PROVINCE OF BRITISH COLUMBIA

DWARF MISTLETOE MANAGEMENT GUIDEBOOK

Authority: Forest Practices Code of British Columbia Act; Operational Planning Regulation; Silviculture Practices Regulation

Dwarf Mistletoe Management Guidebook

Contents

Introduction

Dwarf mistletoes are parasitic seed plants affecting several coniferous tree species in forested ecosystems of North America, including British Columbia. Dwarf mistletoes are integral parts of these forested ecosystems and can have both beneficial and detrimental effects on the health, function and productivity of forests. Negative effects of dwarf mistletoes include reducing tree growth, lowering wood quality and causing mortality.

Forest harvesting, regeneration, and stand management activities can either limit or enhance the spread and intensification of dwarf mistletoes. As obligate parasites, dwarf mistletoes can be effectively controlled by removing live host trees. Spread and intensification are enhanced when dwarf mistletoe infection sources remain in and around openings or within thinned or partial cut harvested stands.

The major dwarf mistletoes covered in this guide book are:

- Lodgepole pine dwarf mistletoe (*Arceuthobium americanum*); damage code DMP*
- Western hemlock dwarf mistletoe (*A. tsugense*); damage code DMH
- Western larch dwarf mistletoe (*A. laricis*); damage code DML
- Douglas-fir dwarf mistletoe (*A. douglasii*); damage code DMF.

* For definition of damage codes, see Ministry of Forests “Damage Agent and Condition Codes” field card (FS 747).

In British Columbia, dwarf mistletoes significantly affect forests and forest resource management objectives in the following areas and forest types:

- coastal western hemlock forests
- interior lodgepole pine forests
- southern interior Douglas-fir and western larch forests.

Evaluation and suitable prescriptions for dwarf mistletoes are required in these situations.

The *Forest Practices Code of British Columbia Act* and regulations require detection and evaluation of dwarf mistletoes as part of forest management planning, prescriptions, and operations.

This guide deals with treatment and management of forest ecosystems to prevent or reduce detrimental effects of dwarf mistletoes.

Distribution of dwarf mistletoes

The following four maps (figures 1 to 4) illustrate the geographic distribution of dwarf mistletoes in British Columbia.

Note: With the exception of a few areas in the Prince Rupert Forest Region, western hemlock dwarf mistletoe occurs only in coastal, not interior, hemlock stands.

Figure 1. Lodgepole pine dwarf mistletoe (*Arceuthobium americanum*).

