Forest Insect & Disease Leaflet 173

U.S. Department of Agriculture • Forest Service

GRAY PINE DWARF MISTLETOE

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Gray pine dwarf mistletoe (*Arceuthobium occidentale*) is an important parasite of gray, or foothill, pine (*Pinus sabiniana*) in California. This dwarf mistletoe does not occur outside of California and is common throughout the range of gray pine in the foothills of the Sierra Nevada Mountains and Coast Ranges around the Central Valley. It occurs in the Coast Ranges from Ventura County north to Siskiyou County (Figure 1).

Although this dwarf mistletoe occurs primarily on gray pine (formerly Digger pine), it also commonly infects Coulter pine (*Pinus coulteri*) and knobcone pine (*Pinus attenuata*) where these species are associated with infected gray pines. Two other pines that may be infected in the Coast Ranges are ponderosa pine (*Pinus ponderosa*) and Jeffrey pine (*Pinus jeffreyi*). In addition, Monterey pine (*Pinus radiata*) and some other pines not native

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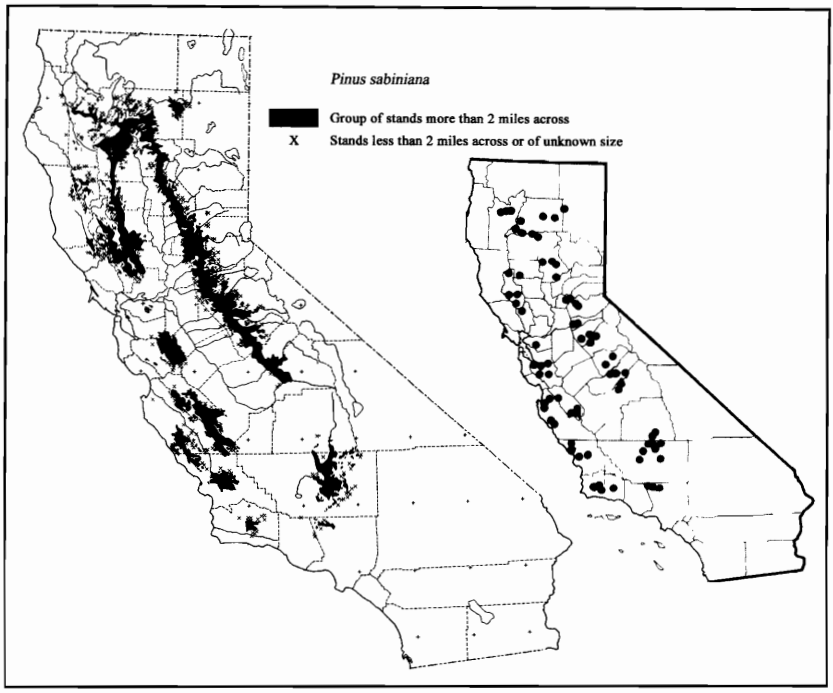

Figure 1. Distribution of gray pine (left) and gray pine dwarf mistletoe (right) in California.

to California are also susceptible to this mistletoe (See Table 1 for a complete list of hosts).

Life History

The external (aerial) shoots of gray pine dwarf mistletoe are yellow to yellow-brown (Figure 2). Dwarf mistletoes do not have large leaves; instead, their leaves are small scales found at the nodes of shoots. The average length of aerial shoots for this mistletoe is about 3 inches (8 cm), but larger ones up to 6 inches (15 cm) are not uncommon.

Aerial shoots arise from a network of root-like absorbing strands imbedded in host tissues. This network, called the endophytic system, consists of (1) cortical strands growing within the bark and (2) sinkers growing radially into the wood. The endophytic system obtains nutrients and water from the host tree, and will usually live as long as adjacent host tissues are alive. The mistletoe is dependent upon its host tree for water and nutrients, and most of its carbohydrates. Although the aerial shoots contain some 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. Gray pine dwarf mistletoe produces flowers in the fall from about the end of September into November. Female flowers are pollinated by insects and wind. Fruits complete their development 12 months after pollination. 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 discharged explosively from ripe fruits from October through December. Seeds may travel 30-40 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 almost any object they strike and also acts

Table 1. Susceptibility classes and hosts of gray pine dwarf msitletoe.

