May 2004
12.0
WEB Feb 2010

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Management Guide for

Dwarf Mistletoe

Arceuthobium spp.

Dwarf mistletoe parasitism reduces the growth, wood quality, seed production ability, and life span of infected host trees. Most western conifer species are host to one or more species of dwarf mistletoe.

Topics

Parasitic Plants that cause significant damage to trees

Dwarf mistletoes are small, leafless plants. They are entirely dependent upon their hosts for water, nutrients, and support. These parasites can infect trees of all sizes and ages. They are generally host specific, but the eight dwarf mistletoe species present in the forests of the Northern and Intermountain Regions can infect 21 tree species (See page 12). While they are generally host specific (occur on one principal host species), cross-over does occur into other tree species.

Dwarf mistletoes are the most widely dispersed pathogens in the western United States. Several forces have influenced their distribution across the landscape. Historically, fire has been the foremost factor in affecting dwarf mistletoe population dynamics.

In terms of acres affected, the major tree species impacted by dwarf mistletoes in the Northern and Intermountain Regions are lodgepole pine, Douglas-fir, and western larch (See page 11).

Key Points

- Dwarf mistletoes affect tree growth and form.
- Dwarf mistletoe plants and brooms may be important ecosystem components.
- Control is accomplished by killing infected trees and preventing spread to young trees.

Features of dwarf mistletoes that make them relatively easy to control.

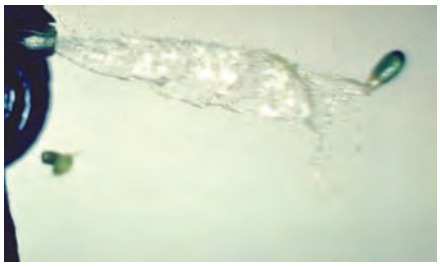
⇒ **Dwarf mistletoes are obligate parasites, always requiring a living host in order to survive.**
⇒ **They are generally host specific.**
⇒ **Dwarf mistletoes have long life cycles (2 to 8 years).**
⇒ **Spread and intensification of dwarf mistletoes is slow in a newly infected stand averaging 1 to 2 feet / year.**
⇒ **Dwarf mistletoe infections in both trees and stands are easy to detect because of the presence of witches' brooms, branch and stem swellings, and presence of the mistletoe shoots.**

Life History

According to fossil records, dwarf mistletoes have co-evolved with their hosts for at least the past 40-million years, meaning they have likely filled many ecological niches in many forest landscapes over time.

Both male and female plants can be produced upon the same host tree. Mature fertilized female shoots produce fruits from which seeds are explosively discharged in the late summer and early fall. The average horizontal distance of seed flight is about 20 feet with 90% of the seed landing within 30-feet. The seeds have a sticky coating that enables them to adhere to any surface they contact. Seeds that land on needles and twigs of susceptible species may germinate the following spring and penetrate the bark resulting in new infections.

The equivalent of a dwarf mistletoe root system that develops within the host is called the endophytic system. Growth of this "root-like"system gives rise to specialized structures called "sinkers" that develop within the host wood, providing the parasite with nutrients and water. Success and spread of the sinkers causes a visible swelling on the twig due to distortion of the annual rings and cambial tissues. Several years after infection, dwarf mistletoe shoots emerge on the twig. New shoots require a couple years of maturity to produce seeds.



Dwarf mistletoe seed is explosively discharged.

Management objectives determine desirability of dwarf mistletoes

We are just beginning to value dwarf mistletoes as unique biological species in their own right and to recognize and define their roles as functional components of ecosystems.

It is only during the last 100 years that the roles of dwarf mistletoes in forest ecosystems were defined by humans as being counter to the predominant forest management goal of maximizing timber production.

Dwarf mistletoe parasitism reduces the growth, wood quality, seed production ability, and life span of infected host trees. Stem infections also provide entrance points for decay fungi. For these reasons, and the fact that they infect so many acres, dwarf mistletoes are considered serious pathogens of the forests in the Northern and Intermountain Regions.

