LAND MANAGEMENT HANDBOOK

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Dwarf Mistletoe Management in British Columbia

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David Rusch, Harry Kope, Michael Murray, Jewel Yurkewich, and Stefan Zeglen

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ABSTRACT

Dwarf mistletoes are parasitic seed plants that require living hosts to survive. They are a natural and important part of many forest ecosystems. From a timber management perspective, dwarf mistletoes can increase tree mortality and reduce tree growth and wood quality. Forest practices play an important role in determining the extent of these negative effects in managed stands. Removal of susceptible host trees through harvesting and eradication of susceptible natural regeneration is the best way to reduce future losses from dwarf mistletoes. Partial harvesting should be avoided in areas with high levels of dwarf mistletoe. However, where partial harvesting is required to meet other resource management objectives, specific measures to reduce future effects from dwarf mistletoes can still be implemented. Possible effects of climate change on dwarf mistletoe are also discussed in this report.

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1 INTRODUCTION

Dwarf mistletoes are parasitic seed plants that require living hosts to survive. They are a natural and important part of many ecosystems in British Columbia. From a timber perspective, dwarf mistletoes can increase tree mortality and reduce tree growth and wood quality. Forest managers play an important role in determining the extent of these negative effects in managed stands. The purpose of this document is to help forest managers mitigate the risk of dwarf mistletoes on forest management objectives.

Beneficial Effects of Dwarf Mistletoes

Dwarf mistletoe brooms provide important foraging and nesting habitat for a number of important species of birds, small mammals, and invertebrates. Two species of hairstreak butterfly (*Callophrys johnsoni* and *C. spinetorum*) feed exclusively on dwarf mistletoe shoots.

2 DWARF MISTLETOE SPECIES AND HOSTS

There are four species of dwarf mistletoe in British Columbia (Table 1), and each has a primary conifer host (Table 2). Secondary hosts are species that can sometimes be infected when they grow near infected primary hosts. Conifer trees not listed in Table 2 as primary or secondary hosts for each dwarf mistletoe species are either immune or rarely infected, and are potentially good candidates for regenerating stands where complete eradication of dwarf mistletoe–infected hosts is neither possible nor desirable.

Unlike the other species of dwarf mistletoe that have branches in a single plane like a fan, lodgepole pine dwarf mistletoe has whorled branches coming off in all directions. This can be an important distinguishing feature in those rare instances where lodgepole pine dwarf mistletoe occurs with other species of dwarf mistletoe. The distribution of dwarf mistletoe species in British Columbia is shown in Appendix 1.

TABLE 1 *Dwarf mistletoes in British Columbia*

Common name	Subspecies (*defined by host)	Species code	Scientific name
Lodgepole pine dwarf mistletoe		DMP	*Arceuthobium americanum*
Hemlock dwarf mistletoe	*on western hemlock	DMH	*Arceuthobium tsugense* subsp. *tsugense*
	*on shore pine	DMH	*Arceuthobium tsugense* subsp. *contorta*
	*on mountain hemlock	DMH	*Arceuthobium tsugense* subsp. *mertensiana*
Larch dwarf mistletoe		DML	*Arceuthobium laricis*
Douglas-fir dwarf mistletoe		DMF	*Arceuthobium douglasii*

TABLE 2 *Primary and secondary hosts of dwarf mistletoes in British Columbia*

Common name	Subspecies (*defined by host)	Primary host(s)	Secondary host(s)
Lodgepole pine dwarf mistletoe		Lodgepole pine	Ponderosa pine, whitebark pine, limber pine
Hemlock dwarf mistletoe	*on western hemlock	Western hemlock	Amabilis fir, mountain hemlock
	*on shore pine	Shore pine	Western hemlock, lodgepole pine
	*on mountain hemlock	Mountain hemlock, amabilis fir, subalpine fir	Whitebark pine, western white pine
Larch dwarf mistletoe		Western larch	Lodgepole pine, western white pine, grand fir
Douglas-fir dwarf mistletoe		Douglas-fir	

Dwarf mistletoe is spread by seeds that are released when water pressure inside the surrounding berry (Figure 1) builds to a high enough level to forcibly discharge the seeds at speeds of nearly 24 m/s or 86 km/h (Hinds and Hawksworth 1965). The distance that the seed travels depends on the height of release, direction of discharge, and probability that the seed will be intercepted by needles or branches. Seeds released from overhead seed sources can travel horizontally up to 15 m but distances of 10 m or less are more common (Geils and Hawksworth 2002).

FIGURE 1 *Female lodgepole pine dwarf mistletoe plants covered in berries.*

Dwarf mistletoe seeds are coated with a substance called viscin. It is initially sticky, which allows the seeds to stick to any needles or branches they land on. Occasionally, the seeds may become stuck to small mammals or birds that could transport them to uninfected trees. After a rain, the viscin becomes slippery, and seeds stuck to needles slide down to the branch at the base of the needle (for needles pointing up) or fall off (for needles pointing down). The viscin eventually hardens, which enables the seeds to remain firmly attached to the bark over the winter.