Susceptibility Class	Pine Hosts
Principal hosts	Gray *(Pinus sabiniana)*
Secondary hosts [1/]	Coulter *(P. coulteri)* Knobcone *(P. attenuata)*
Occasional hosts [2/]	Ponderosa *(P. ponderosa)* Jeffrey *(P. jeffreyi)*
Rare hosts [3/]	Aleppo *(P. halepensis)* Italian stone *(P. pinea)* Japanese black *(P. thunbergii)* Monterey *(P. radiata)* Torrey *(P. torreyana)*

[1/] Trees frequently infected when they are associated with infected gray pines.
[2/] Trees infrequently attacked when associated with infected gray pines.
[3/] Trees susceptible but rarely infected even when growing near severely infected gray pines.

as a lubricant when first moistened by rain. Seeds that strike gray pine needles may slide down them and become lodged on the bark at the base of the fascicle sheath. When the viscin dries, seeds become securely fastened in place. Seeds are often destroyed by insects and fungi, and may be dislodged by heavy rain or snow. Only a very small proportion of the seeds dispersed actually survive and cause new infections.

Seeds remain dormant over the winter and germinate in the early spring. A root-like structure called a radicle emerges from the 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 a penetration peg that grows into host tissue. The mistletoe's endophytic system then develops in the bark and wood tissues of the infected host part. Infection occurs most readily in twigs less than five years old because their bark is more easily penetrated than older twigs. After the mistletoe is established within a twig or branch, it may continue to expand laterally in host tissue for several inches. If this infection is close to the main stem the parasite may grow into it. Although the great majority of dwarf mistletoe infections occur on branches and main stems, *A. occidentale* on gray pine is one of the rare cases where root infections have been reported.

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.

Symptoms and Signs of Infection

The first symptom of dwarf mistletoe infection is a slight swelling of the twig at the point of penetration. Swellings become visible 1 to 2 years after infection occurs. Aerial portions of male and female plants appear a year or two after the swellings are visible. When shoots fall off infected

Figure 2. Mature fruit and female shoots of gray pine dwarf mistletoe

branches they leave behind small cup-like structures embedded in the bark. These are called basal cups. Infected branches typically do not develop into masses of branches called witches' brooms like those caused by many other dwarf mistletoes (Figure 3).

A severely infested pine stand typically exhibits stunted growth, dying or dead tops and branches, and dead trees. Foliage near infections becomes sparse and off-color and gradually the upper branches die. Height growth slows, and such trees may subsequently be attacked and killed by bark beetles. These stands eventually contain numerous dying and dead trees.

Spread and Intensification

Several interrelated factors influence the tree-to-tree spread of gray pine dwarf mistletoe. These include tree size, tree spacing, stand structure, species composition, and the location of infections within the crown. Gray pines frequently grow in dry, savanna-like forests. They often occur in separated pockets of trees or as individual trees that are scattered between other non-susceptible trees, such as oaks or other hardwoods and brush species. In these situations, it is not well understood how gray pine dwarf mistletoe is able to spread among trees, but it has been suggested that birds may be involved in the spread of this mistletoe. Seeds eaten by birds do not survive digestion, but seeds could adhere to feathers and be rubbed off on needles or branches where they may later germinate and cause new infections on isolated trees. In stands of nearly pure gray pine, the spread of this dwarf mistletoe is probably similar to that of other dwarf mistletoes. For single-storied stands, horizontal spread is estimated to be 2-3 feet (0.6-1.0 m) per year. Spread in multi-storied stands is more rapid because understory trees are exposed to dwarf mistletoe seeds from the infected overstory. Presence of non-host tree species can slow the spread of gray pine dwarf mistletoe by presenting physical barriers to seed dispersal. Spread rates in very dense stands are less than in more open stands because dwarf mistletoe seeds are intercepted before they travel far. Dwarf mistletoe seeds from plants high in tree crowns tend to travel farther than those in lower portions of crowns.

The 6-class dwarf mistletoe rating (DMR) system is useful for quantifying intensity of infection in trees and stands of gray pine. For this system, the live crown of the tree is visually divided into thirds along the length of the bole 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 ranging from 0 (healthy trees) to 6 (severely infected trees). The tree ratings of all live trees in a stand or plot (including uninfected ones) are then summed and the total divided by the number of live trees to obtain an average stand rating. Average dwarf mistletoe ratings for a stand can then be used to help determine what management options are feasible for the infested area. Individual tree dwarf mistletoe ratings can be used to help decide which pines should

be removed or retained if a decision is made to conduct control treatments.

