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PINYON PINE DWARF MISTLETOE

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Pinyon pine dwarf mistletoe (*Arceuthobium divaricatum*) is a damaging parasite of pinyon pines (*Pinus monophylla* and *Pinus edulis*) in Arizona, California, Colorado, New Mexico, Nevada, Texas, and Utah (Figure 1). It has also been reported to parasitize other pinyon pines (*Pinus californiarum*, *Pinus cembroides*, *Pinus discolor*, and *Pinus quadrifolia*), but it is not common on these pines. Other conifers and broadleaf trees are not susceptible to pinyon pine dwarf mistletoe.

Life History

Pinyon pine dwarf mistletoe is a small, parasitic flowering plant. The external (aerial) shoots are olive-green to brown, have small scale-like leaves at the nodes of shoots, and are perennial. The plants only average about 3 inches (8 cm) in height, but they are sometimes as tall as 5 inches (13 cm) (Figure 2). Aerial shoots arise from a network of root-like, absorbing strands imbedded in host tissues. This network, called the endophytic system,

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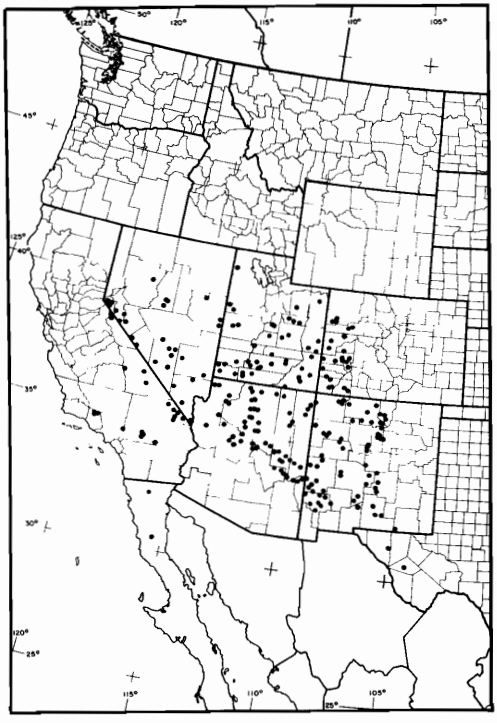

Figure 1. Distribution of pinyon pine dwarf mistletoe in western North America.

consists of cortical strands growing within the bark and sinkers within the wood. The endophytic system extracts 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 for water and nutrients, although the aerial shoots contain chlorophyll that produces small amounts of carbohydrates.

The life cycle of several dwarf mistletoes has been studied extensively. However, the life cycle of pinyon pine dwarf mistletoe has not been studied in as much detail. Therefore, much of the following discussion of the life cycle of pinyon pine dwarf mistletoe is based on what we know about the biology and life cycle of other dwarf mistletoes.

The major function of aerial shoots is reproduction. Male and female flowers are small and produced on separate plants. Flowering takes place from early August through late September. Both insects and wind are involved in pollination.

Fruits complete development within 13 months after pollination. Mature fruit contain one seed averaging less than 0.1 inch (3 mm) in length. Seed dispersal is one of the most interesting characteristics of dwarf mistletoes. Seeds are discharged explosively from mature fruits in September and October. They may travel 35 to 45 feet (12-15 m), but most land within 10-15 feet (3-5 m) of the parent plant. A sticky seed coating called viscin enables seeds to stick to most objects they strike. Viscin, when first moistened by rain, acts as a lubricant. Seeds slide down and either fall off needles or become lodged on bark at the

Figure 2. Female plants of pinyon pine dwarf mistletoe.

base of needles. Fastened in place on small branches when the viscin dries, seeds over-winter in a dormant state. Seeds are often destroyed by insects and fungi, or dislodged by rain and snow, so only a small proportion of those dispersed actually survive and cause new infections.

Seeds usually germinate in the spring. A radicle emerges from a 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. Host tissue is then penetrated from the holdfast during the summer. The mistletoe's endophytic system then develops in the bark and wood of the host. Infection occurs most readily in 1- to 5-year old twigs because their bark is more easily penetrated than older twigs.