Wildfire risk is greatly increased because of dwarf mistletoe infestations, especially in Douglas-fir stands. The large, pendulous brooms usually occur in the lower portion of the crown and are filled with small twigs and dead needles that provide a fuel ladder for upward spread into tree crowns. Brooms broken off by winter storms accumulate around the base of infected trees and increase the fuels on site. It has also been reported by firefighters that large witches' brooms can fall off burning trees on steep hillsides and quickly spread fire downhill via "flaming pinwheels."

On the positive side, dwarf mistletoe seeds and shoots and dwarf mistletoe–affected branches are used in a variety of ways by many animal species.

Ecology: Fire and Dwarf Mistletoes

Fire is the foremost factor in affecting dwarf mistletoe population dynamics. Generally any fire event that kills their host trees will reduce the population of dwarf mistletoes, at least in the short term. Large, high intensity burns will greatly reduce dwarf mistletoe populations across a landscape and may even eliminate small, localized populations. Smaller, but more frequent light intensity fires will temporarily reduce segments of a dwarf mistletoe population. However, infected residual trees that survive a fire provide a source of dwarf mistletoe seeds to infect newly developing regeneration. Large and numerous brooms in dwarf mistletoe infected-stands increases the fire potential on a site, greatly increasing the likelihood of returning the forest to an early successional stage through a stand-replacing fire event.

Human influences, including fire suppression and logging have affected dwarf mistletoe distribution and disease severity.

Ecology: Successional Effects

In areas where dwarf mistletoes infect trees that are early seral species, dwarf mistletoe-related mortality will advance forest succession toward the climax species. Mortality of large, mature seral individuals provides an opportunity for the release of the shade-tolerant species. Significant mortality generally does not occur until trees are 100+ years of age, when height growth has slowed, allowing infections to move upward and intensify throughout the entire tree crown. Seedlings and saplings of seral species growing under a heavily infected overstory of the same species will be killed at an accelerated rate, further increasing the rate of stand succession toward the climax species.

Ecology: Animal Utilization

There is increasing evidence that important interactions exist between dwarf mistletoes and animals living in the forested ecosystems where the parasitic plants occur. Bird species, including black-capped chickadees, sparrows, ruffed grouse and blue grouse, are reported to eat dwarf mistletoe seeds, and porcupines and squirrels preferentially eat the bark associated with dwarf mistletoe infection. Dwarf mistletoe shoots can be an important winter food source for many animals including porcupines, mule deer, elk, Abert's squirrels, ruffed grouse and blue grouse. Several insect species are also reported to feed on various parts of dwarf mistletoe plants. Cavity-nesting birds utilize trees killed by dwarf mistletoe, and witches' brooms provide cover and nesting sites for many different birds and mammals. Many species of songbirds and owls are attracted to mistletoe brooms for nesting.

Dwarf mistletoe shoots and seeds are consumed by a variety of birds, mammals and insects.

Dwarf mistletoes affect tree growth and mortality

Western larch with brooms caused by dwarf mistletoe infection.

Dwarf mistletoe witches' brooms extract water and nutrients from their hosts thereby reducing the amount of available stored photosynthetic energy that is necessary for tree maintenance and growth. Consequently, witches' brooms grow at a faster rate than the rest of the tree, causing reduction in both tree stem diameter growth and height. Ultimately the witches' brooms become such a drain on the host tree that both the vegetative and reproductive tissues die from the top down.

The more severely infected a tree, the more severe the growth impacts are. Once the dwarf mistletoe has spread throughout the entire tree crown, it usually takes 10+ years for tree mortality to occur. Growth effects and mortality rates generally increase as site quality decreases. Growth loss, as expressed in terms of cubic foot volume, can be quite significant. In addition to direct tree mortality, infected trees are predisposed to attack by other pathogens and/or insects.

Management Strategies

Dwarf mistletoe impacts can be effectively reduced through timing the use of any silvicultural treatments that emphasize the removal or killing of infected branches or trees.