In the spring, seeds germinate and form a root-like structure that wedges its way through the bark, then produces fine root-like structures in the bark. Over time, the infections cause a swelling in the host branch (Figure 2). Tree buds and new growth near the swelling are often stimulated by the dwarf mistletoe, which results in abnormal clumps of branches called brooms. Once infection occurs, it takes 2–3 years for swelling to form, and another 2 years for aerial shoots and flowers to form (Figure 3). Shoots have a relatively short life span of 2–3 years (Baranyay and Smith 1972), but the parts of the plant under the bark can remain alive for as long as the tree is living. Infected branches will continue putting out new shoots as long as there is sufficient light to stimulate shoot production. When dwarf mistletoe shoots break off, they leave behind small basal cups that remain visible for many years. Each dwarf mistletoe infection produces either male or female flowers on separate plants. Pollination occurs by wind and insects (Hawksworth and Wiens 1996). Seeds take a full year to mature following fertilization and are generally expelled in late summer or early fall.

FIGURE 2 *Swelling caused by hemlock dwarf mistletoe.*

FIGURE 3 *Male lodgepole pine dwarf mistletoe shoots and flowers.*

The major effects of dwarf mistletoe on trees are reduced growth, increased mortality, and reduced wood quality. Dwarf mistletoe can affect both tree diameter and height growth. The effects increase with increasing disease severity. The severity of dwarf mistletoe is commonly measured using the Hawksworth dwarf mistletoe rating (DMR) system (sidebar). Stand severity is measured by averaging the dwarf mistletoe severity of all trees in a stand. Most dwarf mistletoe models use the Hawksworth rating system as a basis for estimating future losses. Significant growth losses occur when 50% or more of a tree's crown becomes infected (Geils and Hawksworth 2002).

Effects on wood quality include increased longitudinal shrinkage and latewood percentage, increased knot size, reduced wood strength, and changes in moisture content and specific gravity (Hawksworth and Wiens 1996). Dwarf mistletoe infections can also provide entry points for wood decay fungi (Geils and Hawksworth 2002) and can negatively affect cone and seed production (Wanner and Tinnin 1989).

Hawksworth Dwarf Mistletoe Rating (DMR)

Divide the crown equally into the top, middle, and bottom. Rate each third as:

- 0: no dwarf mistletoe present;
- 1: ≤50% of branches are infected; or
- 2: >50% of branches are infected.

Sum the values for each third = DMR.

(Appendix 10a, BCMOFLNRORD 2018)

4.1 Hemlock Dwarf Mistletoe

Studies on mature western hemlock trees with no or low hemlock dwarf mistletoe (DMH) infection levels (DMR < 3) show little growth effect, while more moderately infected trees (DMR 3 or 4) lose 20–25% of stem volume (Smith 1969; Thomson et al. 1985). Severely infected trees (DMR 5 or 6) lose about 40% of stem volume compared to lightly infected trees. Severe dwarf mistletoe infection reduces height growth, which reduces the height-to-diameter ratio, and increases stem taper. Very large stem swellings caused by hemlock dwarf mistletoe drastically reduce wood quality.

Studies of effects at the stand level have been conducted infrequently, and have relied on the extrapolation of single-tree effect data to entire stands using incidence data. In British Columbia, western hemlock dwarf mistletoe reduces mature stand growth by 4–6 m^3/ha per year (Van Sickle and Smith 1978). Furthermore, the annual growth reduction for western hemlock in coastal British Columbia is estimated at more than 1 million m^3/yr (Muir et al. 2004).

4.2 Lodgepole Pine Dwarf Mistletoe

Very few studies have examined stand effects from lodgepole pine dwarf mistletoe (DMP) infection in British Columbia. Thomson et al. (1997) estimated a volume reduction in the Nechako area of 1% for stands aged 101–120 years and 1.7% for stands older than 120 years. In the Westlake area, the authors estimated volume reductions of 2.9% for stands aged 101–120 years and 5.6% for stands > 120 years. The effect of DMP on diameter at breast height was almost twice as large for stands aged 121–150 years as for stands aged 101–120 years. Van Sickle and Smith (1978) reported volume reductions of 25–35% in stands in the Cariboo Forest District.

Based on data from Colorado, DMP severity (DMR) increases by one Hawksworth unit every 14 years (Hawksworth and Johnson 1989). Unpublished data from British Columbia suggest similar rates of increase in DMP severity. Measurable effects on growth occur when trees and stands have a DMR > 3. It generally takes stands many years to reach this level of infection. As a result of the recent mountain pine beetle (IBM) epidemic that killed many of the mature lodgepole pine throughout the Southern Interior of British Columbia, current losses from DMP are low. However, many stands killed by IBM that have regenerated back to lodgepole pine have high levels of dwarf mistletoe in the live understorey. Appendix 2 shows dwarf mistletoe incidence and DMR in Young Stand Monitoring plots in British Columbia based on 2018 data.

4.3 Larch Dwarf Mistletoe

Although larch dwarf mistletoe (DML) is common in southeastern British Columbia, no published studies are available. In the inland northwest region of the United States, larch dwarf mistletoe is considered the most important biotic cause of larch mortality (Schmitt and Hadfield 2009), yet, very little is known about spread and growth effects. Where infected overstorey trees are present, regeneration begins to become visibly infected at 7–10 years of age (Mathiasen 1998). Growth effects may be absent until regeneration is more than 20 years old (Taylor et al. 1993). Severely infected trees can suffer >50% growth loss (Beatty et al. 1997). Furthermore, infections can cause trees to form burls on the main stem, which reduce lumber quality.