Aerial shoots typically appear from 3 to 5 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 approximately 4 to 6 years. Many successive crops of aerial shoots may be produced from an established endophytic system.

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. However, the most striking symptoms of dwarf mistletoe infection on infected pines are witches' brooms. Witches' brooms are variously shaped masses of abnormal branch and twig growth. Witches' brooms caused by pinyon pine dwarf mistletoe are usually small and compact (Figure 3).

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. Although the lateral rate of spread of pinyon pine dwarf mistletoe is currently unknown, the lateral spread of other dwarf mistletoes that infect pines is about 1.5 to 2 feet (0.5-0.6 m) annually in single storied stands.

For most dwarf mistletoes, spread in multistoried stands is more rapid. It can be assumed that the presence of non-host tree species, such as junipers, can slow the spread of pinyon pine dwarf mistletoe. However, no data are available to support this assumption at this point in time. In addition, we can assume that spread rates in very dense stands are less than in more open stands because dwarf mistletoe seeds are intercepted by close neighboring trees, and therefore, cannot spread as far as in more open stands with more widely dispersed pinyon pines.

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 their bodies and later are rubbed off on to susceptible trees.

Because the distribution of pinyon pines in the Great Basin and Southwest was probably much more widespread in the past, we can assume the distribution of pinyon pine dwarf mistletoe was also more widespread. Although small populations of pinyon pine dwarf mistletoe occur in widely scattered locations in the Great Basin and southern California, these probably represent situations where this dwarf mistletoe has survived in isolated populations of its hosts and not long-range dissemination by animals. The pinyon pine dwarf mistletoe only survived in some areas as the distribution of its hosts decreased in area over thousands of years.

There are natural factors that affect the distribution of pinyon pine dwarf mistletoe, especially wildfires, which have been nature's primary control agent. Also, several species of insects and fungi may attack and kill pinyon pine dwarf mistletoe shoots or fruits.

Figure 3. Witches' brooms on severely infected pinyon pines.

The 6-class dwarf mistletoe rating (DMR) system is useful for quantifying intensity of infection in pine 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 branches in the third infected), or 2 = severe infection (more than half of the branches in the third infected). 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 pinyon pines 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 rating. Average dwarf mistletoe ratings for a stand can then be used to help determine what management options can be considered for the infested area. Dwarf mistletoe ratings can also be used to help decide which trees should be removed or retained if a decision is made to conduct harvesting or thinning treatments in the infested area.

Impacts

Infection by pinyon pine dwarf mistletoe causes increased mortality, reduced growth rates and loss of vigor, 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 and reproductive processes. The parasite is often the major factor contributing to tree death. The effects of dwarf mistletoe on tree growth increase with severity of infection. Reduced growth is especially acute in severely infected trees (DMR 5 or 6).

Increased mortality is also associated with severe dwarf mistletoe infection. Dead and dying trees can detract from visual quality in scenic areas. Potential for destructive wildfires is increased because of dead branches in witches' brooms, the increased number of dead trees, and the accumulation of dead, resin-soaked witches' brooms around the base of infected trees.

While it is assumed that severe infection of pinyon pines results in reduced seed and cone production, there is currently no research that demonstrates this. However, research on the effects of severe dwarf mistletoe infection of other pines has shown that seed and cone production is reduced. Therefore, severe mistletoe infection probably reduces seed and cone production of pinyon pines as well. This relationship needs to be studied, because many people use pinyon nuts as a food source.

Pinyon pine dwarf mistletoe infection can also have beneficial effects. Flowers, shoots and fruits are food for insects, birds, and mammals. The witches' brooms produced in severely infected trees may be used for hiding, thermal cover, and nesting sites by birds and other animals. The 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.

Pinyon pine dwarf mistletoe is commonly associated with another mistletoe, juniper mistletoe (*Phoradendron juniperinum*), in pinyon-juniper woodlands in Arizona and New Mexico. How often these two mistletoes co-occur is still uncertain, but recent surveys in northern Arizona have shown that juniper mistletoe is more common than pinyon pine dwarf mistletoe on the Coconino National Forest. However, these surveys also indicate that in many locations pinyon pine dwarf mistletoe is co-distributed with juniper mistletoe, and that juniper mistletoe frequently occurs in areas where there is no pinyon pine dwarf mistletoe.

