletoe on radial, height, and volume growth rates is greatest in trees with good live crown ratios (> 80%), the fastest growing, and become almost negligible in trees with live crown ratios < 40%, the slowest growing. On the other hand, trees with good live crown ratios but with severe infections grow better than uninfected trees with poor live crown ratios.

Fig. 3. Female shoots of fir dwarf mistletoe.

Quality of lumber in infected trees can be reduced because fir dwarf mistletoe often forms large swellings in the main stems of true firs. Large knots often are associated with branches supporting witches' brooms. Severely infected trees typically produce few cones and those that are produced are smaller than normal and contain fewer sound seeds.

Other forest values are affected adversely by fir dwarf mistletoe. 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.

Fir dwarf mistletoe infection also can have beneficial effects. Flowers, shoots, and fruits are food for insects, birds, and mammals. Fir mortality caused by dwarf mistletoe, 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 fir dwarf mistletoe must recognize the value of dwarf mistletoes as functional components of forest ecosystems. In areas where timber production or developed recreation is the primary goal, direct control of dwarf mistletoe may be warranted. In other areas, where wildlife or esthetic values are more important, maintaining or even increasing dwarf mistletoe populations may be appropriate.

Cultural Controls

The only practical control of fir dwarf mistletoe over large forested areas is through cultural treatments. No chemical or biological controls are available for treating stands. Profitable production of true fir 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 stands where dwarf mistletoe occurs.

Successful timber volume production is almost impossible in multi-storied, infested fir stands. Silvicultural treatments designed to achieve single-storied stands offer the best prospects of preventing unacceptable losses to dwarf mistletoe.

The most effective method for eliminating fir dwarf mistletoe from timber-producing forests is complete harvest of infested stands by clearcutting. After usable trees are harvested, all remaining infected trees should be killed. To minimize invasion of young fir stands by dwarf mistletoe from infected border trees, the ratio of perimeter to area of clearcuts should be as low as possible. That is, they should be roughly circular and not long, narrow strips. Advantage should be taken of any potential barriers to dwarf mistletoe spread, such as roads, ridgetops, natural openings, and changes in timber types when laying out the boundary of a clearcut.

When clearcutting of dwarf mistletoe-infested fir stands is not appropriate, shelterwood and seed tree harvests can be good alternative even-age management methods. Trees selected to provide shelter or seeds should be uninfected or only lightly infected (DMR < 3). 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.

In mixed-species stands that contain fir infected by dwarf mistletoe, silvicultural treatments should favor other tree species. Non-hosts left between infected and non-infected true firs prevent or slow spread and intensification of the parasite.

Fig. 4. Branch mortality and flags associated with fir dwarf mistletoe and cytospora canker in severely infected grand fir.

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. True firs 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.

Thinning priorities of true fir should be based on both dwarf mistletoe severity and live crown ratios. First priority for removal should be all trees with a live crown ratio < 40% or trees with live crown

ratios < 60% with a DMR of 5 or 6. Last trees to be removed should be those with a live crown ratio > 80% and DMR < 3.

In stands where management of hiding and thermal cover for wildlife is a primary consideration, infected trees with large witches' broom should be treated by girdling rather than felling. 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. Such stands should either be clearcut and regenerated or left unthinned to avoid their rapid decline.

Latent dwarf mistletoe infections in trees in densely stocked stands and in shaded reproduction are very difficult to detect. It should be assumed that understory trees more than 3 feet (1 m.) tall that have been overtopped by infected trees for at least 15 years are probably infected.

Recreation Management

In recreation areas, sanitation treatments that favor non-susceptible hosts or remove infected overstory trees are appropriate. Pruning, in conjunction with removal of severely infected trees, can prolong the life of individual trees. For high value trees, removal of live witches' brooms that exert a large drain on infected trees can improve their vigor and prolong their life. Trees may have to be repruned occasionally to remove developing witches' brooms. Candidates for 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. Trees with bole infections may contain decayed wood and therefore have a high potential to fail.

Assistance

Resources managers and forest landowners can get more information about the identification and management of fir dwarf mistletoe by contacting a County Cooperative Extension Agent, their state forestry office, or their local USDA Forest Service, Forest Health Protection office.

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