- ⇒ **Regeneration operations**: The greatest opportunity to control dwarf mistletoes is by the removal of infested stands and replacement with mistletoe-free regeneration.
- ⇒ **Precommercial thinning**: Lightly infested precommercial stands can be brought through to rotation age using sanitation thinning operations but heavily infested stands may not benefit from sanitation thinning.
- ⇒ **Commercial thinning**: Select leave trees with a dwarf mistletoe rating (DMR) of 3 or less, preferably those with infections in the lower crown.
- ⇒ **Chemical control**: The chemical, Florel ® is registered for dwarf mistletoe control. It doesn't kill the parasite but prevents seed production for a short period of time(one to three years).
- ⇒ **Prescribed fire**: Western dwarf mistletoe (*A. campylopodum*) has been reduced somewhat in ponderosa pine stands using prescribed underburning. Heavily infested trees were less than half as likely to survive underburning than their healthy counterparts.

Assessing Dwarf Mistletoe Infection in Stands

Dwarf mistletoe management should only be considered after an analysis of the impacts that the parasite has in the trees, stands, and ecosystems they inhabit. One tool has been used for over 25-years to standardize the quantity of dwarf mistletoe parasitism within a stand. The Hawksworth 6-class dwarf mistletoe rating system (DMR) provides a quantitative reference scale for determining the relative population status of a dwarf mistletoe infestation within a stand and its potential for spread and intensification.

Partial cutting creates multi-storied stands, which serves to increase the distribution and intensity of dwarf mistletoe.

The 6-class dwarf mistletoe rating system (DMR)
(Hawksworth 1977)

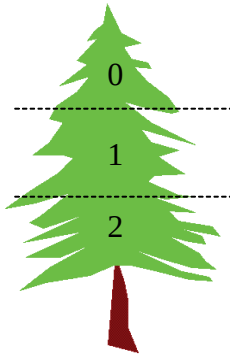
Instructions

STEP 1. Divide live crown into thirds.

STEP 2. Rate each third separately. Each third should be given a rating of 0, 1 or 2 as described below.
(**0**) No visible infections.
(**1**) Light infection (1/2 or less of total number of branches in the third infected).
(**2**) Heavy infection (more than ½ of total number of branches in the third infected).

STEP 3. Finally, add ratings of thirds to obtain rating for total tree.

Example



If this third has no visible infections, it's rating is (**0**)

If this third is lightly infected, it's rating is (**1**)

If this third is heavily infected, it's rating is (**2**)

The tree in this example will receive A rating of **0+1+2=3**.

Management of Dwarf Mistletoe in Stands

Human influences, including fire suppression and logging have also affected dwarf mistletoe population dynamics. In many cases, dwarf mistletoe intensity has been increased by partial cutting. Conversely, dwarf mistletoe populations may have been reduced in certain age-classes, habitat types, elevation zones, or topographic positions that have been intensively managed. Fire suppression and cutting practices that encouraged shifts in species composition may increase or decrease disease severity depending on the species of trees and dwarf mistletoes present on the site.

Dwarf mistletoe impacts can be effectively reduced through timing the use of any silvicultural treatments that emphasize the removal or killing of infected branches or trees. Direct control is usually only necessary when the parasite interferes with accomplishment of clearly defined land management goals.

Dwarf mistletoe management is based on the five biological characteristics of this parasite

(See "Features of Dwarf Mistletoes... on page 1).

Management

The dwarf mistletoe spread rate is fastest in multi-storied stand conditions where mistletoe seeds from infected overstory trees "rain down" on susceptible understory trees.

In evenaged stands, the spread rate is faster in single species stands than in mixed species stands, and the rate decreases as stand density increases.

The Forest Vegetation Simulator (Wykoff and others 1982) is a stand based tree growth regeneration and mortality model developed by the US Forest Service.

