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by O. J. Dooling and R. G. Eder

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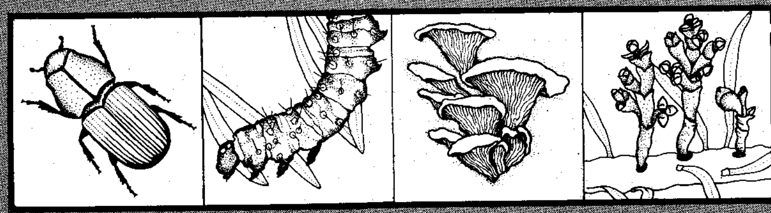

AN ASSESSMENT OF DWARF MISTLETOES IN MONTANA

by

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ABSTRACT

Dwarf mistletoes reduce tree height and diameter, and thereby cause a reduction in volume production. We estimate that volume reduction in Montana is about 33.2 MM cubic feet per year. Mistletoe effects are problems in some areas because of the demands we have placed on the Forests for goods and services. Much of their impact can be reduced to levels consistent with resource management objectives through cultural practices. The resource manager considers information on the stands, pest-caused losses, and environmental and social considerations in deciding for or against cultural control.

INTRODUCTION

The dwarf mistletoes (<u>Arceuthobium</u> spp.) and western conifers are no strangers to each other; they have probably evolved together since the Miocene period, or about 25 million years (8). Remember this any time you tend to regard the dwarf mistletoes as something foreign to forest ecosystems (7). Dwarf mistletoe effects are considered problems in some areas because of the demands we have placed on the forests for goods and services. These demands are increasing at the same time the total area of forest land is decreasing. Many billions of board feet have been harvested despite the dwarf mistletoes, but we will not get the potential benefits from the land with the present distribution and intensities of these pests. The challenge is clear: produce more and more on less and less.

WHO ARE THESE GUYS?

Dwarf mistletoes are parasitic seed plants dependent upon conifer hosts. Their modified root system is embedded in bark and wood tissues. Their aerial shoots are basically reproductive structures, although they do contain chlorophyll and manufacture some of their carbohydrates. Most of their carbohydrates and all of their water and minerals come directly from the host.

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The dwarf mistletoes are generally host specific; that is, they are usually confined to a single host species or a group of closely related species. We have four dwarf mistletoe species in Montana, of which three are economically important. These are listed in table 1.

Table 1.--Dwarf mistletoes of Montana (9)

Dwarf mistletoe species	Primary hosts	Secondary hosts
Arceuthobium douglasii Engelm.	Douglas-fir	none
A. laricis (Piper) St. John	western larch	lodgepole pine subalpine fir mountain hemlock
A. americanum Nutt. ex Engelm.	lodgepole pine	ponderosa pine
A. cyanocarpum Coulter and Nelson 1/	limber pine	whitebark pine

1/ Not economically important. Scattered distribution throughout the range of limber pine.

Distribution of the three major hosts (Douglas-fir, western larch, lodgepole pine) and their parasites is shown in figures 1, 2, and 3.