4.4 Douglas-fir Dwarf Mistletoe

Infection by Douglas-fir dwarf mistletoe (DMF) alters tree form, reduces vigour and growth, reduces cone and seed production, and increases susceptibility to other diseases and insects. Lightly infected trees have few effects, but severely infected trees have 40–70% less radial growth than uninfected trees in the same stand (Shaw et al. 2018). The mortality rate of trees in dwarf mistletoe–infected Douglas-fir forests is three to four times greater than in dwarf mistletoe–free forests.

5 DWARF MISTLETOE MANAGEMENT

A detailed dwarf mistletoe assessment is recommended prior to harvesting or thinning in stands that have a high hazard for dwarf mistletoe. Appendix 3 lists dwarf mistletoe hazard by species and biogeoclimatic variant when the primary host is present.

Dwarf mistletoe plants and basal cups (Figure 4) are the most reliable signs of dwarf mistletoe infection, especially on understorey regeneration. It may be difficult to identify dwarf mistletoe on very young trees because of the delay between infection and the first appearance of shoots. Dwarf mistletoe shoots are also more difficult to see in understorey regeneration growing under low light conditions or in high-density repressed stands. Repressed stands should be carefully assessed prior to undertaking any thinning operations. In some infected stands, dwarf mistletoe brooms are relatively uncommon. In these situations, it may be necessary to use binoculars to identify dwarf mistletoe shoots in the upper crowns. Brooms can be caused by factors other than dwarf mistletoes. In lodgepole pine stands in the Cariboo Region, brooms produced by elytroderma needle cast on lodgepole pine are commonly mistaken for lodgepole pine dwarf mistletoe brooms.

Dwarf mistletoes should be identified in the site plan. Site plans should indicate the distribution of dwarf mistletoe in the block, the percentage of susceptible overstorey trees and regeneration, the incidence and severity of dwarf mistletoe, and the measures that will be taken to address dwarf mistletoe during and after harvest. It may be desirable to knock down patches of heavily infected unmerchantable or immature trees during harvesting operations in order to reduce post-harvest silviculture costs and allow for larger slash accumulations to be piled while heavy machinery is still present on site.

Hazard and Risk

Hazard is the probability of finding a particular disease in a particular area. Risk includes hazard but also takes into account proximity and abundance of the pathogen. Therefore, a site assessment is required to determine risk.

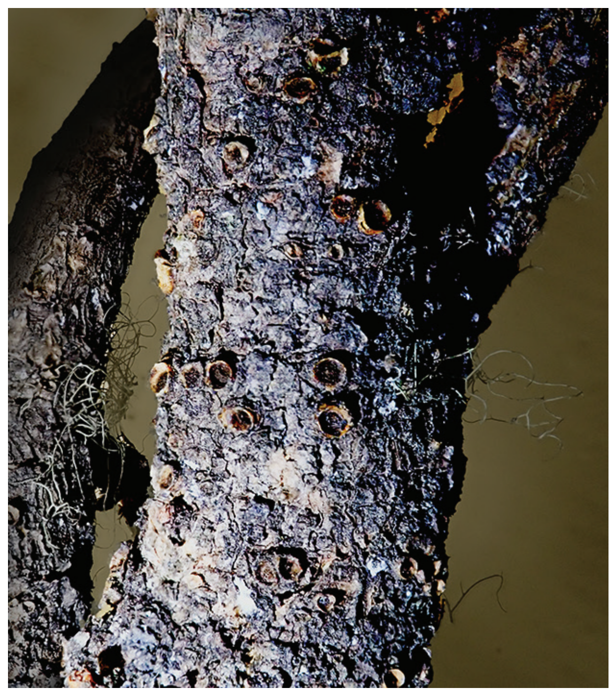

FIGURE 4 *Lodgepole pine dwarf mistletoe basal cups.*

Removal of all susceptible host trees through harvesting and eradication of susceptible natural regeneration is the best way to reduce future losses from dwarf mistletoes. In the Southern Interior, removal of lodgepole pine regeneration infected with DMP is commonly achieved after clearcut harvesting through sanitation treatments that remove all susceptible trees over a specified height. In a sanitation trial (single site) in the Dry Cool Interior Douglas-fir subzone, sanitation of trees down to 0.3 m, 1 m, and 2 m reduced the number of dwarf mistletoe infected trees by 88, 63, and 23%, respectively. Figures 5–8 show the effect of sanitation in one of the 0.3-m sanitation treatment plots, and the projected 10-year spread assuming a spread rate of 0.4 m/yr for small trees and 10 m over 10 years for overtopping trees. A sanitation height of 0.5 m is recommended for DMP and 2 m for DMH. Trees should be cut as close to the ground as possible to remove all live branches.