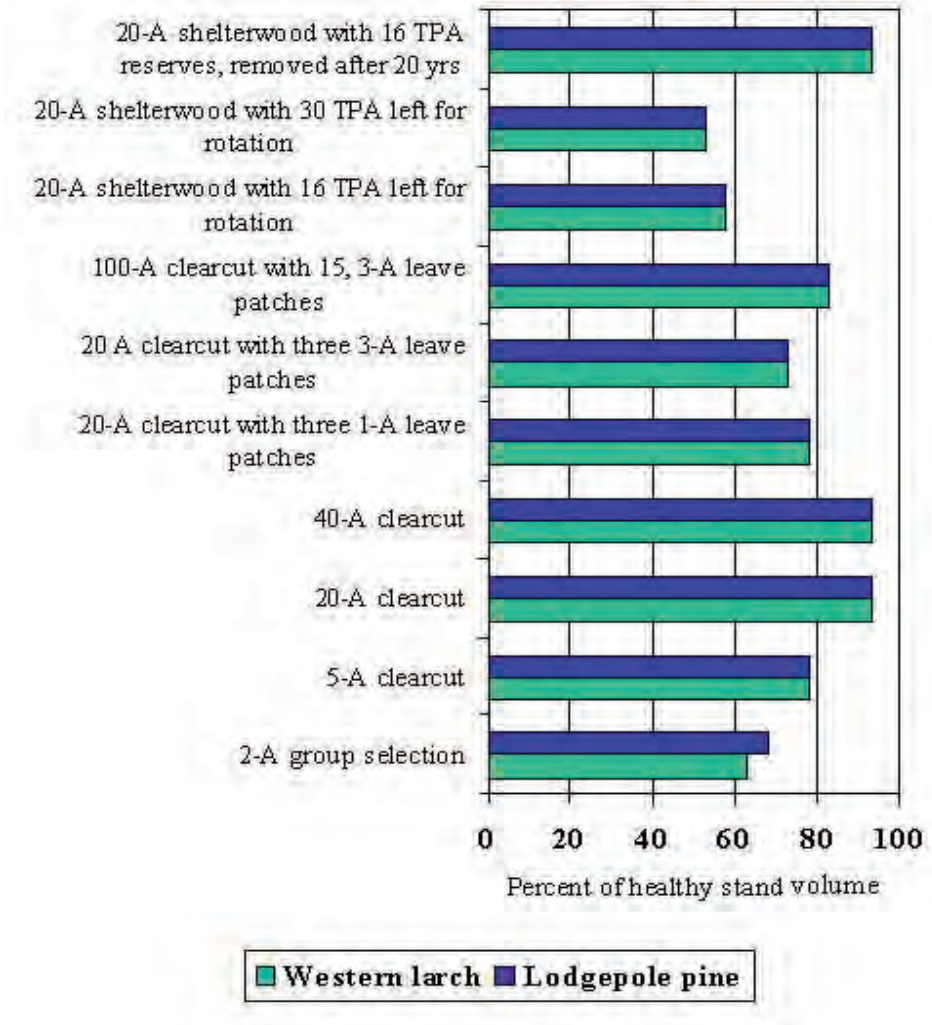
This model is widely used to predict forest productivity and composition under a variety of site and management conditions.

Wykoff, W. R., N. L. Crookston, A.R. Stage. 1982 User's guide to the Stand Prognosis Model. USDA-Forest Service, Intermountain For. And Range Exp. Sta., Gen. **Tech. Rep. INT-133. 112P.**

Regeneration Operations -

These methods include the use of clear cuts, and seed tree and shelterwood operations. A possible downside of clearcutting in some ecosystems is that it leads to the establishment of an even-aged stand. However, if mistletoe control is successful at time of regeneration, it is usually possible to convert the stand to an uneven-aged state in subsequent rotations.

Clear cuts in infested stands should have as large of an area/ perimeter ratio as possible to minimize edge effects and reinvasion from bordering stands (see graph below). Preferably, the harvest unit should be at least 20-acres in size, and narrow strips should be avoided.



Expected productivity of western larch and lodgepole pine stands with moderate initial dwarf mistletoe infection rates with a variety of management methods. Analysis results for western larch using northern Idaho variant of the Forest Vegetation Simulator (Wykoff and others 1982), and for lodgepole pine using the eastern Montana variant. Percent of non-infected stand merchantable cubic-foot volume at 120 years of age.

Management: Regeneration Operations

Whenever possible, cutting unit boundaries should be located in non-infested stands, and take advantage of natural and/or manmade barriers such as roads, meadows, natural openings and species type changes.

