DWARF MISTLETOE MANAGEMENT IN THE PACIFIC NORTHWEST

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Abstract: Most Pacific Northwest foresters know how to control dwarf mistletoes. High levels of control are being obtained because foresters are assigned control responsibility, training is continuously provided, and money is available. Dwarf mistletoes are managed by treatment unit layout, overstory removal, residual removal, sanitation thinning, stand replacement, species manipulation, pruning, and combination treatments. Dwarf mistletoe control techniques are an integral part of forest management.

INTRODUCTION

Dwarf mistletoes are estimated to reduce Oregon and Washington forest productivity by 148 million cubic feet annually. There are eight dwarf mistletoe species and 19 tree species affected. The most serious damage occurs in Douglas-fir, western hemlock, ponderosa pine, lodgepole pine, and western larch. Dwarf mistletoes are thought to occur on about one-half of the forest land in these two States. True mistletoes occur on Oregon oak, incense cedar, and juniper.

Projects with the sole objective of controlling dwarf mistletoes were not initiated in the Pacific Northwest until 1959. This seems somewhat surprising because as early as 1916 James Weir, one of the first forest pathologists to visit the Pacific Northwest, had clearly documented the seriousness of dwarf mistletoe damage. He suggested control procedures which are still appropriate today.

Dwarf mistletoes were certainly not ignored by Pacific Northwest foresters prior to 1959. They were considered in most forest operations; their presence influenced selection of sites to be cut, methods of harvesting, size of cutting units, and reforestation practices. Mistletoes were being controlled by routine forest operations.

When dwarf mistletoe control programs first began in the early 1960's, the idea was to eliminate all or nearly all mistletoe from treatment areas. Eradication is possible in clearcutting operations but in thinnings and uneven-aged management, primarily east of the Cascades, total mistletoe removal can seldom be. Now foresters ask "How much dwarf mistletoe can I tolerate and still grow a productive forest?" This makes mistletoe management more compatible with other forest management practices and it calls for much more professional judgment.

The goal of Pacific Northwest dwarf mistletoe management is to reduce the parasites to levels that allow trees and stands to grow at acceptable rates without incurring undue costs in control efforts.

Most Pacific Northwest foresters understand how to control dwarf mistletoes and are applying mistletoe management practices. Dwarf mistletoe management is more than ever before an integral part of management activities on most forest lands in Oregon and Washington. Mistletoe control is viewed along with precommercial thinning, selection of genetically superior trees, and fertilization as an intensive management tool to increase forest productivity. Many thousand acres receive dwarf mistletoe treatments each year. Part of this high level of control can be attributed to the good growing conditions in the Region and the favorable economic position of forest-
ry, but mostly it is due to the average forester's good understanding of dwarf mistletoes. Mistletoes are managed more intensely on Federal and State forests than on most private holdings, but many of the industrial forestry companies are aggressively controlling the disease.

GAINING COMMITMENT

It may seem to some that a discussion on gaining commitment is out of place at this symposium. However, based upon our combined 19 years of experience with dwarf mistletoe control in the Pacific Northwest, we feel strongly that without foresters' commitment, control programs will not work. Most western foresters know the damaging effects of mistletoes. Forest pathologists incessantly speak of the evils of dwarf mistletoes and exhort foresters to control them. However, in many cases these actions are not enough. Control opportunities are missed because there is lack of commitment at one or more organizational levels.

The importance of gaining foresters' commitment to dwarf mistletoe control has been recognized by most people responsible for developing the programs in Oregon and Washington. Three actions have been taken—public agencies and some companies have officially declared it their policy to control mistletoes, training is being provided continuously, and funds are made available for dwarf mistletoe management.

The Forest Service Pacific Northwest Region and Washington State Department of Natural Resources (WDNR) have declared it their policy to reduce losses caused by dwarf mistletoes on lands they administer. These declarations assign responsibilities for mistletoe management. Guidelines are provided for managing mistletoes in numerous Pacific Northwest forest conditions. Other public forest land managing agencies have policies calling for reduction of disease losses but dwarf mistletoes are not specifically identified in the statements.

Dwarf mistletoe control guidelines and policy statements have to be clearly understandable, present attainable goals, and be based on facts. If they are too general, difficult to understand, or present unattainable goals, they will be ignored. People charged with carrying out these instructions have more commitment if they are involved in their formulation.