Promoting regeneration of non-susceptible tree species will help reduce the spread of dwarf mistletoe. Treating for dwarf mistletoe may be important even in situations where the susceptible species is not the species being managed, especially if natural regeneration may result in a susceptible species making up a significant percentage of the future stand. A good

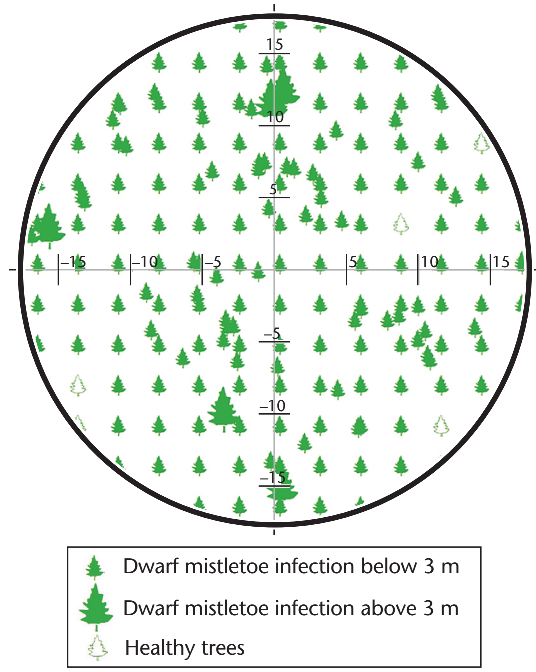

FIGURE 6 *Ten-year projection of dwarf mistletoe spread in plot shown in Figure 5 after planting 1200 stems per hectare of lodgepole pine in year 1. Spread from small dwarf mistletoe–infected trees is assumed to be 0.4 m/yr. Spread from tall trees is assumed to be 10 m over the 10-year projection.*

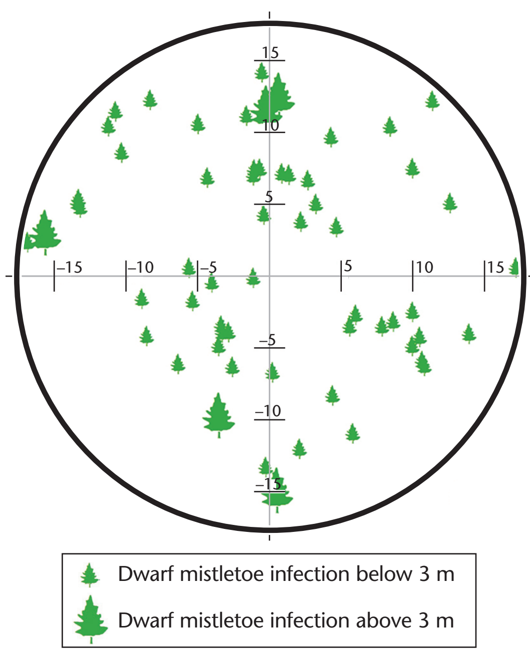

FIGURE 5 *Stem map of 0.1-ha lodgepole pine dwarf mistletoe–infected plot prior to sanitation. Small trees represent trees with an average height of 1.7 m (range 0.5–5.1 m) and DMR < 4. Large trees have an average height of 6.7 m (range 4.4–9.6 m) and DMR ≥ 4.*

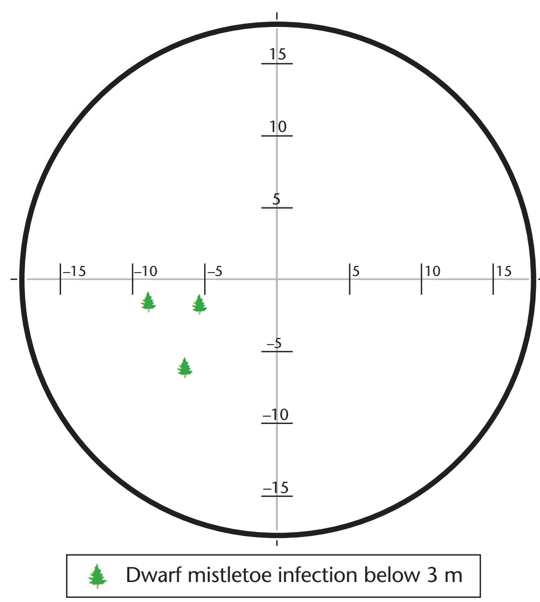

FIGURE 7 *Stem map of 0.1-ha lodgepole pine dwarf mistletoe–infected plot shown in Figure 5 after operational sanitation treatment. Trees were measured one growing season after sanitation. The prescription was to cut all trees > 0.3 m tall. The height of the three remaining trees was 32, 38, and 68 cm.*

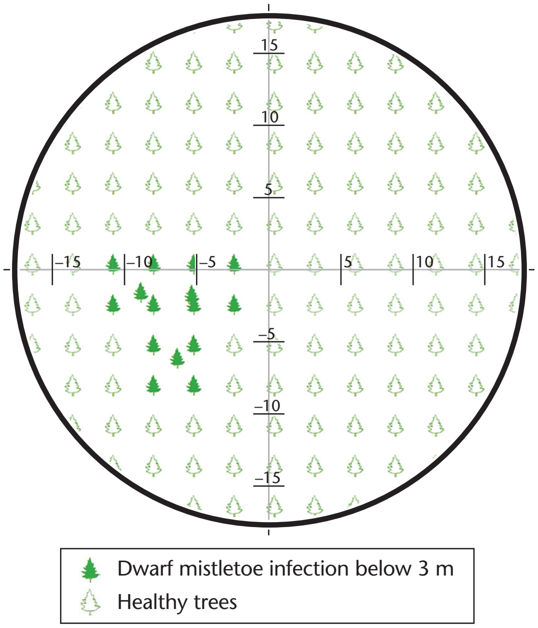

FIGURE 8 *Ten-year projection of dwarf mistletoe spread from plot shown in Figure 7 after planting 1200 stems per hectare of lodgepole pine in year 1. Spread from dwarf mistletoe–infected trees is assumed to be 0.4 m/yr.*

example of this would be natural infill of western hemlock in stands being managed for Douglas-fir or western redcedar on the coast.