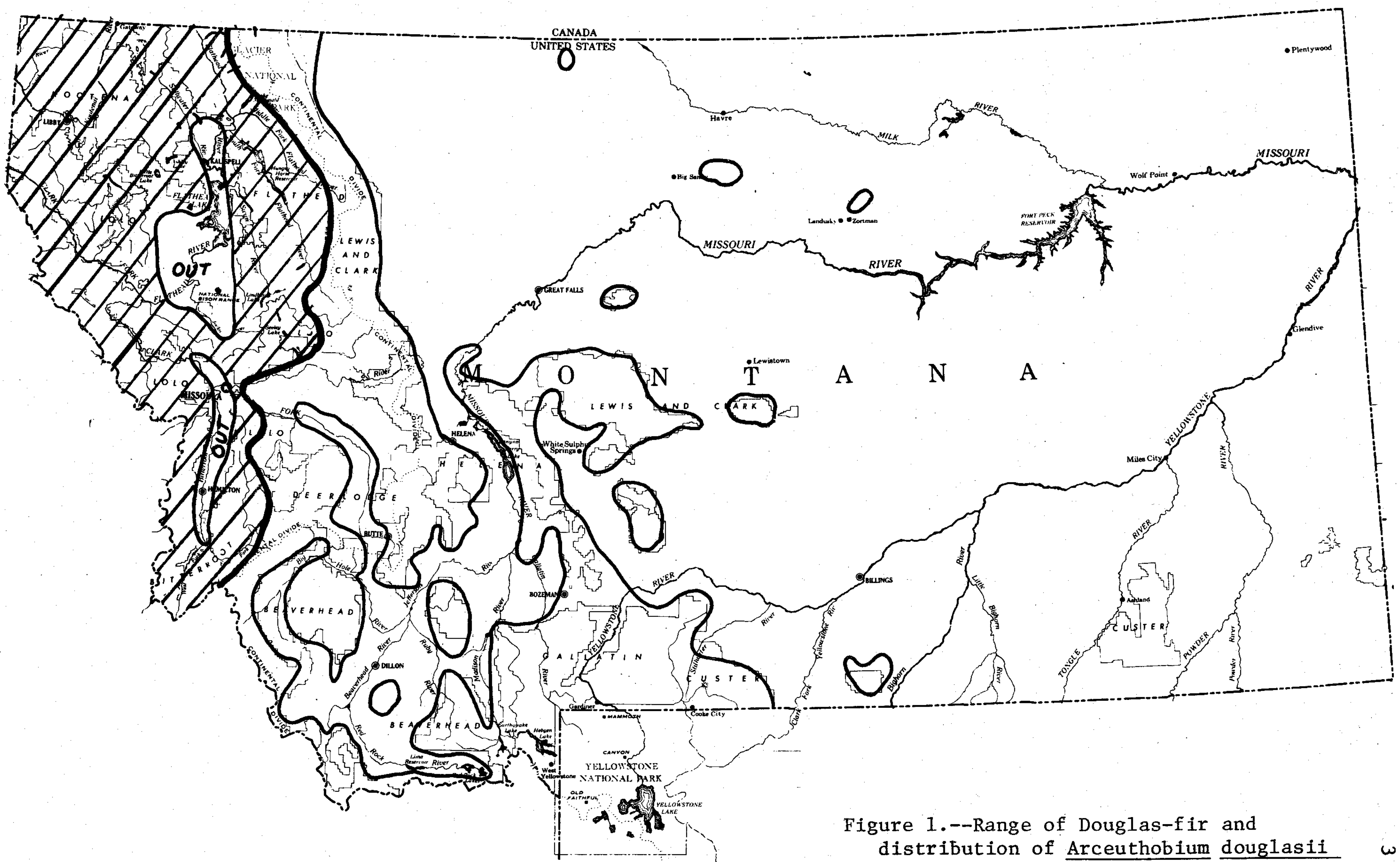

Figure 1.--Range of Douglas-fir and distribution of Arceuthobium douglasii in Montana