The issuance of directives is not, of course, totally responsible for commitment to control mistletoes. They are a contributing factor because they can be used to hold people accountable for their actions or lack of them. Without written policies and guidelines dwarf mistletoe management is left to the discretion of individuals. This has usually resulted in only interested people performing control and widely varying standards of work quality. This problem can be seen on some private lands.

Training has probably been among the most effective means of attaining high levels of commitment to dwarf mistletoe control in Oregon and Washington. The Forest Service conducts forest insect and disease management workshops on at least six National Forests per year. Dwarf mistletoes are a major topic, with emphasis being placed on practical management approaches. State forestry organizations provide the same type of training. In addition, the Forest Service has developed a 2-day dwarf mistletoe workshop which is presented upon request. Training pays big dividends because it keeps dwarf mistletoe on foresters' minds, provides an outlet for research findings, exposes the subject to those unfamiliar with mistletoes, and provides exposure of pathologists to people who need their services. Plans are well underway to provide dwarf mistletoe training to privately employed foresters in the two States under the auspices of the Northwest Forest Pest Action Council.

Oregon and Washington State forestry agencies and the Forest Service have all prepared easy to read how-to-do-it dwarf mistletoe publications. The latest is "Dwarf Mistletoes of Oregon" by the Oregon State Department of Forestry. One of the first management publications was "A Training Aid on Dwarf Mistletoe and Its Control" by Donald Graham, issued in 1967. Several thousand copies were distributed and requests are still being received. This one publication probably contributed more to Pacific Northwest foresters' knowledge of mistletoes than anything else.

The WDNR and Forest Service have demonstration areas for training foresters how to recognize and manage dwarf mistletoes. Both good and bad techniques are shown. The purpose of the areas is to demonstrate how prescriptions offered in guidelines, publications, and training sessions are actually applied and look. In most cases demonstration areas are also study plots. Plans call for establishment of many more demonstration sites.

Directives and training are important to gaining commitment, but it is money that accomplishes dwarf mistletoe control in the Pacific Northwest. Allocation of funds for dwarf mistletoe control emphatically states management commitment.
Appropriation of funds by the Forest Service specifically for dwarf mistletoe control started in 1959 and reached a peak early in the '70's with close to $400,000 being spent in one year. The WDNR has made about $190,000 available to its districts for control. Crown Zellerbach Corporation has recently budgeted money for hemlock dwarf mistletoe control in Washington. Since 1959, close to 2 million dollars have been obligated specifically for control in the Pacific Northwest.

A highly important benefit achieved by allocating these funds is stimulation of foresters' awareness of the need for and value of dwarf mistletoe control. Dwarf mistletoe control funds have served as seeds to spark interest. Once foresters become aware of the desirability and feasibility of controlling dwarf mistletoes, they rely less on funds specifically earmarked for control and more on regular timber stand improvement and sale preparation funds. Today at least five times as much acreage is treated with these funds than with dwarf mistletoe control funds.

We believe that these actions, specific policy direction, training, and funding form the basis for the high level of commitment Pacific Northwest foresters have to dwarf mistletoe control.

**DWARF MISTLETOE MANAGEMENT TECHNIQUES**

**Treatment Unit Layout**

Layout of dwarf mistletoe treatment units is important both in keeping costs down and preventing spread into new regeneration or sanitized stands. Borders of treatment units should incorporate natural and manmade barriers to prevent or slow reinvasion. Barriers which have been used include: Small natural openings in stands, larger meadow edges, timber type species changes, uninfected edges of the same timber type, rock outcrops, streams, lakes, roads, power lines, adjacent clearcuts, and others. Ridge tops do not make good boundaries because upwell winds can carry dwarf mistletoe seed over the top. Valley bottoms are better. Barriers should be about 1 chain wide, but we have recommended narrower strips; particularly if the dwarf mistletoe species present does not discharge its seeds long distances.

Dwarf mistletoes infestations do not normally occur continuously over large areas. Instead, the pattern consists of infected, then noninfected zones scattered throughout stands. Foresters are encouraged to include entire stands in control units rather than treat infected portions so drastically different that new smaller stands are created where only one previously existed. For example, we would recommend that foresters not patch cut 1- to 2-acre mistletoe-infected spots in a 50-acre pole-size stand but consider sanitizing the entire stand. Generally, the smallest unit of commercial forest land managed separately is 5 acres. Smaller units are considered too costly to manage.