As a general rule-of-thumb, intensification of dwarf mistletoe averages about one DMR class every 10-15 years for individual trees, but varies with tree size, stand position, and amount of overstory infection. Infection intensifies most rapidly in sapling or pole-size trees under severely infected larger trees. One study of inoculated gray pines found that gray pine dwarf mistletoe spread upward in individual trees faster than the trees can grow in height. Therefore, even when infected overstory trees are not present, the intensification of this mistletoe can be very rapid.

Impacts

Infection of gray pine by dwarf mistletoe causes increased mortality, reduced growth rates and loss of vigor, reduced cone and seed production, and increased susceptibility to other damaging agents. These harmful 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). The open and sparse nature of gray pine foliage allows for the rapid spread of mistletoe within the crown. Areas within the southern portion of gray pine's range have experienced significant mortality due to severe dwarf mistletoe infections. Many trees have died quickly and with little apparent insect activity contributing to the mortality.

Dwarf mistletoes can adversely affect other forest values. Dead branches can increase the hazard potential in recreation sites because they may break and fall. Dead and dying trees detract from visual quality.

Figure 3. Severely infected gray pine. Note that dense masses of branches known as witches' brooms are not formed on gray pine.

Potential for wildfires is increased because resin soaked live branches, dead branches, increased tree mortality, and the accumulation of dead, resinous branches around the bases of infected trees all add to the fuel loading for a given area.

However, dwarf mistletoe infection also can have beneficial effects. Flowers, shoots, and fruits are food for insects, birds, and mammals. Snags created by dwarf mistletoe, either directly or by predisposing trees to other agents, provide 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 gray pine dwarf mistletoe must recognize its value as a functional component of forest

ecosystems. Gray pines, and its associated vegetation, have little or no commercial value, and normally, active management of gray pine over much of the land that it occupies is minimal. An important role of gray pine is to maintain vegetative cover in arid watersheds, and it is of value when it occurs adjacent to people's homes and in developed recreation sites. In these situations direct control of dwarf mistletoe may be warranted. In other areas, where wildlife or esthetic values are more important, allowing the mistletoe to run its course may be more appropriate.

The objective of any control treatment should be to reduce the amount of dwarf mistletoe to levels that are relatively harmless to the pines. Complete elimination of the parasite is unnecessary and very difficult, if not impossible.

Cultural Controls

For most dwarf mistletoes, the only practical control over large forested areas is through cultural treatments. If these treatments are warranted and can be justified for gray pine, the following approaches may be helpful.

In mixed-species stands that contain gray pines 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 and reduce its overall impact.

Thinning or sanitation by removal of infected trees can be an effective treatment in lightly infested stands, around homes or businesses, and in recreation areas. 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. Trees 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.

Thinning priorities 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 less than 40% or trees with live crown ratios less than 60% with a DMR of 5 or 6. The last trees to be removed should be those with a live crown ratio greater than 80% and a DMR less than 3.

Re-examination 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.

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 greater than 3 feet (1 m) tall that have been overtopped by infected trees for at least 10 years are probably infected.

Chemical Control

The chemical Florel® (active ingredient = ethephon) is registered for use in California to control dwarf mistletoe. This growth regulating material, when sprayed directly on mistletoe plants, releases ethylene which accelerates the abscission process. If applied at the proper time, Florel® will cause aerial shoots to fall off the host before fruits mature and seeds can be discharged. Thus, the effect of Florel® is to prevent the spread of dwarf mistletoe to other parts of the tree and to other trees. The internal portion of the mistletoe plant

is not killed and will eventually sprout and produce new aerial shoots. Periodic re-treatments will be necessary to prevent future seed production. The length of time that an ethephon application is effective varies between host species and has been reported for as little as 1 year and up to 4 years. Specific tests of ethephon on gray pine infected by *A. occidentale* have not been reported in the literature.

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 nearby severely infected trees, will reduce the amount of dwarf mistletoe present, and can prolong the life of individual trees. Pines may have to be re-pruned occasionally to remove latent infections that could not be observed when the tree was initially treated. The best candidates for pruning are trees with infections restricted to the lower half of their crown. In addition to prolonging tree life, pruning can reduce the danger of trees or branches breaking and prevent damage and subsequent liability from falling branches. Trees with bole infections may contain decayed wood and, if so, they should be evaluated for their potential to fail. Florel®, as described above, is available for individual tree application in residential settings and recreation sites to reduce the spread of gray pine dwarf mistletoe.

Assistance

Additional information concerning the identification and management of gray pine dwarf mistletoe can be obtained by contacting a County Cooperative Extension agent, a local California Department of Forestry and Fire Protection service forester or the nearest USDA Forest Service, Forest Health Protection (FHP) Service Area office.

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August 2004

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