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EASTERN SPRUCE DWARF MISTLETOE

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Description

Eastern spruce dwarf mistletoe *(Arceuthobium pusillum)* is a parasitic flowering plant that causes the most serious disease of black spruce *(Picea mariana)* throughout its range. The parasite occurs in the Canadian provinces of Saskatchewan, Manitoba, Ontario, Quebec, New Brunswick, Nova Scotia, Prince Edward Island, and Newfoundland; in the Lake States of Minnesota, Wisconsin, and Michigan; and the Northeastern states of New York, Pennsylvania, Vermont, New Hampshire, and Maine. (Figure 1). The eastern spruce dwarf mistletoe is rarely found in Rhode Island, Connecticut, New Jersey, and Massachusetts.

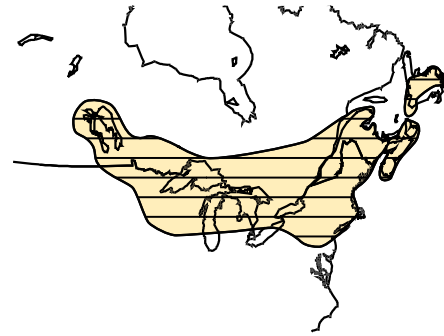

Figure 1. *Distribution of Arceuthobium pusillum (from Hawksworth and Wiens 1996).*

Arceuthobium pusillum is most damaging in black spruce stands. Black spruce is a valuable species used in the manufacture of high-quality paper. Primarily a lowland species, black spruce is often the only commercially important species that can grow on those sites. Therefore, it is important to protect black spruce from dwarf mistletoe infection. In an aerial survey of important spruce-producing forests in northern Minnesota, Anderson (1949) conservatively estimated that 3-11% of the land was out of production due to

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eastern spruce dwarf mistletoe. Although white spruce *(Picea glauca)* and red spruce *(Picea rubens)* are also highly susceptible to this parasite, eastern dwarf mistletoe is not as common on these trees, perhaps because they rarely occur in pure stands. In the United States white spruce is frequently infected along the coast of Maine and on the north shore of Lake Michigan. Red spruce is commonly infected in old growth forests in New York, Vermont, New Hampshire, and Maine. Other hosts include eastern larch *(Larix laricina),* jack pine *(Pinus banksiana),* eastern white pine *(Pinus strobus),* red pine *(Pinus resinosa),* balsam fir *(Abies balsamea)*, and blue spruce *(Picea pungens),* but these hosts are infected only when growing near other infected species of spruce.

Figure 2. *Flowers on staminate (male; top) and pistillate (female; bottom)*

Figure 3. *Basal cups remaining after aerial shoots are shed.*

Life History

Dwarf mistletoes are small, seed-bearing, parasitic plants. Eastern dwarf mistletoe has green to brown external (aerial) shoots, usually no secondary branching, and leaves reduced in size to small scales. The shoots are perennial, usually about 0.4 -1.0 inches (1-2.5 cm) long. The major function of aerial shoots is reproduction. Male and female flowers are small and produced on separate plants (Figure 2). Flowering takes place from late March until early June, peaking in April and May. Insects and wind are involved in pollination of female flowers. Male aerial shoots are shed soon after flowering, female shoots are shed after they disperse their seeds. Basal cups remain on the portions of branches where aerial shoots had formed (Figure 3).

Dwarf mistletoe plants contain chlorophyll so they produce some photosynthate, but they obtain most of their nutrients from the living tissues of the host through what is called the endophytic system. This root-like network consists of cortical strands growing within the bark and sinkers within the wood. The

Figure 4. *Mature fruits (berries) on a pistillate plant.*

endophytic system lives as long as adjacent host tissues are alive.