Range of Douglas-fir

Distribution of A. douglasii

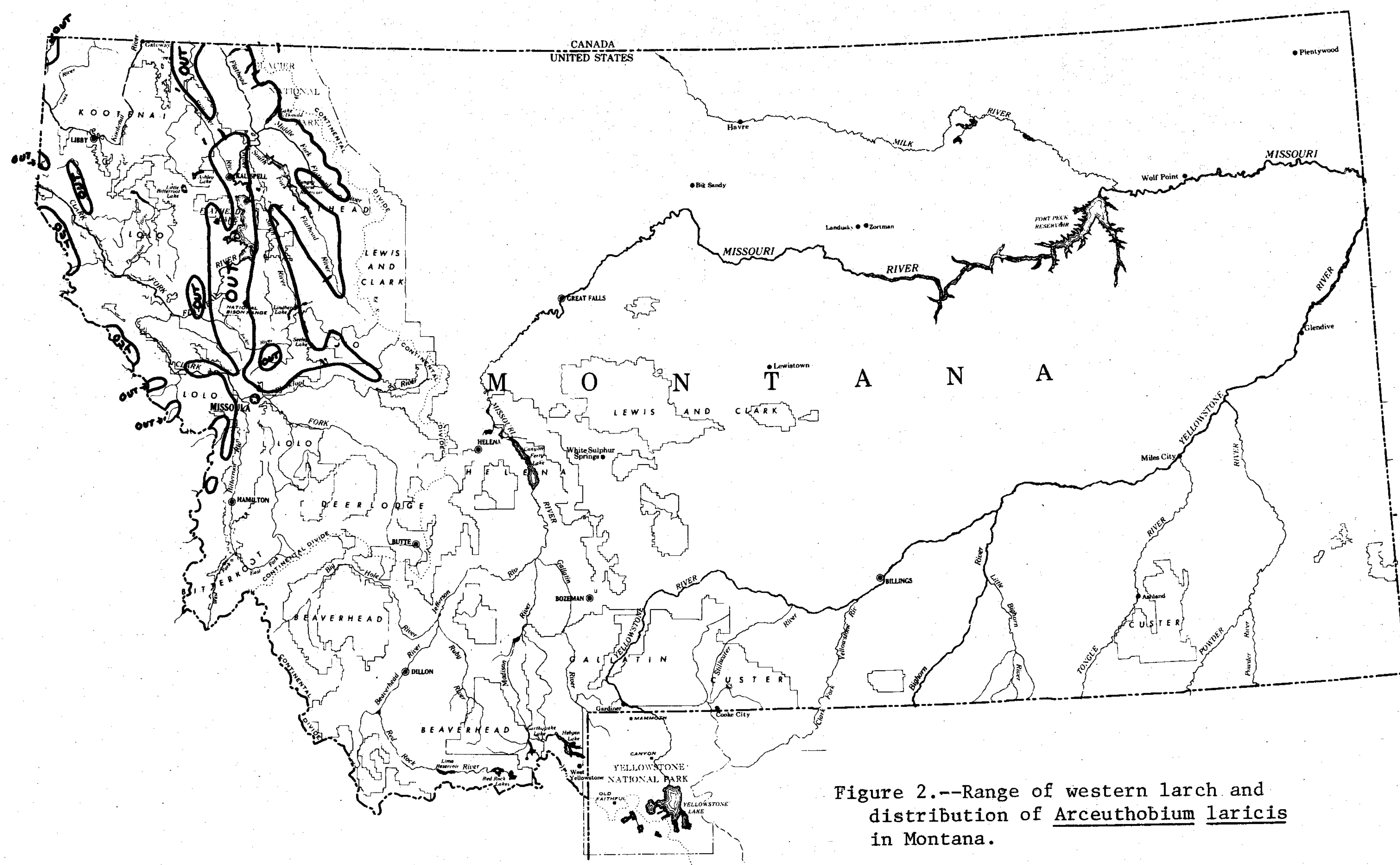

Figure 2.--Range of western larch and distribution of Arceuthobium laricis in Montana.