When overhead seed sources are eliminated, dwarf mistletoe spread rates are typically in the range of only 0.3–1.5 m/yr, with closed canopies having reduced rates of spread relative to open canopies. The main factors that affect the rate of spread are the number of seeds produced; the probability that the seed will be intercepted by needles or branches of a susceptible host, which in turn depends on the size, density, and distribution of susceptible host trees; and the amount of light entering the stand. In dense stands there is often inadequate light for dwarf mistletoe to successfully produce shoots and seeds. Site index can also play an important role in determining the rate of spread of hemlock dwarf mistletoe in western hemlock stands. In the absence of an infected overstorey, trees on high site index sites grow faster than the upward spread of dwarf mistletoe and shade out infected branches sooner, so they cannot produce as much seed (Richardson and van der Kamp 1972).

It is critical to remove all infected overstorey and minimize the amount of dwarf mistletoe–infected edges by carefully considering the shape of the cutblock and the location of wildlife-tree patches that contain infected trees, and using natural boundaries or barriers. This includes road right-of-way fringes that are not technically part of the block, and policies that prevent harvesting up to the edges of existing roads. Very narrow strips of infected trees along road rights-of-way do little to provide screening for wildlife, and increase the risk of dwarf mistletoe spreading into the stand. Infected residual overstorey and edge trees produce abundant dwarf mistletoe seed and disperse this seed up to 15 m into the tops of surrounding susceptible understorey trees.

5.1 Partial Harvesting

Partial harvesting should be avoided in areas with high levels of dwarf mistletoe. Partial harvesting is likely to result in increased levels of dwarf mistletoe, even when steps are taken to try to minimize its future spread, including:

- favouring non-susceptible trees as leave trees
- using dwarf mistletoe–free boundaries and minimizing infected edges and reserves
- retaining only susceptible trees with a DMR < 3 if susceptible trees must be retained
- removing residuals > 2 m when DMH is present
- removing or killing any seed trees or shelterwood trees with a DMR ≥ 3 as soon as possible after regeneration becomes established
- removing severely infected trees at frequent intervals to ensure that retained trees have a DMR < 3

5.2 Dwarf Mistletoe Management for Wildlife or Recreational Values

In certain instances, management of infected stands might be desirable to fulfill resource management objectives other than timber production. Infected trees with large dwarf mistletoe brooms and some infected stands appear to be preferentially used by some animals and birds for nesting, cover, and other habitat purposes. However, any prescriptions made where these other resource management objectives are paramount should consider the expected effects of dwarf mistletoes on future stand yields.

In recreation sites or other areas, dwarf mistletoe–infested stands can be maintained or managed for certain features, such as wildlife habitat. However, hazards associated with infected trees should be considered. Dwarf mistletoe brooms can act as fuel ladders, thereby increasing the fire hazard, and large brooms are prone to breakage. Pruning can be used to remove large brooms and maintain tree vigour.

Between 1900 and 2013, the annual temperature in British Columbia increased 1.4°C. Seasonal changes in precipitation vary by region. By the end of the 21st century, average annual temperature may reach 4.5°C above the 1961–1990 average (BCMOE 2016). There are significant uncertainties in predictions about future climate, and the relationship between climate and dwarf mistletoes is poorly understood. However, climatologists predict that mean and minimum temperatures and fire severity and size will increase, and droughts will be more frequent and prolonged due to climate change. These trends are likely to have an effect on dwarf mistletoe distribution and host mortality rates.

6.1 Effect of Rising Temperatures on Dwarf Mistletoe Distribution

Cold temperatures can limit the reproductive success and range of mistletoe species (Smith and Wass 1986; Kliejunas et al. 2009). Warmer temperatures are expected to cause an increase in the range of dwarf mistletoes. In southeast Alaska, rising temperatures and reduced snowfall are predicted to allow the latitudinal and elevational expansion of western hemlock dwarf mistletoe (Barrett et al. 2012).

6.2 Dwarf Mistletoes and Fire

Fire plays a critical role in the distribution of dwarf mistletoes and severity of infection. Shaw and Agne (2017) published an extensive review on the interactions between fire and dwarf mistletoes, and compared fire and dwarf mistletoe interactions for hemlock and lodgepole pine dwarf mistletoes in Oregon and Washington. Fire frequency has been linked to lower rates of stand-level infection by lodgepole pine dwarf mistletoe (Hawksworth and Johnson 1989; Kipfmueller and Baker 1998). Prescribed burning has also been used to reduce dwarf mistletoe by killing infected branches and regeneration in the understorey (Shaw and Agne 2017). However, in fire-adapted species such as lodgepole pine, low-severity fires can result in a scattered distribution of live dwarf mistletoe–infected hosts, which can then successfully infect post-fire natural regeneration over a large area. This may be especially true in areas where lodgepole pine is present as both a climax and pioneer species (Shaw and Agne 2017).