Fruits mature in August or September of the same year they were pollinated. Each mature fruit contains one seed about 0.1 inch (3 mm) in length (Figure 4). Seeds are discharged explosively from ripe fruits in August and September. They may travel as far as 55 feet (16.5 m), but most land within 10-15 feet (3-5 m) of the disseminating shoot. A sticky seed coating called viscin enables seeds to stick to objects they strike. Foliage is the most common receiving surface. Seeds also can stick to the bodies of birds and squirrels as they forage in infected trees. Animals can inadvertently carry seeds to trees farther away than by natural discharge, potentially starting new infection centers. Viscin, when first moistened by rains, acts as a lubricant. Seeds slide down and either fall off needles or become lodged on bark at the base of needles (Figure 5). Seeds are fastened in place when the viscin dries and they overwinter in a dormant state. Many seeds are destroyed by insects and fungi or dislodged by rain and snow, so only a small proportion of the those dispersed actually survive and give rise to new plants.

Figure 5. *Dwarf mistletoe seed attached to black spruce needles with viscin threads.*

Figure 6. *Germinating seed of Arceuthobium pusillum with its characteristic red radicle (arrow).*

Seeds germinate in the spring. A structure called a radicle emerges from a germinating seed and grows along the bark surface, and penetrates the host tissue (Figure 6). 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. For two or more years, these infections are quiescent, or latent, and there are no symptoms. The first symptom is a swelling at the point of infection. Buds proliferate

Figure 7. *Epinastic effect in infected tissue (left image). Apical dominance is disrupted.*

Figure 8. *Dwarf mistletoe infected branches have longer internodes (left image) than uninfected tissue in vigorous trees.*

Figure 9. *Developing witches' broom. Note the orange discoloration of the bark of infected tissue.*

at this point, giving rise to a witches' broom, a compact mass of branches and twigs. The apical dominance of infected tissue is released, and the branches often exhibit an epinastic effect (Figure 7). If the tree is vigorous, the infected tissue may have longer internodes than uninfected tissue (Figure 8). Initial growth of the witches' broom may be quite vigorous (Figure 9). Aerial shoots typically appear 4 years after infection, and these produce flowers and fruits in their fifth year. Thus, plants need at least 5 years to complete their life cycle from initial establishment to dissemination of the first seed crop. Many successive crops of aerial shoots may be produced from the established endophytic system.

Symptoms and Signs of Infection

Witches' brooms are the most apparent symptom of dwarf mistletoe infection on spruce (Figure 10). They live as long as the host remains

Figure 10. *Large witches' brooms on infected trees. Note the thin upper crowns of these declining trees.*

alive and may reach 3-10 feet (1-3 m) in diameter. Branches in these brooms may have several mistletoe plants on them. Uninfected tissues decline first, until nearly all the foliage is contained in the witches' brooms, and the tree is near death. The upper crown often dies first, so severely infected trees usually have dead tops. After a tree dies and loses its needles, basal cups on branches allow observers to distinguish mistletoe brooms from those associated with spruce broom rust *(Chrysomyxa arctostaphyli).*

Spread and Intensification

While many factors influence tree-to-tree spread of eastern spruce dwarf mistletoe, these are not terribly important because the trees are killed so quickly. The parasite spreads about 2.4 feet per year, as measured on the ground between the boles of infected trees. The spread rate through a stand, as indicated by the enlargement of mortality centers, is almost double this at 4.7 feet per year. While we might expect spread rates in very dense stands to be less than in more open stands, the rapid mortality of infected trees negates any such effects. 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 with seeds on their bodies can rub them off onto susceptible trees, creating new mortality centers. The 6-class dwarf mistletoe rating (DMR) system in common use in the western U.S. is not useful for quantifying intensity of infection in stands of black and white spruce. Dwarf mistletoe kills these trees so quickly, often within 15 years, that there is little benefit to rating disease intensity.

Impacts

Damage to spruce due to mistletoe infection includes increased mortality, reduced growth rates and loss of vigor, lowered timber quality, reduced cone and seed production, 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, defense, and reproduction. Dwarf mistletoe is the major cause of reduced stocking in the black spruce forest type. In severely infested areas, stocking levels are so low that a commercial harvest is impossible. Dwarf mistletoe kills young spruce saplings, which also contributes to reduced stocking.