Clearcut corridors along edges of treatment units are discouraged primarily because of cost. It is better to readjust boundaries if possible. Cleared strips are sometimes used where treated acres adjoin old-growth infected trees of different ownership. Since dwarf mistletoes are quite host specific, infected or susceptible species are kept out of a 1 chain wide strip separating treated and untreated stands. Resistant species are either retained, planted, or allowed to regenerate naturally in the strip.

Treated units are often left with infected perimeters when adjacent stands will be harvested within 5 to 10 years. Only a small amount of dwarf mistletoe infection would occur in this short time. This requires careful long-term planning and follow-up.

Foresters are encouraged to design treatment units, especially clearcuts, with as large an area-to-perimeter ratio as compatible with other management considerations to prevent rapid reinvasion. In infected stands, where there is little opportunity to create uninfected edges, large, circular shaped clearcuts are favored over smaller long, narrow, clearcuts. To illustrate the potential importance of this point, consider the following example. There are two 30-acre clearcuts. One is circular, the other rectangular with dimensions of 10 by 30 chains. If the entire perimeters of both are infected and they are regenerated with susceptible tree species, the rectangular unit will be invaded fastest. After 15 years, 23 acres of the circular unit will be uninfected; but in the rectangular unit slightly less than 21 acres will be uninfected. Recommendations on size and shape of treatment units should be developed in consultation with landscape architects and wildlife biologists to avoid potential conflicts.

**Overstory Removal**

Dwarf mistletoes spread most rapidly in multi-story stands. Control activity is usually directed at creating single story stands. For example, an infected stand of old-growth ponderosa pine with a well-stocked but infect-
ed understory would first have the overstory removed, then the infected understory would receive a sanitation-precommercial thinning. Overstory removal is practically always accomplished by timber sales. Occasionally, scattered infected overstory will be either dropped or left standing and girdled.

A simple technique we have found useful in overstory removal is to paint the stumps of overstory trees which are infected. This alerts crews who will be thinning at a later date to examine trees surrounding painted stumps closely for infections.

The shelterwood system is a proven method for successfully regenerating Douglas-fir and other species on certain sites. Occasionally it is necessary to leave infected trees to provide shelter. When susceptible regeneration develops under infected shelterwood, the infected overstory should be removed as soon as the regeneration is established. The Forest Service uses a rule that infected overstory should be removed before regeneration reaches 3 feet tall or 10 years old, whichever occurs first. WDNR recommends for western hemlock management that infected overstory be removed within 5 years.

Most commerical forest land in the Pacific Northwest is, or will be, under even-age management, so removal of infected overstory trees is considered standard operating procedure.

Residual Removal

Infected trees often remain after stands are clearcut or burned. Pacific Northwest loggers, a proud group of rugged individualists, often consider it beneath them to cut unmerchantable size trees when clearcutting. Standard clauses in Forest Service and WDNR clearcut timber sale contracts require all trees above 4 inches dbh be cut. Smaller trees which may be infected can be left. The WDNR has clauses which may be inserted in timber sale contracts requiring a clearcut where all stems are to be severed when dwarf mistletoe is present. Many agencies, companies, and small landowners have no requirements concerning removal of trees in clearcuts. Many clearcuts are not broadcast burned, allowing infected residuals to survive. Wildfires usually do not kill all trees within burns.

These residuals constitute an infection threat to susceptible regeneration. For example, it was shown that dwarf mistletoe plants in one western hemlock on Vancouver Island, British Columbia, cast seeds over an area encompassing 5,800 square feet (0.13 acre). Less than eight of these trees, evenly spaced, could serve to spread mistletoe seeds over an entire acre. It is not at all uncommon to have more than eight infected residuals left per acre after clearcutting. We estimate that untreated residuals will cause at least 8,000 square feet around them to be unproductive in a normal rotation.

In many cases, infected residuals left after clearcutting will be killed by slash burning. Residuals are also removed for other reasons, such as firewood cutting or to reduce hazards to brush spraying helicopters.

Residual removal is one of the most effective and least costly dwarf mistletoe control techniques used in the Pacific Northwest. Considering that more than 300,000 acres are clearcut each year and that about 30 percent of this area may be infected, residual removal provides excellent opportunity for greatly reducing losses, particularly when it can be accomplished during logging.

Mistletoe control is frequently the only reason residuals are destroyed. Forest Service policy is to use money (K-V) from timber sales for this. When these funds are not available, other funds (P&MC or FIDM) will be allocated. Top priority for Forest Service dwarf mistletoe control funds in the Pacific Northwest is residual removal.