Dwarf mistletoes affect their hosts in a number of ways that could affect fuel loading, such as causing reduced canopy base height due to the presence of dense large and persistent brooms in the lower crown, and increased branch, top, and whole-tree mortality. In lodgepole pine stands in south-central Oregon, higher dwarf mistletoe ratings were associated with lower canopy base heights but had little effect on fuel loading. Results of studies on the effects of ponderosa pine dwarf mistletoes show variable results ranging from little or no effect to increased fuel loading (Shaw and Agne 2017). The amount of crown scorch in dwarf mistletoe–infected ponderosa pine stands increases with dwarf mistletoe disease severity. Severely infected trees with moderate levels of crown scorch are less likely to recover than uninfected trees (Harrington and Hawksworth 1990).

Interactions between fire and dwarf mistletoe are likely influenced by IBM outbreaks. Turner et al. (1999) reported a higher likelihood of crown fires in lodgepole pine stands affected by IBM and lodgepole pine dwarf mistletoe. In south-central Oregon, high levels of pre-fire IBM mortality have been associated with lower fire severity and higher levels of lodgepole pine dwarf mistletoe (Shaw and Agne 2017).

6.3 Dwarf Mistletoes and Drought

Parasitic infection on its own is rarely lethal to trees. Rather, a combination of multiple stress factors on the tree host amplifies stand mortality rates. Dwarf mistletoes are known to affect water and nutrient allocation within their hosts (Geils and Hawksworth 2002), and have higher transpiration rates than their hosts, particularly during periods of water stress (Tocher et al. 1984). High mortality of dwarf mistletoe–infected branches following drought has been observed in ponderosa pine (Childs 1960). Larch dwarf mistletoe has a negative effect on tree water potential at the end of summer, but Douglas-fir dwarf mistletoe has no negative effect on water potential (Sala et al. 2001). During a prolonged drought in California, dwarf mistletoe–infected ponderosa pines died at four times the rate of non-infected trees (Page 1981). The results of these studies suggest that higher rates of mortality may occur in dwarf mistletoe–infected trees due to increased drought associated with climate change.

The provincial damage criteria (BCMOFLNRORD 2018) for dwarf mistletoes state that a tree is unacceptable (not free-growing) if:

a) any infection occurs on the stem or a live branch, or
b) a susceptible tree that is located within 10 m of an overtopping tree of the same species that is infected with dwarf mistletoe is unacceptable. An overtopping tree is a tree that is three or more times taller than the height of the tree being assessed.

Where a forest stewardship plan states that the dwarf mistletoe free-growing damage criteria do not apply when a dwarf mistletoe treatment is carried out, the plan must carefully define what is meant by a dwarf mistletoe treatment (including sanitation height).