In shelterwood and seed tree operations, it is essential to leave non-infected trees. However, if only infected trees are in the treated stand, silvicultural objectives may be met by retaining trees with a dwarf mistletoe rating (DMR) of 3 or less, providing they are felled, girdled, or removed before the regeneration is 3 feet tall or 10-years old. If non-susceptible species are present, it may be desirable to favor these species as leave trees for shelter, to meet management objectives, or for regeneration purposes. Infected overstory trees may be left if the site is regenerated with a non-susceptible species. This is frequently the best option in recreation or riparian areas.

It is essential to leave only uninfected seed trees or shelterwood trees unless they will be removed before the regeneration is three feet tall or ten years of age.

Management: Thinning Operations

Precommercial Thinning

Lightly infested precommercial stands can be brought through to rotation age using sanitation thinning operations. The stand should be surveyed to determine the degree of infestation when deciding whether or not sanitation thinning is practical. If an acceptable stocking level of noninfected trees will be left following thinning little growth loss will occur. If heavily infested stands remain, severe growth losses may occur. It is generally recommended that sanitation thinning should be attempted only if < 40% of the trees of the susceptible species are infected and the average stand DMR is 3 or less. In stands with higher infection levels, the removal of infected trees will reduce stocking below acceptable levels. In these cases, it would be better to adjust the spacing guidelines to retain more trees per acre on the site. A denser stand will slow both individual tree growth and the expansion of dwarf mistletoe intensity within the stand.

Commercial Thinning

Stands should be surveyed for the level of dwarf mistletoe infestation before treatment is prescribed. If timber growth and yield are not the objectives of the stand, it is possible that control measures will not be warranted at this time. However, if growth and yield are major concerns, the following guidelines can be followed. It is known that significant growth losses do not occur until trees reach a DMR >3. Therefore, it is advisable to select trees for removal that have a DMR > 3. Trees with DMR 3 and less, especially those with infections limited to the lower 1/3 of the crown, will probably not incur major growth effects, as the anticipated growth of the thinned trees should exceed the dwarf mistletoe impacts. It is also important to consider the time of harvest and site quality. If time until harvest is short, or if the site is good, leave trees with moderate levels of dwarf mistletoe infection to maintain stocking.

Management: Chemical Control

Florel ® (active ingredient, ethephon) doesn't kill dwarf mistletoe but does slow the spread.

The only chemical approved by the Environmental Protection Agency (EPA) for use in controlling dwarf mistletoes is Florel (the active ingredient is ethephon), an ethylene-releasing growth regulator that causes mistletoe shoot abscission. Unfortunately ethephon doesn't kill the root-like endophytic system of the dwarf mistletoe, and the parasite resprouts quickly. However, the chemical does delay production of dwarf mistletoe seeds, which postpones spread of the parasite by 2 - to 4-years. High-valued trees in recreation, residential, or commercial sites may benefit from applications of ethephon to control dwarf mistletoe spread and intensification.

Management: Prescribed Fire

Dwarf mistletoe brooms may provide fuel ladders to move fire from the ground to the crown.

Fire has long been recognized as the most important single factor governing the natural distribution and abundance of dwarf mistletoes, however, there are few studies and papers on fire-mistletoe interactions. Dwarf mistletoe-infested stands have been measured and demonstrated to have higher total fuel loadings compared to un-infested stands. Moreover, dwarf mistletoe-infected branches are larger, more resinous, and persist longer than healthy branches. In these ways dwarf mistletoe infections increase the fire risk within an infected stand.

Direct Control by fire:

Western dwarf mistletoe can be partially sanitized from both thinned and unthinned ponderosa pine stands using prescribed understory fires. It is essential, though, to attain scorch heights 30- to 60% of the crown length to significantly reduce dwarf mistletoe infestations. On ponderosa pine on the south rim of the Grand Canyon infected with southwestern dwarf mistletoe, it was found that a larger proportion of tree crowns were scorched because infected trees have highly flammable witches' brooms in the lower portion of the live crown. With equal amounts of crown scorch in the 40 to 90% range, the probability of survival of heavily infested trees was less than half that of healthy trees. Mortality of dwarf mistletoe infected trees following the prescribed fires ranged from 9% to 36%.