Weakened trees are more susceptible to drought and attack by insects and fungi. Black spruce growing on organic sites are not windfirm. Where the stand canopy has been opened by mortality caused by dwarf mistletoe, large losses due to windthrow can occur.

Dwarf mistletoes are a functional component of many forest ecosystems, having intrinsic value as individual species and as disturbance agents, influencing both the structure and function of forest communities. In areas where wildlife and plant diversity or aesthetic values are more important, allowing a dwarf mistletoe

infestation to continue may be appropriate. In other areas where timber production or developed recreation is the primary goal, direct control of dwarf mistletoes may be warranted.

Management

Effective management of mistletoe-infested black spruce stands requires eradication of the parasite because *A. pusillum* kills black spruce very quickly, creating mortality centers in a stand. The mortality center continues to enlarge during rotation, ultimately removing significant areas of the stand from production. In stands managed for timber, the mortality caused by dwarf mistletoe is almost always unacceptable. To prevent these losses, the mistletoe should be eradicated from regenerating stands. Volume losses and area out of production can be projected using DMLOSS, which has recently been modified to work with a geographic information system (Table 1). Any treatment that kills all trees surviving on the site, infected or not (because trees may be infected without showing symptoms), will eliminate dwarf mistletoe. Prescribed burning the slash remaining after logging can eliminate residual black spruce. In addition to consuming or scorching residual trees, fire also favors sphagnum mosses, which provide an optimal seed bed for black spruce. However, black spruce stand are commonly harvested using full tree and tree length logging systems. These logging methods rarely yield the aerial slash necessary to carry a fire of sufficient intensity to kill residual trees. Harvesting equipment, if not restricted by deep snow, shallow frost, or both, can kill the residuals, and eliminate dwarf mistletoe in the regenerating stand. Where residual trees survive harvesting, additional measures are required. Dispatching crews to cut residuals with chain saws or brush saws has not been effective, perhaps because only infected trees were cut, and "apparently mistletoe-free" trees were infected. Sodium trichloroacetate (TCA) can effectively kill black spruce at a reasonable cost, without affecting the

Table 1. *DMLOSS projection of losses in a 15-hectare infested black spruce stand. This stand regenerated with 16 infected trees per acre. Treatment area includes a 20-m buffer around the infested area.*

Stand Age	Infested area (ha)	Stand volume without dwarf mistletoe (m^3)	Stand volume with dwarf mistletoe (m^3)	Stand volume lost (m^3)	Volume lost (%)	Treatment area (ha)
32	0.3					3.1
42	1.0	1,160	1,127	33	3	4.0
52	1.9	1,247	1,157	91	7	6.1
62	3.1	1,321	1,140	181	14	7.5
72	4.4	1,396	1,090	305	22	8.8
82	5.7	1,466	1,019	447	30	9.9

sphagnum moss seedbed or germinating spruce seeds. Regardless of the method, all residual black spruce must be killed to ensure that the regenerating stand is free of dwarf mistletoe. Mechanical treatments such as shearing or using a hydroaxe may be used to eliminate residual spruce, but cost, access, and ability to move on the site during most of the year can limit their effectiveness.

Leaving even 16 infected trees per acre after harvest has allowed dwarf mistletoe to increase and cause serious losses in the regenerated stand (Table 1). Regardless of how residuals on the site are eliminated, treatment block boundaries must be established in mistletoe-free areas. Harvesting should extend at least 2 chains (40 m) beyond obvious infection to ensure that all latent infections are removed. If a dwarf mistletoe-free perimeter cannot be established in regenerating stands, an area 20-40 m wide adjacent to the infestation should be maintained free of host plants or regenerated with a less susceptible species such as eastern larch. A buffer of resistant species will provide a barrier to dwarf mistletoe invasion of the regenerating stand.

Assistance

Resource managers and forest landowners can get more information about the identification and management of black spruce dwarf mistletoe by contacting their local state forestry office, or their regional USDA Forest Service, Forest Health Protection (FHP) office.

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