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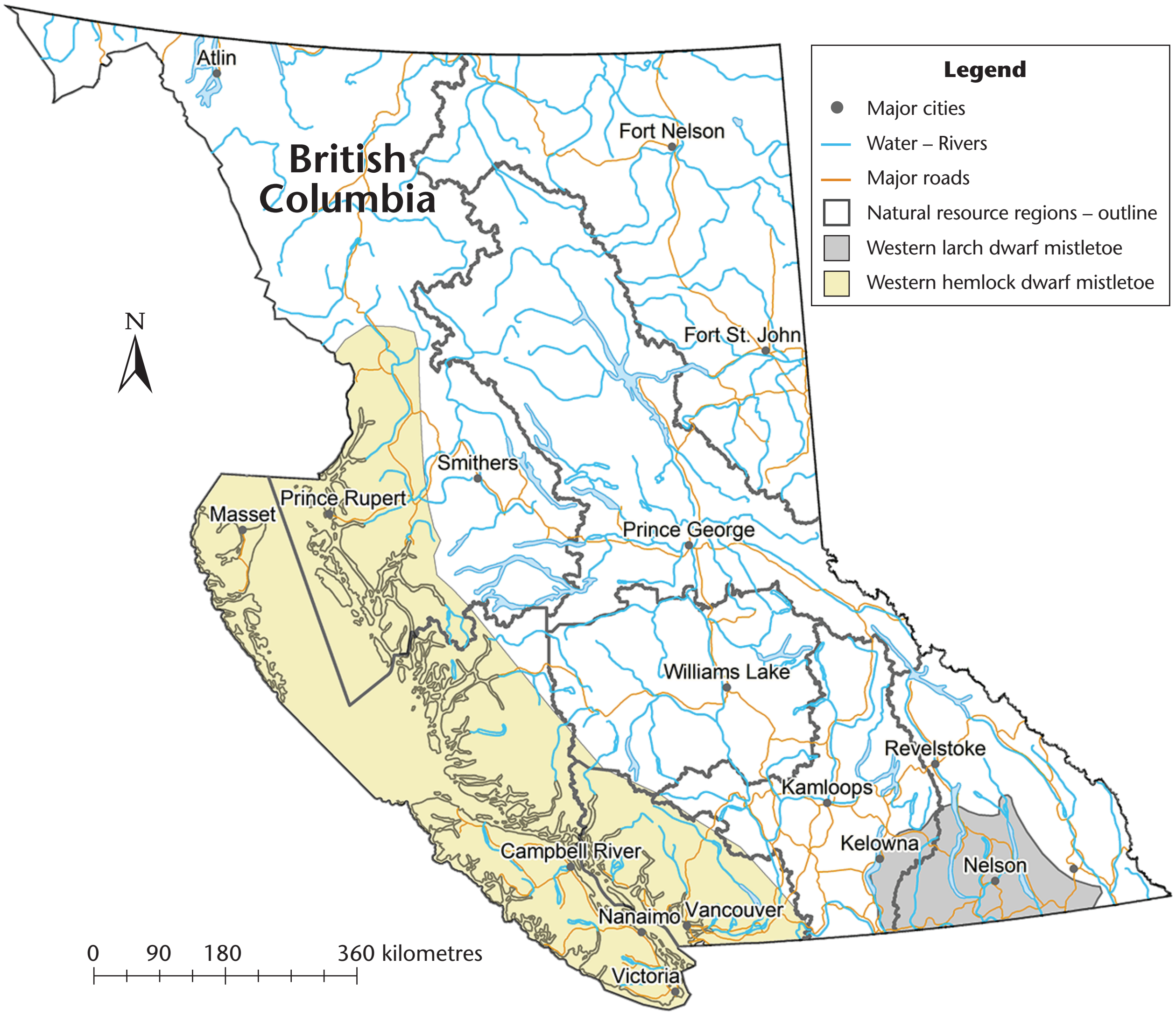
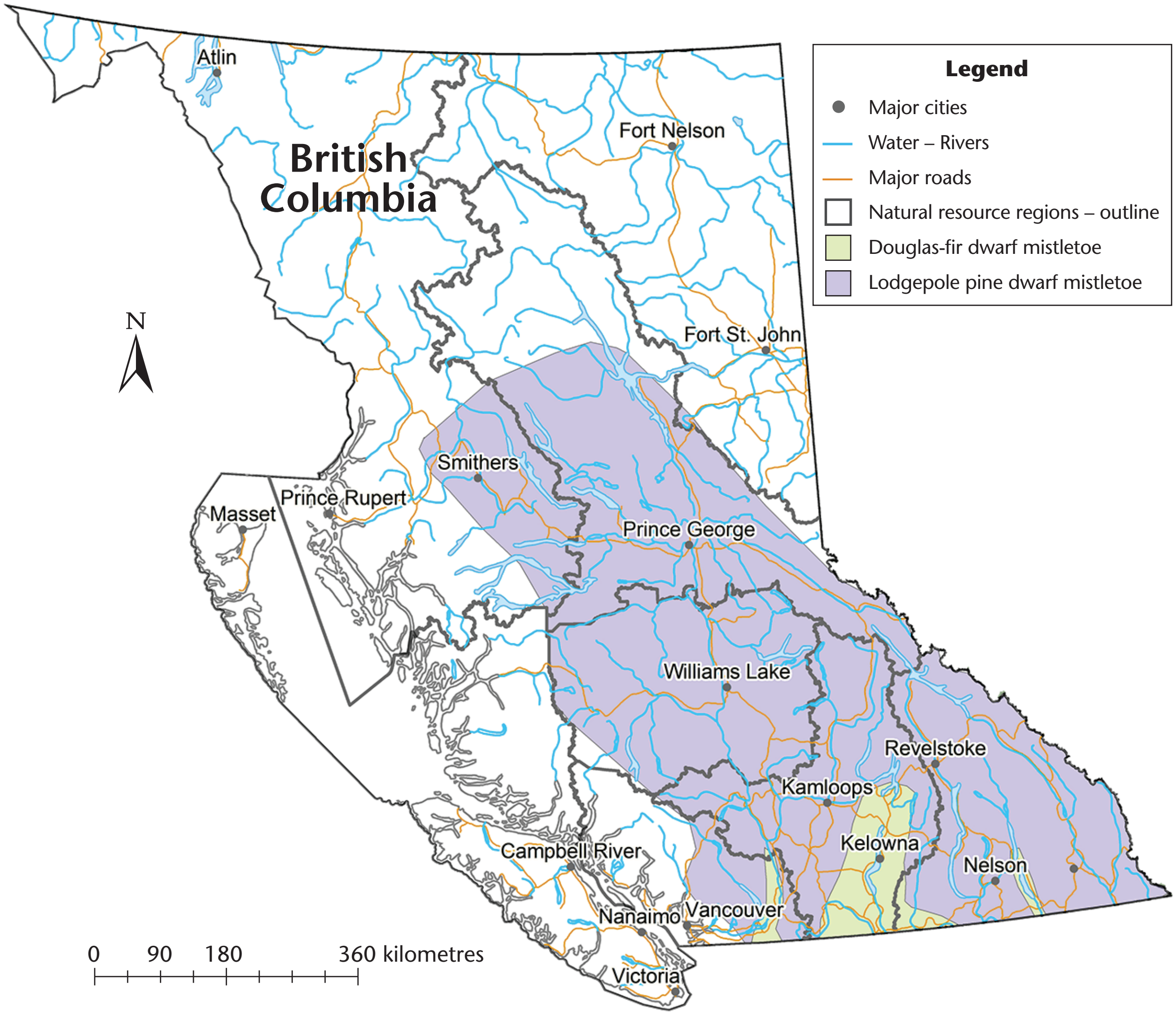