Range of western larch and distribution of A. laricis

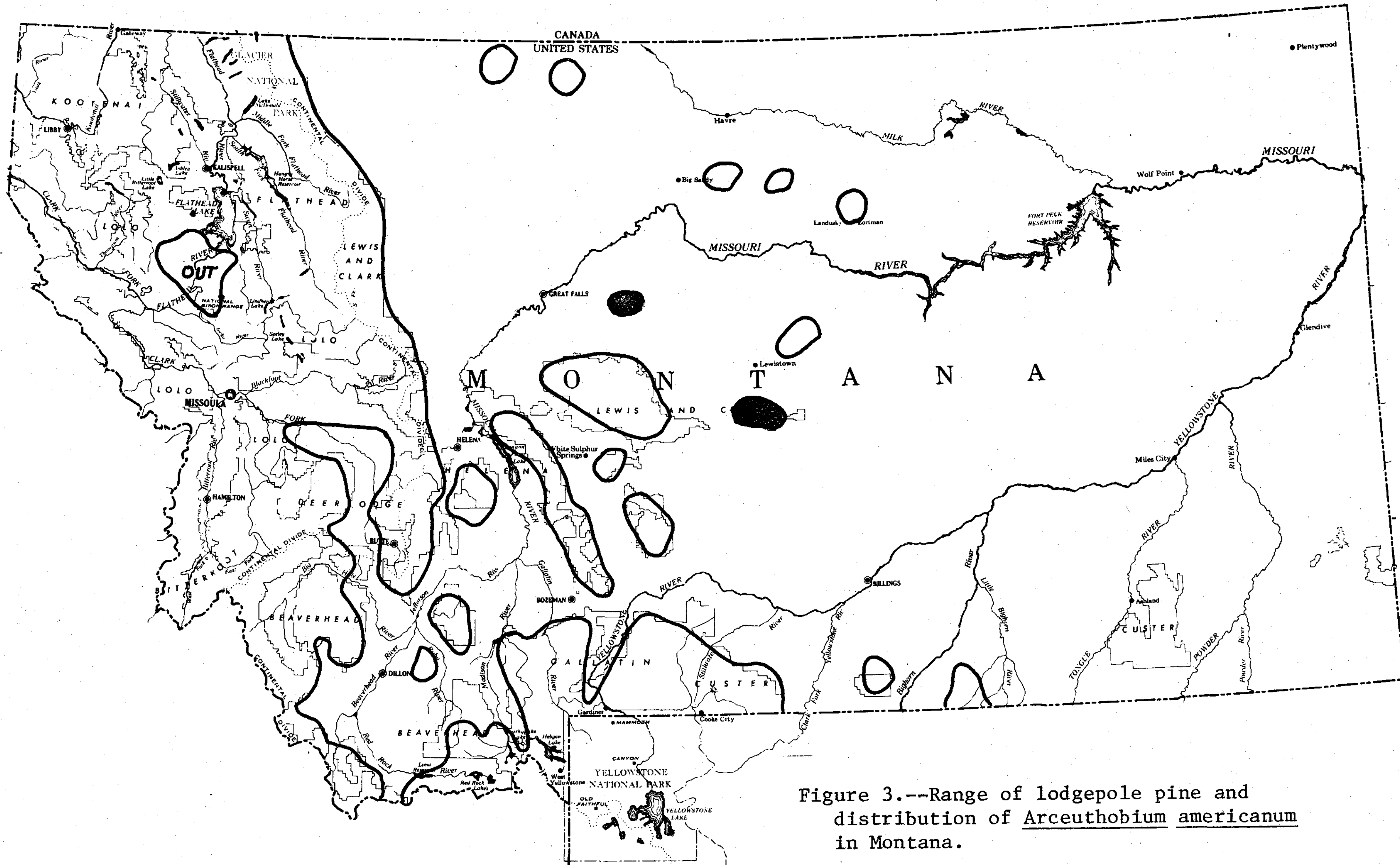

Figure 3.--Range of lodgepole pine and distribution of Arceuthobium americanum in Montana.

Range of lodgepole pine

Only areas where A. americanum does not occur.