Existing management guidelines do not specify how many infected residuals per unit area are required for control to be initiated. However, we would certainly recommend treatment even if there were as few as one tree per acre. If clearcuts are less than 5 years old, all living residuals of the infected tree species are killed. When there are numerous residuals and the stands will not be broadcast burned, we recommend treatment efforts be concentrated on those 3 or more feet tall; but we would prefer to see all destroyed. Foresters are encouraged not to attempt to save apparently uninfected trees because they may have latent infections. If clearcuts are 5 or more years old, only visibly infected trees have to be killed although we encourage all trees to be treated.

Cutting residuals is preferred to girdling or poisoning because it guarantees trees will be killed and it is easier to check work thoroughness. In some instances, trees are girdled or poisoned, particularly if needed for wildlife.

There have been several occasions when an agency or company with several thousand acres
of clearcuts, ranging from less than a month to more than 20 years old, has decided to initiate residual removal for dwarf mistletoe control. Usually we advise them not to do residual removal as a separate operation on units more than 15 years old. It should be combined with sanitation precommercial thinning. The 10- to 15-year-old units are treated first because studies have shown the rate of stand infection increases rapidly once trees reach this age. The 5- to 10-year-old units are treated next and finally the 0 to 5 units until the backlog is eliminated.

Experienced crews can treat residuals during slow seasons, instead of being terminated. Unemployed people or youth crews can do this work with a small amount of training.

Residual removal costs vary tremendously depending upon number and size of trees, topography, and availability of labor. We have seen costs from $5 to over $200 per acre. Costs seem to average less than $40 per acre.

Foresters are urged to eliminate residuals during logging or reforestation. We have had success in getting loggers to knock over residuals as they are yarding logs to landings. High lead logging destroys more residuals than tractor, skyline, helicopter, or balloon logging. Broadcast burns are advocated, if ecologically sound for the sites. Pathologists advocate cleancuts instead of clearcuts.

Sanitation Thinning

In the late 1960's when dwarf mistletoe control was first begun on WDNR lands east of the Cascades, a few problems were encountered. Logical steps to control are to: (1) remove infected overstory, (2) sanitize infected understory by specialized precommercial thinning, and (3) follow-up 5 to 7 years later if necessary. Managers had difficulty finding acres eligible for precommercial thinning-sanitation because infected overstory was almost always present. Years of selective logging with occasional regard for dwarf mistletoe control had produced these stands.

It often became necessary to set up special timber sales just to provide acres for the precommercial thinning-dwarf mistletoe control. The cart was before the horse! Now, a better approach is being used: (1) dwarf mistletoe problem areas are identified, (2) the infected area is gradually converted to single story management through carefully planned overstory removal timber sales, and (3) the more or less even-aged shorter stand is sanitized while being precommercially thinned.

Note that the order of doing things is about the same as described above but the priorities are different! Instead of trying to find suitable stands for precommercial thinning first, the manager begins with the timber sale recognizing that if dwarf mistletoe is to be reduced only one level of canopy can exist. The disease control operation is now integrated with normal management.

Dwarf mistletoe sanitation on WDNR lands has been concentrated in ponderosa pine stands. The Hawksworth mistletoe rating system is used to select trees for removal. The amount of infection a tree can have and still be kept in a stand depends upon its size. The following table lists allowable ratings.

<table>
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<th>dbh Class</th>
<th>Maximum Allowable Rating</th>
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<td>1-2</td>
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<tr>
<td>3-4</td>
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<td>5-6</td>
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<td>7+</td>
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Cutters are required to cut or kill all trees exceeding these ratings. Oregon State Department of Forestry advocates the same system.

Sanitized areas are examined 5 to 7 years after treatment to determine success and decide if additional treatment is necessary.

Forest Service dwarf mistletoe sanitation thinning guidelines differ somewhat from those of the WDNR. The guidelines apply to all tree species and a different infection severity rating system is used.

Sanitation is an integral part of all thinnings in infected stands. Expenditure of funds for sanitation is limited to lightly infected precommercial size stands from which all overstory has been removed. Severely infected stands are replaced rather than thinned.