Legend
Major cities
Water – Rivers
Major roads
Natural resource regions – outline
Western larch dwarf mistletoe
Western hemlock dwarf mistletoe
British Columbia
N
Atlin
Fort Nelson
Fort St. John
Smithers
Prince Rupert
Masset
Prince George
Williams Lake
Revelstoke
Kamloops
Kelowna
Nelson
Campbell River
Nanaimo
Vancouver
Victoria
0 90 180 360 kilometres


British Columbia
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Major cities
Water – Rivers
Major roads
Natural resource regions – outline
Douglas-fir dwarf mistletoe
Lodgepole pine dwarf mistletoe
N
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Fort Nelson
Fort St. John
Smithers
Prince Rupert
Masset
Prince George
Williams Lake
Revelstoke
Kamloops
Kelowna
Nelson
Campbell River
Nanaimo
Vancouver
Victoria
0
90
180
360 kilometres

Young Stand Monitoring plots are selected by laying a grid (usually 5 × 10 km) over the national forest inventory grid (20 × 20 km). Grid intersections that overlap young stands aged 15–50 years, based on Vegetation Resource Inventory data, are selected for sampling. All trees ≥ 9 cm diameter at breast height are sampled using an 11.28-m fixed radius plot, and all trees ≥ 4 cm are sampled using a nested 5.64-m fixed radius plot. Plots are scheduled for re-measurement every 5 years. Timber Supply Areas (TSAs) most affected by mountain pine beetle are given priority for sampling. At the time of publication, only a few TSAs had been sampled more than once, and only a few coastal TSAs had been sampled. Due to the lack of sampling in coastal TSAs, hemlock dwarf mistletoe has not been included in Tables A2.1 and A2.2. The low Hawksworth stand rating values in Table A2.2 are a reflection of the young age of those stands. Modelling could be used to predict future effects in different rotation ages.

TABLE A2.1 *Number of Young Stand Monitoring plots (15–50 years) with lodgepole pine and lodgepole pine dwarf mistletoe (DMP), percent of lodgepole pine plots with lodgepole pine dwarf mistletoe, and mean incidence of dwarf mistletoe for all lodgepole pine plots by Timber Supply Area. The table is based on 2018 data.*

Timber Supply Area	Biogeoclimatic unit	Number of plots with lodgepole pine	Number of plots with DMP	Plots with DMP (%)	Mean incidence all lodgepole pine plots (%)
Merritt	IDFdk2, MSxk1	20	2	10	5.0
Quesnel	SBPS, SBS	57	4	7	0.1
Williams Lake	IDF, SBPSxc	40	9	22	6.2
100 Mile House	IDFdk3, SBPSmk	14	5	36	5.6

TABLE A2.2 *Percent of Young Stand Monitoring plots with 0–0.49, 0.5–1.49, and 1.5–2.49 Hawksworth stand dwarf mistletoe ratings (DMR). The table is based on 2018 data.*

Timber Supply Area	Biogeoclimatic unit	DMR 0–0.49 (%)	DMR 0.5–1.49 (%)	DMR 1.5–2.49 (%)
Merritt	IDFdk2, MSxk1	95	0	5.0
Quesnel[a]	SBPS, SBS	–	–	–
Williams Lake	IDF, SBPSxc	95	2.5	2.5
100 Mile House	IDFdk3, SBPSmk	95	0	5.0

a No severity data have been collected.

TABLE A3.1 *Biogeoclimatic Ecosystem Classification (BEC) units with a high hazard of dwarf mistletoe damage*

Common name	BEC zone	BEC subzone/variant
Lodgepole pine dwarf mistletoe	ESSF	dc1, dc2, dc3, dh1, dh2, dk1, dk2, mc, mk, wc1, wm, xc1, xc2, xc3, xv1, xv2
	ICH	dk, dw, mc1, mc1a, mc2, mk1, mk3, mm, mw1, mw2, mw3, vk, wk3, wk4, xw
	IDF	dk1, dk2, dk3 (very high), dk4 (very high), dm1, dm2, xh1, mw1, mw2, ww, xm, xw
	MS	dc1, dc2, dc3, dk, dm1, dm2, xk1, xk2, xk3, xv, mw1, mw2
	SBPS	dc, mc, mk, xc (very high)
	SBS	dh1, dh2, dk, dw1, dw2, dw3, mc1, mc2, mc3, mh, mk1, mk2, mm, mw, wk1, wk2, wk3
Western hemlock dwarf mistletoe	CWH	All subzones/variants
	ICH	mc1, mc1a, mc2
Western larch dwarf mistletoe	ESSF	wc1
	ICH	dw, mk1, mw1, mw2, xw
	IDF	dm1, dm2, mw1
	MS	dk, dm1
Douglas-fir dwarf mistletoe	ICH	xw
	IDF	dk1, dk2, dm1, mw1, xh1, xh2
	PP	xh1, xh2, xh3