Indirect effects of fire:

The effects of heat and smoke from fires need additional study. One study found southwestern dwarf mistletoe seed germination was reduced to almost zero by exposure to smoke for 60-minutes or longer, but exposing seeds to smoke for 30-minutes had little effect on their germination. Seeds of lodgepole pine dwarf mistletoe were unaffected by 40-minutes of exposure to smoke from fuels with a high moisture content, and germination was even enhanced by 30-minutes of smoke exposure from dry fuels.

Modeling Dwarf Mistletoe Spread and Effects

Growth and yield simulation models have been developed which can be used in the planning of silvicultural decisions. One of the most widely used models throughout the USDA Forest Service in the western United States is the Forest Vegetation Simulator (FVS) model. The dwarf mistletoe impact model is initiated through FVS automatically when mistletoe data is encountered. This process allows the user to estimate dwarf mistletoe effects on yield in stands under different silvicultural treatments.

Analyses of the effects of silvicultural treatments on the estimated volume reduction from dwarf mistletoe in infected western larch and lodgepole pine were presented in the graph on page 6. For the comparison, certain conditions were assumed: 120-year rotation, regenerated stand is 90-100 percent host species, cutting unit edge contains infected residuals, leave-patches and reserve trees are infected, and no sanitation treatments occur during the rotation.

Projected Productivity of Dwarf Mistletoe-infected Stands

Treatment	Percent of non-infected stand volume (merchantable cubic feet) at 120 years	
	Western larch	Lodgepole pine
2-acre group selection	60-65	65-70
5-acre clear cut	75-80	75-80
20-acre clear cut	90-95	90-95
40-acre clear cut	90-95	90-95
20-acre clear cut with reserves (Three 1-acre leave patches)	75-80	75-80
20-acre clear cut with reserves (Three 3-acre leave patches)	70-75	70-75
100-acre clear cut with reserves (Fifteen 3-acre leave patches)	80-85	80-85
20-acre shelterwood with reserves (16 trees/acre left for rotation)	55-60	55-60
20-acre shelterwood with reserves (30 trees/acre left for rotation)	50-55	55-60
20-acre shelterwood with reserves (16 trees/acre, removed after 20 years)	90-95	90-95

Analysis for larch was done using the northern Idaho variant of the Forest Vegetation Simulator. For lodgepole pine, the eastern Montana variant was used.

Modeling Dwarf Mistletoe Spread and Effects

These simulations suggest that the impacts of dwarf mistletoe on merchantable cubic foot volume increase as the size of the cutting unit decreases and if infected residuals are left standing throughout the rotation. If cutting units are at least 20-acres in size, and residual trees are removed before the regeneration is 10- years old, growth losses may be reduced to as little as 5-10 percent when compared to volume produced in a non-infected stand growing under similar conditions.

Dwarf mistletoes are widespread and damaging in many forest types throughout the northern and central Rocky Mountains.

Distribution of Dwarf Mistletoes

Surveys in the northern and central Rocky Mountains have demonstrated the widepread distribution and, often, damaging effects of dwarf mistletoes in conifer forests. The overall distribution and intensity of these parasites changes slowly through time as host age and abundance changes. The following tables show the estimated percent of area by forest types on National Forest lands which are infested by dwarf mistletoes.

Distribution of Dwarf Mistletoes in the northern and central Rockies

UTAH	Percent Acres Affected by Forest Type			
National Forest	**Lodgepole pine**	**Ponderosa pine**	**Douglas-fir**	**Western larch**
Ashley	45	0	8	0
Dixie	__	20	10	__
Fishlake	__	0	9	__
Uinta	12	0	10	__
Wasatch-Cashe	34	0	9	__

(Continued on page 11)

Distribution of Dwarf Mistletoes in the northern and central Rockies

(continued from page 10)

WYOMING National Forest	Lodgepole pine	Ponderosa pine	Douglas-fir	Western larch
Bridger-Teton	53	—	14	—

NEVADA National Forest	Lodgepole pine	Ponderosa pine	Douglas-fir	Western larch
Humboldt	*	*	*	*
Toiyabe	17	20	15	—