The dwarf mistletoes are pollinated by both insects and wind (14). Seeds mature in 12 to 14 months in late summer or fall. The dwarf mistletoes have an explosive seed dispersal mechanism; the single seed is shot from the fruit at 80 to 90 feet per second (60 miles per hour) (10). Distance of seed flight depends on height of the plant above ground, angle of seed discharge, wind velocity, and stand density. Average horizontal distance of seed flight is about 20 feet, but sometimes may be as great as 100 feet (8). Long distance spread (more than 100 feet) by birds is quite limited and can probably be ignored from a practical standpoint (8). Seeds shot from the fruit are sticky, or viscous, and usually adhere to whatever they hit. Conifer needles take up a large volume of air space and are quite resilient; these two characteristics make them very effective seed catchers. Trees intercept about 40 percent of the 300,000 to 800,000 seeds per acre per year produced in an infested stand (6). Seeds stick to the needles until it rains, when the viscous coating swells and acts as a lubricant allowing seeds to slide down the needles toward the twig (16). Most infection takes place through the needle-bearing parts of the twig; older tissues are generally not susceptible. The radicle grows along the branch until it hits an obstruction, develops a mound of tissue and penetrates the branch. Many seeds are lost to insects, fungi, birds, and washing off by rain and snow (19). The ratio of new infections to dwarf mistletoe seeds produced may be as great as one in 20, but is probably closer to one in 100 (6). Shoots emerge from the bark 2 to 3 years after infection. Seed germination to mistletoe maturity requires 4 to 6 years. Individual shoots live 2 to 5 years, but the endophytic system lives as long as the host tissue and new shoots continue to arise. The endophytic system can live within the host without producing aerial shoots.

WHAT ARE THEY DOING TO US?

Effects of dwarf mistletoes on their hosts must not be confused with impacts. An effect is biological, and is always present; an impact is something we perceive as a loss, and may or may not be present. Effects of dwarf mistletoes on their hosts are of six kinds:

1. Reduction of growth rates is the most common result of dwarf mistletoe infection. Height growth is generally more seriously affected than diameter growth. Growth reduction ranges from none in lightly infected trees to severe in those heavily infected.

2. Although most mortality is indirect, dwarf mistletoe does kill trees directly. The extent of mortality depends on the host/parasite combination, stand age, and site factors.

3. Dwarf mistletoes weaken trees and may make them more susceptible to attacks by insects, especially bark beetles. In some cases, beetle populations may build up and spread to adjacent noninfected stands. Dwarf mistletoe/bark beetle interactions are quite nebulous and need more study (11, 13, 18).

4. Heavily infected trees produce both fewer seeds and seeds of lower viability (12).

5. Host wood in dwarf mistletoe bole infections is altered. Tracheids are shorter and distorted, and the wood has a much higher proportion of ray tissue than healthy wood, so strength and pulping characteristics are reduced (15). The practical significance of strength reduction is slight, since most affected wood is near the surface and usually removed in the slab (8). Infections also tend to increase knot size (8).

6. Dwarf mistletoes can have ecologic effects on stands. Wildfires have been the primary controlling factors in the past; but dwarf mistletoes also affect fire hazard conditions in infested stands because dead trees, lower limbs, and heavy brooms make trees much more flammable (8). The dwarf mistletoes also influence forest succession and changes in species composition by removing severely infected trees from competition (20).

Loss assessment surveys made in 1978, 1979, and 1980 have given us good estimates (table 2) of dwarf mistletoe-caused growth reduction on National Forest lands in Montana (1, 2, 3). The 1978 and 1979 estimates were based on a combination road/plot system described by Dooling (1). The 1980 estimates were based on data from revisiting selected inventoried subcompartments. We consider these estimates to be accurate within ±20 percent.

Table 2.--Estimates of dwarf mistletoe-caused growth reduction on Montana National Forests

National Forest	Growth reduction, Mft^3/year
Beaverhead	1,291
Bitterroot	3,757
Custer	106
Deerlodge	2,499
Flathead	1,607
Gallatin	500
Helena	814
Kootenai	3,278
Lewis & Clark	1,541
Lolo	3,063
Total	18,456

None of the data was collected on lands managed by other agencies, States, or private owners. We can make growth reduction estimates on these other lands if we assume dwarf misteltoe infestation intensities are similar to adjacent National Forest lands. We have done this for three host/parasite combinations: Douglas-fir, western larch, and lodgepole pine (table 3).