Stand infection severity is not based directly upon the standard 0 to 6 rating system even though it is used in routine stand examination surveys. Stand infection intensity is rated none, light, or severe. It is based upon the number of potential crop trees for the site. Silviculturists have determined acceptable stocking levels for many tree species by site index. Presence of mistletoe affects crop tree potential. In stands where the average potential crop tree dbh is less than 2 inches, crop trees should have no visible infections. They should meet all other crop tree criteria. In stands with potential crop tree dbh averaging 2 inches or larger, priorities for crop tree selection are as follows.
1. Uninfected dominants and codominants.

2. Dominants and codominants with dwarf mistletoe confined to branches in the lower one-third of live crown.

3. Dominant and codominants with dwarf mistletoe confined to less than 50 percent of the branches in the lower one-half of live crown.

4. Intermediates with no visible infections.

These priorities correspond roughly to ratings of 0, 1, and 2, 3, and 0 using the standard mistletoe rating system.

If enough trees meeting these criteria exist to achieve acceptable stocking, the stand would be rated lightly infected. Stands are considered severely infected if there are not enough trees with the above characteristics to meet minimum stocking guidelines for the particular site.

This approach allows selection of trees based upon severity and location of infections. Trees with upper crown infections are not potential crop trees. Research has shown high crown infections cause more growth impact and contribute more tree-to-tree spread than lower crown infections. We feel one of the strong points of this crop tree selection method is that foresters must consider other tree and site characteristics in addition to mistletoe.

In the first several years of the Forest Service mistletoe control program, emphasis seemed to be placed upon eliminating infected trees during thinning. Little regard was paid to superior tree characteristics, resulting in many stands that look like silvicultural abominations. Dominant and codominant trees were felled, even if they were only lightly infected, and suppressed trees were chosen for crop trees because they were seemingly uninfected. Large openings were created where all infected trees were cut, regardless of infection intensity. Spacing and stocking was erratic. Good silvicultural practices were abandoned in the zeal to eliminate mistletoe. Fortunately, this problem has been corrected. Stands sanitized under present standards often contain infected trees to provide adequate stocking but they will grow at acceptable rates. Tree killing by dwarf mistletoe is uncommon in thinned stands.

Forest Service sanitation thinning guidelines recommend against spending funds for resanitizing stands. We feel foresters will remove the most severely infected trees in the first entry. Infected trees which may be left are capable of reaching merchantable size by the time of normally scheduled commercial thinnings or regeneration cuts. Infected trees may cause some infection in adjacent trees, but usually these new infections will be low in the crown and have little effect on growth.

The importance of spacing is stressed in stands with infected crop trees. A minimum spacing distance of 12 feet is recommended in precommercial size stands if infected trees are to be left. Infection by contagion declines when spacing between trees increases. Theoretical calculations for ponderosa pine have indicated that infection by contagion is greater at spacings of 9 feet and lower at 18 feet. Infected crop trees must have sufficient space for good growth response so annual height increment will exceed upward spread of dwarf mistletoe. Spacings suggested for mistletoe-infected stands are essentially the same used in healthy stands.

Existing sanitation guidelines apply uniformly to all species. However, we advise foresters to discriminate more severely against infected Douglas-fir and hemlocks than true firs, pines, or larch, because they suffer more damage.

The Forest Service and Oregon State Department of Forestry sanitation guidelines suggest use of a Canadian developed formula to assist thinners in locating infected trees. It assumes spread from a single source, such as a residual to surrounding regeneration. The formula is distance (ft.) = initial spread + ([years since logging - 5] x 2). Trees within this distance of an infected residual should be examined carefully for infections. For example, in a hemlock stand logged 15 years ago the following calculations would apply.

Distance = 40 + ([15 - 5] x 2) = 60 ft.

Forest Service pathologists are frequently asked for advice on thinning stands which appear to be severely infected. Usually the best trees average at least 4 inches dbh. They are too small for commercial thinning and too large for precommercial thinning. Left untreated, such stands tend to disintegrate. Frequently we recommend they be thinned even though leave trees may have numerous infections. We suggest these thinned stands be grown to minimum merchantable product size and then replaced early rather than carrying them the normal rotation period. Infected trees which are 4 inches dbh can usually be grown at least 8 or 9 inches in 20 years, even on poor sites.
Sometimes it is desirable to delay sanitation thinning infected western hemlock stands of precommercial size until the average potential crop tree is 4 to 5 inches dbh. If infected trees are released when they are only 1 to 3 inches dbh, hemlock mistletoe intensifies rapidly and causes severe reductions in growth. When these stands are allowed to grow in their normal dense condition, many infections which are located low in the crowns become shaded and die. When these trees reach 4 to 5 inches dbh the top halves of crowns are often mistletoe free. After the stands are thinned, canopies usually close in 5 years and trees often grow to merchantable size in 10 or less years on the best sites.