IDAHO National Forest	Percent Acres Affected by Forest Type Lodgepole pine	Ponderosa pine	Douglas-fir	Western larch
Boise	40	20	30	10
Caribou	52	—	21	—
Clearwater	9	*	1	55
Idaho Panhandle	10	*	10	55
Nez Perce	40	*	55	50
Payette	40	28	30	21
Salmon	49	0	45	—
Sawtooth	70	0	53	—
Targhee	60	—	40	—

MONTANA National Forest	Percent Acres Affected by Forest Type Lodgepole pine	Ponderosa pine	Douglas-fir	Western larch
Beaverhead	52	*	—	—
Bitterroot	44	*	43	40
Custer	28	*	—	—
Deerlodge	47	*	—	—
Flathead	18	*	1	34
Gallatin	42	*	—	—
Helena	35	*	1	15
Kootenai	23	*	10	50
Lewis & Clark	37	*	—	—
Lolo	23	*	17	30

*** insufficient survey data available; — dwarf mistletoe not found on this Forest**

Dwarf mistletoes in the Northern and Central Rockies

Dwarf mistletoe species	General location	Principal Host	Secondary Host	Occasional (o) or Rare (r) hosts
A. abietinus, f.sp. concoloris White fir dwarf mistletoe	Southern Utah and Nevada	White fir		Subalpine fire (o)
A. americanum Lodgepole pine dwarf mistletoe	Idaho, Montana, Wyoming, Northern Utah and far western Nevada.	Lodgepole pine		Ponderosa pine (o) Whitebark pine (o) Limber pine (o) Engelmann spruce (o) Blue spruce (r) White spruce (r) Douglas-fir (r)
A. campylopodum Western dwarf mistletoe	Western Nevada and, rarely, in northern Idaho.	Ponderosa pine and Jeffrey pine		Lodgepole pine (o)
A. cyanocarpum Limber pine dwarf mistletoe	Dispersed in Idaho, Montana, Utah, Wyoming and Nevada	Limber pine, Whitebark pine,Great Basin bristlecone pine	Western white pine Mountain hemlock	Engelmann spruce (r) Lodgepole pine (r) Ponderosa pine (r)
A. divaricatum Pinyon pine dwarf mistletoe	Nevada and Utah	Singleleaf pinyon and common pinyon pines		
A. douglasii Douglas-fir dwarf misteltoe	Idaho, western Montana, Utah and one location in eastern Nevada	Douglas-fir		Grand fir (o) Subalpine fir (r) Engelmann spruce (r) Blue spruce (r) Limber pine (r)
A. laricis Larch dwarf mistletoe	Northern Idaho and western Montana	Western larch	Lodgepole pine Mountain hemlock Subalpine fir	Grand fir (r) Engelmann spruce (r) Ponderosa pine (o) Western white pine (r) Whitebark pine (o)
A. vaginatum, subsp. ***cryptopodum*** Southwestern dwarf mistletoe	Southern Utah	Southwestern ponderosa pine		Rocky Mountain bristlecone pine (o) Southwestern white pine (r) Limber pine (r)

Recognizing Dwarf Mistletoe infections

Dwarf mistletoe plants appear as perennial shoots, either simple or branched. Length varies from less than 1-inch in the case of Douglas-fir dwarf mistletoe, to nearly a foot-long in the case of southwestern dwarf mistletoe in Utah. They may occur as tufts or be scattered along the young twigs. Shoots are jointed with opposite pairs of scale-like leaves at the top of each segment. Color varies from yellow to purple to brownish-green or olive-green. If the shoots have dropped, the small basal cups from which they developed often remain on the bark.

It is far easier to identify dwarf mistletoe infections from the symptoms they cause to their host trees than to look for the plants. Even from a long distance, infected stands can be noticed by the presence of deformed, stunted, spike-topped, dead and dying trees. Infected trees are most easily recognized by witches' brooms, a pendulous dense cluster of small twigs on a branch, and/or swellings or other abnormalities on the branches and tree stems.

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Forest Health Protection and State Forestry Organizations

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