Table 3.--Estimates of dwarf mistletoe-caused growth reduction on lands of all ownerships in Montana

Landownership	Growth reduction, Mft^3/year			
	Douglas-fir	Western larch	Lodgepole pine	Total
National Forest	4,942	3,820	13,268	22,030
Other Federal	604	452	726	1,782
Industrial Private	888	1,024	355	2,267
Nonindustrial Private	1,952	1,728	2,281	5,961
State/County/ Municipal	502	374	335	1,211
Total	8,888	7,398	16,965	33,251

See appendix for a detailed breakdown of growth reduction estimates summarized in tables 2 and 3.

WHAT CAN WE DO ABOUT THEM?

Several features of the dwarf mistletoes make them ideal candidates for cultural management:

1. The dwarf mistletoes are obligate parasites; that is, they need a living host to survive. Once an infected tree or branch is cut, the mistletoe dies.

2. Dwarf mistletoes are generally host specific. Favoring a nonhost species during cutting reduces dwarf mistletoe damage.

3. Dwarf mistletoe infection from seed germination to seed production requires 4 to 6 years. This long life cycle means population buildup in trees is relatively slow.

4. Dwarf mistletoes spread slowly through stands. Seed flight is limited to no more than 100 feet from a tall isolated tree. In even-aged stands, seed flight is even more limited. The parasite spreads through an even-aged stand at about 1 to 2 feet per year.

5. Dwarf mistletoe infected trees and stands are easy to detect because signs and symptoms--dwarf mistletoe plants, swellings, and witches-brooms--are readily visible.

All aspects of the dwarf mistletoes can easily be understood by nonpathologists; practicing foresters can take advantage of these features in developing management strategies.

In April 1978, a symposium on dwarf mistletoe control was held in Berkeley, California (17). The symposium was designed to bring together current knowledge and experience in dwarf mistletoe control, with emphasis on forest management. The five sessions covered:

1. Biological and silvicultural information on which control procedures are based.

2. Methods of collecting and applying information essential to control planning and decisionmaking.

3. Mechanics of control operations and assessment of accomplishment.

4. Needs for refining and improving control techniques.

5. Integration of dwarf mistletoe control with other pest control and silvicultural requirements in stand management.

These proceedings (17) are useful as an overall reference for dwarf mistletoe management.

Management strategies are classed as either prevention or suppression. Prevention should be given high priority because it is much more efficient to prevent mistletoe establishment in uninfested stands than to remove it from infested stands or to replace severely infested stands. Prevention can be accomplished through:

1. Treatment unit layout to take advantage of natural or manmade barriers to reinfestation such as roads, streams, type changes, or meadows.

2. Removal of all infected residuals prior to artificial reforestation.

3. Using clearcutting as much as possible.

4. Leaving uninfected seed trees or shelterwood when possible. If infected trees must be left, they should be removed before regeneration becomes 3 feet tall or 10 years old.

5. Conversion to nonsusceptible species.

Suppression can be accomplished through:

1. Sanitation thinning of infested understory after removal of infested overstory.

2. Careful selection of crop trees to retain as many noninfected or lightly infected trees as possible.

3. Destruction of severely infested stands and regeneration.

4. Pruning of infected branches in recreation sites and other high-use areas to maintain tree vigor.

Dwarf mistletoe management strategies usually include a combination of several prevention and suppression activities.

SHOULD WE DO SOMETHING ABOUT THEM?

Before deciding to do something, the resource manager uses a decisionmaking process consisting of a logical sequence of steps. The process is based on information about the stands, pest-caused losses, management goals, environmental and social considerations, and control options. Freeman (4) describes the process as follows:

Step 1. Detection.--Mistletoe is detected by some means. The resource manager does not know yet if it is a problem.