Occasionally, two-storied stands are found which have a moderately dense infected overstory and fully stocked understory. It may be difficult to tell if the understory is severely infected because shading has not allowed vigorous development of aerial plants and witches' brooms. If such sites are not difficult to regenerate, the recommendation often given is to remove all overstory then wait 3 years before thinning the understory. The 3-year period will allow most mistletoe present at the time of overstory removal to become readily detectable. If the stand appears to be severely infected at this time, it would be destroyed and the site regenerated.

The importance of having thinners trained to recognize dwarf mistletoe infections is stressed. Most sanitation thinning is accomplished by contractors and many, when first starting, do not recognize dwarf mistletoes. Aids are provided to help them select proper crop trees. Contracts describe desirable crop trees; some require thinners to use the 0-6 rating system for crop tree selection. Others use the previously described crop tree criteria. Contract descriptions have to be simple to be understood and applied.

Stand Replacement

The only practical alternative for severely infected stands is to regenerate them so site potential can be realized. Under Forest Service guidelines a stand is considered severely infected if removal of undesirable trees would leave it understocked.

Clearcutting is the most common method of regeneration cutting. It is most frequently employed west of the Cascade Crest but has been used many times to remove mistletoe-infected stands on the east side. Shelterwood cutting is increasingly used. Both systems have already been discussed.

Some interesting methods have been used to replace severely infected stands on sites considered difficult to regenerate. On at least two severely infected sites all merchantable volume was removed. The stands were then burned, and seedlings were planted in the shade of dead trees. Consideration has been given to spraying severely infected stands with herbicides then planting in the shade. Another approach used in ponderosa pine stands was to remove merchantable volume, followed by a mechanical brush cutter to create cleared swaths approximately 20 feet wide through the very dense, severely infected understory. Leave strips were 4 to 6 feet wide. Seedlings were planted in the cleared swaths and as soon as they become established the remaining infected trees will be destroyed.

Forest Service guidelines recommend that infected stands of small diameter true firs not be destroyed for the sole purpose of dwarf mistletoe suppression. Research conducted by the PSW Station indicates true firs with good crowns will usually grow well in spite of infections if they are released.

Species Manipulation

Most dwarf mistletoe species found in the Pacific Northwest have limited host ranges. One major exception is hemlock dwarf mistletoe, which in addition to infecting western and mountain hemlocks, commonly infects all true firs (Abies) and occasionally western white pine.

Species manipulation is used as a dwarf mistletoe management technique in several ways in the Pacific Northwest. Where perimeters of stands adjoining plantations contain infected trees that can cast mistletoe seeds onto regeneration in the cut areas, 50- to 100-foot wide strips along the edges are sometimes planted with nonsusceptible trees. Occasionally it might be necessary to remove susceptible seedlings which regenerate naturally in the strips. A variation of this approach that has been used only occasionally is to harvest infected species for a distance of 50 to 100 feet into stands surrounding plantations.

Shelterwood cuts are becoming increasingly common in the Pacific Northwest. Nonsusceptible species of seedlings are often planted under infected shelter trees. Ponderosa pine is frequently planted under infected lodgepole pine. Douglas-fir is often planted under or close to infected hemlock and true firs.

Species manipulation is advantageous during thinnings. Uninfected species are favored
as crop trees. Common examples include favoring Douglas-fir instead of hemlock in infected stands in western Oregon and Washington, and white fir instead of infected Douglas-fir in eastern Oregon and Washington. In some areas, particularly southern Oregon, there may be three different species of dwarf mistletoe on a single acre—Douglas-fir, hemlock, and white fir—and all tree species may be infected. Forsters will favor trees least damaged by mistletoe, usually white or red fir. Another example occurs in higher elevations in the Cascades where hemlock mistletoe often infects true firs and hemlocks in the same stands. True firs are favored because mistletoe damages them less than hemlock. This situation often becomes complicated because some true firs are severely damaged on these sites by balsam woolly aphid. Fortunately, true fir susceptibility to the aphids varies with elevation.