Because juniper mistletoe resembles dwarf mistletoe, it is often misidentified as one. However, juniper mistletoe can be distinguished from pinyon pine dwarf mistletoe by its fruits. Juniper mistletoe plants have round, white to pink berries on female plants. Generally, juniper mistletoe plants are orange to green and are larger than the plants of pinyon pine dwarf mistletoe. Pinyon pine dwarf mistletoe female plants have greenish-brown, oval fruits and generally the plants are smaller and greenish-brown in color.

Management

In natural ecosystems, dwarf mistletoes have value as individual, biological species and act as disturbance agents, influencing both the structure and function of forest communities. Management based on the effects of pinyon pine dwarf mistletoe must recognize the value of dwarf mistletoes as functional compo-

nents of forest ecosystems in which they occur. The key to proper management of this parasitic plant is to recognize its importance in the overall diversity of ecosystems and to devise management alternatives that recognize and maintain that diversity while meeting management objectives.

Cultural Controls

The only practical control of pinyon pine dwarf mistletoe is through cultural treatments. The damaging effects of pinyon pine dwarf mistletoe can be reduced through good selection and marking during cultural treatments within infested pinyon-juniper woodlands. Areas with severe infestations of pinyon pine dwarf mistletoe are difficult to actively manage, and the best options may be to clearcut the stand or perhaps to defer treatment altogether.

The most effective method for attempting to eliminate pinyon pine dwarf mistletoe from forests is complete harvest of severely infested stands. After usable trees are harvested, all remaining, visibly infected trees should be killed. To minimize invasion of young pine 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, ridge-tops, natural openings, and changes in timber types when laying out the boundary of a clearcut.

When clearcutting of dwarf mistletoe-infested 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 less than 3). Moderately and severely infected trees, in addition to being a source of dwarf mistletoe seeds, produce poorer crops of tree seeds. Lightly infected trees can be expected to live and grow reasonably well for several decades before being severely impacted by dwarf mistletoe.

Infected shelterwood or seed trees should be removed as soon as susceptible reproduction becomes established. Although this is not known for pinyon dwarf mistletoe, 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. However, because pinyon pines grow slowly, this recommendation could be extended to at least 20 years old. More information on when young pinyon pines are infected by dwarf mistletoe is needed.

In mixed-species stands that contain pines infected by pinyon pine dwarf mistletoe, silvicultural treatments should favor other tree species such as junipers. Non-hosts left between infected and non-infected pinyon pines prevent or slow spread and intensification of the parasite.

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 (DMR 3 and 4) should not be left when stands are being sanitized. Thinning infested areas should attempt to reduce infection levels as much as possible without removing the best trees.

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 4 feet (1.3 m) tall that have been overtopped by infected trees for at least 15 years are probably infected. Lightly infected (DMR 1-2) dominant and co-dominant pinyon pines are often better choices for retention than intermediate or suppressed trees with visible mistletoe infections because these latter trees often have many latent infections.

Recreation Management

In recreational forests, 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 re-pruned occasionally to remove developing witches' brooms. The best candidates for pruning are trees with a few large witches' brooms in their crowns.

Assistance

Resource managers can get more information about the identification and management of pinyon pine dwarf mistletoe by contacting a County Cooperative Extension agent, their local state forestry office, or their regional USDA Forest Service, Forest Health Protection (FHP) office.

References

Hawksworth, Frank G. 1977. The 6-class dwarf mistletoe rating system. USDA Forest Service Research Note RM-48, 7 p.

Hawksworth, Frank G., and Del Wiens. 1996. Dwarf mistletoes: biology, pathology, and systematics. USDA Forest Service Agriculture Handbook 709, 410 p.

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Pesticides used improperly can be injurious to humans, animals, and plants. Follow directions and read all precautions on the labels. Consult your local forest pathologist, county agricultural agent, or State extension agent about restrictions and registered uses of particular pesticides.

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