Step 2. First management decision.--Someone is required to decide if mistletoe might be important in the management of the stand. If the answer is "no," the process ends and no further action is required. If the answer is "yes," proceed to step 3.

Step 3. Definition of the problem.--Biological information needed for decisionmaking is assembled: where the problem is, what host trees are affected, current losses, interrelationships with forest conditions and/or other diseases and insects that may have caused the situation, and a prediction of what will happen if no action is taken.

Step 4. Definition of management goals.--Resource management plans are the source for defining objectives and goals for a particular unit.

Step 5. Mistletoe effects on management goals.--The resource manager examines the information from steps 3 and 4 together to learn if the mistletoe damage is affecting current management goals adversely to any significant degree, and whether it may prevent achievement of future goals.

Step 6. Second management decision.--If there are no negative effects, the process ends and no further action is required. If there are negative effects, proceed to step 7.

Step 7. Management options.--After a decision that goals are adversely affected, the resource manager needs to identify options available. They may include mechanical, biological, or cultural approaches.

Step 8. Environmental and social consequences.--Consequences of taking no action are identified and arrayed with the consequences associated with each alternate management option. This step may eliminate some options from future considerations.

Step 9. Benefit/cost relationships.--Economic effects of taking no action and of taking each of the alternative options are determined. Economic values are applied to current and predicted effects of mistletoe on management goals. Human values (seeing wildlife, solitude, scenic views, etc.) must be identified and weighed by the decisionmaker.

Step 10. Comparison of alternatives.--The resource manager compares the biological, environmental, social, and economic consequences of taking no action and of taking each of the alternative actions that were identified.

Step 11. Third management decision.--After comparing various alternative actions and the consequences of each, the resource manager makes a decision. The decision may be no action, or a combination of alternatives previously identified.

Step 12. Integration of mistletoe management with resource management programs.--The resource manager plans the meshing of mistletoe activities into the program of work in order to reach the objectives effectively, efficiently, and with as little disruption of other resource management activities as possible. Because the planned action could clash with other pest management programs in the same area, a pest management specialist should assist the resource manager in planning implementation.

Step 13. Implementation, including post treatment evaluation.--Planning and decisionmaking processes should lead to action. The post treatment evaluation determines whether objectives were met, and includes the results of monitoring activities that were part of the project.

The process may look complicated, but it is quite simple in actual practice. Dwarf mistletoe management is part of forest management, and prevention and suppression are integral parts of the silvicultural prescription.

Dwarf mistletoe considerations reduce to:

1. Are they present?

2. Are they affecting present or potential management goals?

3. What are the management alternatives?

4. Which alternatives are cost-effective, will accomplish management goals, and protect environmental values?

5. Incorporate selected alternatives into the prescription.

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APPENDIX

Tables A through E show detailed breakdowns of volume losses due to dwarf mistletoes by host species and location. These tables are based on field data collected in 1978, 1979, and 1980 (1, 2, 3).

Table A. Estimates of dwarf mistletoe-caused growth reduction on Montana National Forests

National Forest	Tree spp 1/	M acres comm. type 2/	Infested		Growth reduction		
			%	M acres	ft^3/ac/ year	Mft^3/ year	Total Mft^3
Beaverhead	LP	406.5	52.4	213.0	6.1	1,291	1,291
Bitterroot	DF	377.0	43.2	162.9	20.0	3,258	
	WL	4.0	40.0	1.6	20.0	32	
	LP	133.4	44.3	59.1	7.9	467	3,757
Custer	LP	42.4	28.2	12.0	8.8	106	106
Deerlodge	LP	482.7	46.6	224.9	11.1	2,499	2,499
Flathead	DF	219.0	0.7	1.5	20.0	30	
	WL	138.8	33.7	46.8	20.0	936	
	LP	228.0	18.4	41.9	15.3	641	1,607
Gallatin	LP	156.6	42.0	65.8	7.6	500	500
Helena	LP	249.9	35.4	88.5	9.2	814	814
Kootenai	DF	448.7	1.4	6.3	20.0	126	
	WL	294.8	15.3	45.1	20.0	902	
	LP	540.4	22.5	121.6	18.5	2,250	3,278
Lewis & Clark	LP	421.1	36.6	154.1	10.0	1,541	1,541
Lolo	DF	610.0	17.4	106.1	20.0	2,122	
	WL	40.0	30.0	12.0	20.0	240	
	LP	449.4	22.6	101.6	6.9	701	3,063
TOTAL		5,242.7		1,464.8			18,456