Species manipulation provides about the only hope for uneven-age management of dwarf mistletoe-infected stands. It is also one of the very few ways to manage infected stands that have been designated for rotations as long as 200 years because of visual or wildlife management considerations. Numerous examples of species manipulation have been applied in stands visible from heavily traveled highways in eastern Washington and Oregon. West of Wenatchee, Washington, foresters have removed mistletoe-infected Douglas-fir and larch from stands which also contain white fir, Engelmann spruce, ponderosa pine, and lodgepole pine. The area was referred to as a silvicultural slum because of the large number of dead trees. It is now much more scenic because of the species manipulation.

**Pruning**

Pruning is not recommended in forestry operations, except in incidental cases where infections can be removed at no additional cost while precommercial thinning. It is recommended only in campgrounds or recreational sites where trees are a premium.

Coastal recreation sites are frequently located in western hemlock stands. Heavily infected crowns produce dwarf mistletoe brooms that may weigh up to 200 pounds or more. Falling broomed branches could severely damage property or injure recreationists. Pruning heavy brooms in these stands is a good practice.

East of the Cascades, pruning of dwarf mistletoe brooms is occasionally done to enhance tree vigor in recreation sites. Ponderosa pine responds most favorably to pruning when at least half of the upper crown is either uninfected or only lightly infected. The lower infected crown is pruned away. Douglas-fir benefits even more from pruning of brooms.

**Combination Treatments**

In many dwarf mistletoe-infected stands, a combination of control treatments is used. For example, in two-storied ponderosa pine stands overstory is removed, then infected understory receives a sanitation thinning. If the understory is severely infected, it might be destroyed and the overstory partially removed. The site is then planted and as soon as the seedlings become established, the remaining overstory is removed. In some stands, severely infected spots may be destroyed, while adjacent lightly infected areas are thinned, favoring uninfected species.

In older clearcuts residual removal is combined with sanitation thinning, species manipulation, and sometimes removal of infected edge trees.

Dwarf mistletoe control treatments frequently reduce other pest damage. For example, sanitation thinning infected ponderosa pine stands makes them less susceptible to mountain pine beetle attacks and possibly Elytroderma needle blight.

**Contracts**

Practically all dwarf mistletoe control on WDNR and Forest Service lands is done by contractors.

Mistletoe contract clauses must be uncomplicated. Long, detailed descriptions of dwarf mistletoe conditions on trees were found undesirable and unreal in early control contracts. The WDNR incorporates the 0-6 Hawksworth rating system into their precommercial thinning contracts and issues walletsize cards with rules on them to aid thinners. They have found this system highly reliable. Timber sale contracts have a standard list of clauses managers can choose that will help reduce the parasites.

The Forest Service has contracted several dwarf mistletoe surveys. In all cases other stand information has been collected during the same surveys.
Post Suppression Evaluation

Quality of dwarf mistletoe suppression must be monitored. Forest pathologists continuously monitor control programs, even those which are not accomplished with dwarf mistletoe control funds. All work done under contract is examined for compliance. WDNR uses a plot system to evaluate long-term control effectiveness.

NEEDED IMPROVEMENTS

Although we feel the mistletoe control programs in Oregon and Washington are successful, they can be considerably improved.

Training.--Privately employed foresters and small landowners presently are not receiving training on dwarf mistletoes. Fortunately, it looks like this is soon to change because the Northwest Forest Pest Action Council is going to conduct insect and disease workshops. How-to-do-it publications and slide-tape programs are needed because many foresters are unable to attend training sessions. More demonstration plots should be established. Mistletoe needs to stay in the news.

Impact.--Research is needed on the ability of infected trees of all species to respond to release. This information is practically nonexistent for western hemlock and scanty for Douglas-fir. Much of the past mistletoe research was conducted in unmanaged stands--we are interested in managed stands.

Yield Programs.--Simulated yield programs such as RMYLD are not available for the Pacific Northwest. They would be helpful management tools.

Economics.--The economic benefits of dwarf mistletoe control have not been adequately investigated. We strongly suspect control has a favorable benefit/cost ratio, but with some exceptions this has not been confirmed. More economics research is needed.

Coordination.--There is a need for better coordination between forest pathologists, landscape architects, wildlife biologists, ecologists, and silviculturists. In numerous occasions these disciplines have offered conflicting advice to foresters. Landscape architects and wildlife biologists need a better understanding of mistletoe epidemiology and damage. Pathologists need to understand the other disciplines' objectives and techniques.