1/ Tree species: DF = Douglas-fir, WL = western larch, LP = lodgepole pine.

2/ Acres of commercial type from land status records.

Table B.--Estimates of dwarf mistletoe-caused growth reduction in Douglas-fir on lands of all ownerships in Montana. 1/

Landownership	M acres comm. type 2/	Percent infested	M acres infested	Growth reduction	
				ft^3/ac/yr	Annual Mft^3
National Forest	1,573.7	15.7	247.1	20	4,942
Other Federal	192.5	15.7	30.2	20	604
Indus. Private	283.1	15.7	44.4	20	888
Nonind. Private	621.9	15.7	97.6	20	1,952
State/County/ Municipal	160.1	15.7	25.1	20	502
TOTAL	2,831.3	-	444.4	-	8,888

1/ See range map (figure 1). Douglas-fir dwarf mistletoe does not occur east of a north-south line about 25 miles east of Missoula.

2/ From Green and Setzer (5).

Table C.--Estimates of dwarf mistletoe-caused growth reduction in western larch on lands of all ownerships in Montana. 1/

Landownership	M acres comm. type 2/	Percent infested	M acres infested	Growth reduction	
				ft^3/ac/yr	Annual Mft^3
National Forest	641.1	29.8	191.0	20	3,820
Other Federal	75.7	29.8	22.6	20	452
Indus. Private	172.0	29.8	51.2	20	1,024
Nonind. Private	289.9	29.8	86.4	20	1,728
State/County/ Municipal	62.9	29.8	18.7	20	374
TOTAL	1,241.6	-	369.9	-	7,398

1/ See range map (figure 2). Western larch does not occur east of the Continental Divide.

2/ From Green and Setzer (5).

Table D.--Estimates of dwarf mistletoe-caused growth reduction in lodgepole pine on lands of all ownerships in eastern Montana. 1/

Landownership	M acres comm. type 2/	Percent infested	M acres infested	Growth reduction ft^3/ac/yr	Growth reduction Annual Mft^3
National Forest	1,712.5	40.2	688.4	9.3	6,402.1
Other Federal	105.7	40.2	42.5	9.3	395.2
Indus. Private	2.0	40.2	0.8	9.3	7.4
Nonind. Private	306.5	40.2	123.2	9.3	1,145.8
State/County/ Municipal	16.1	40.2	6.5	9.3	60.4
TOTAL	2,142.8	-	861.4	-	8,010.9

1/ Infestation levels and growth reduction differs between eastern and western Montana and were calculated separately.

2/ From Green and Setzer (5).

Table E.--Estimates of dwarf mistletoe-caused growth reduction in lodgepole pine on lands of all ownerships in western Montana. 1/

Landownership	M acres comm. type 2/	Percent infested	M acres infested	Growth reduction ft^3/ac/yr	Growth reduction Annual Mft^3
National Forest	2,109.2	26.9	567.4	12.1	6,865.5
Other Federal	101.5	26.9	27.3	12.1	330.3
Indus. Private	106.7	26.9	28.7	12.1	347.3
Nonind. Private	348.8	26.9	93.8	12.1	1,135.0
State/County/ Municipal	84.4	26.9	22.7	12.1	274.7
TOTAL	2,750.6	-	739.9	-	8,952.8

1/ Infestation levels and growth reduction differs between eastern and western Montana and were calculated separately.

2/ From Green and Setzer (5).