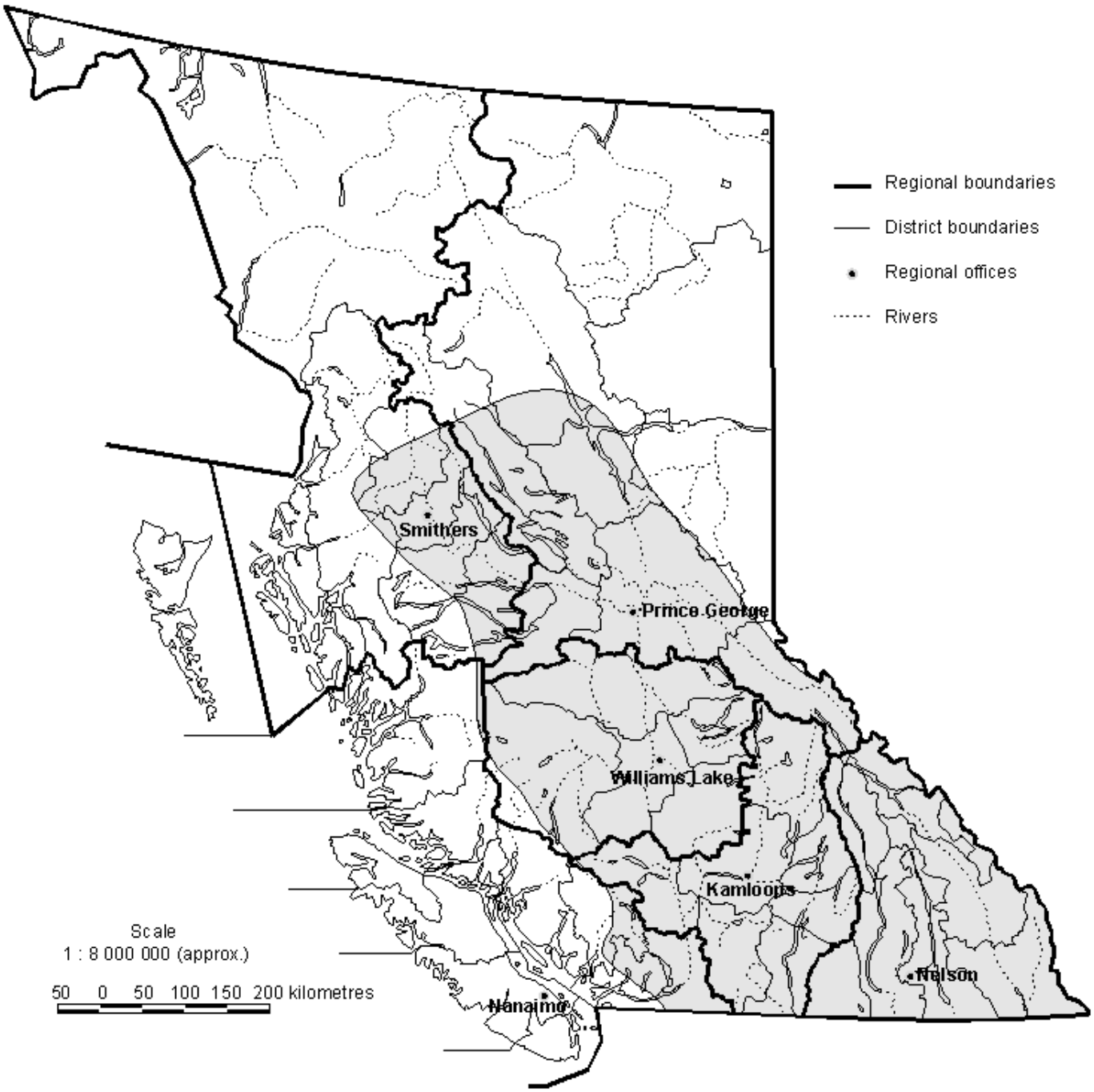


Figure 2. Western hemlock dwarf mistletoe (Arceuthobium tsugense).

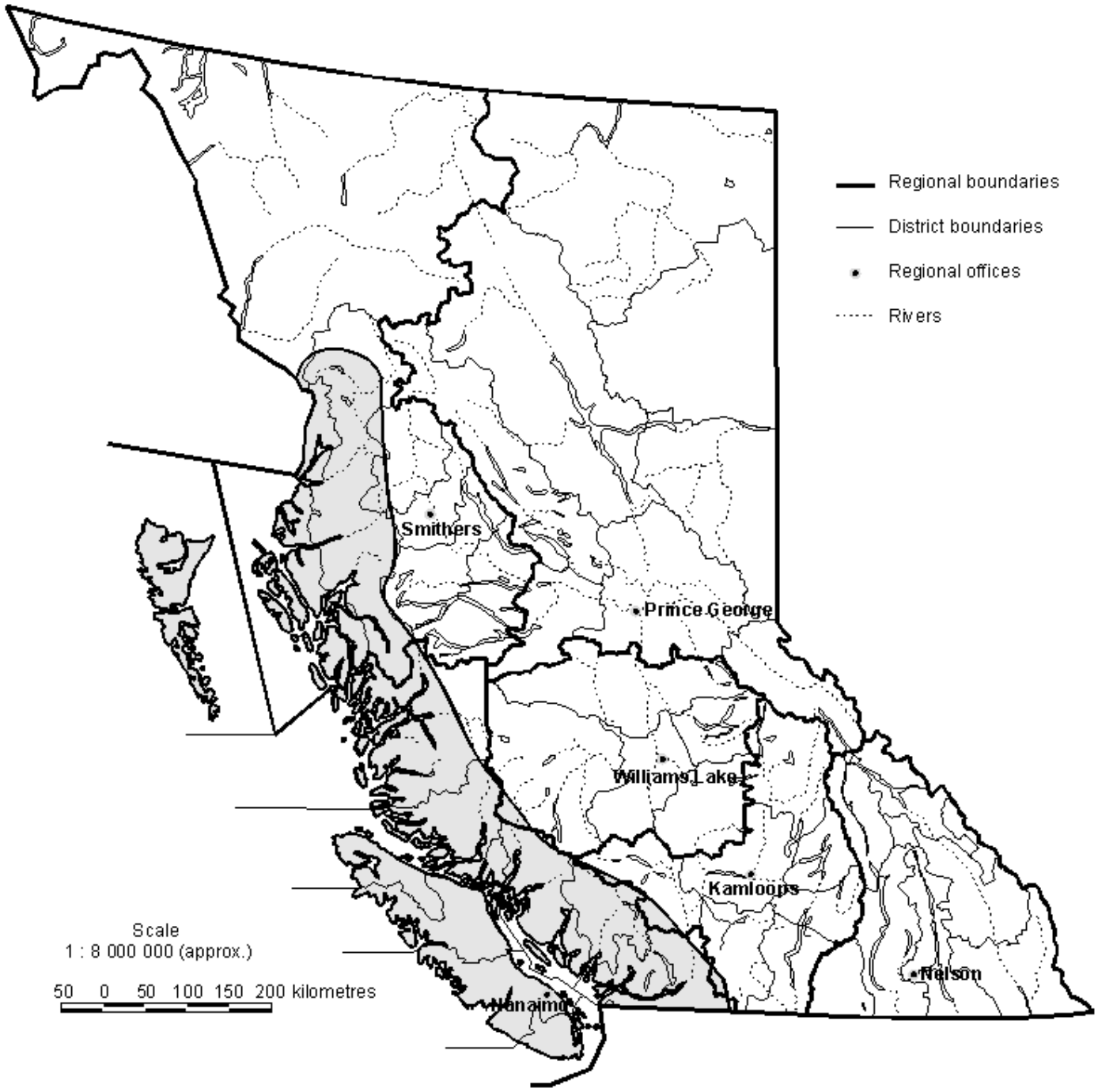


Figure 3. Western larch dwarf mistletoe (Arceuthobium laricis).

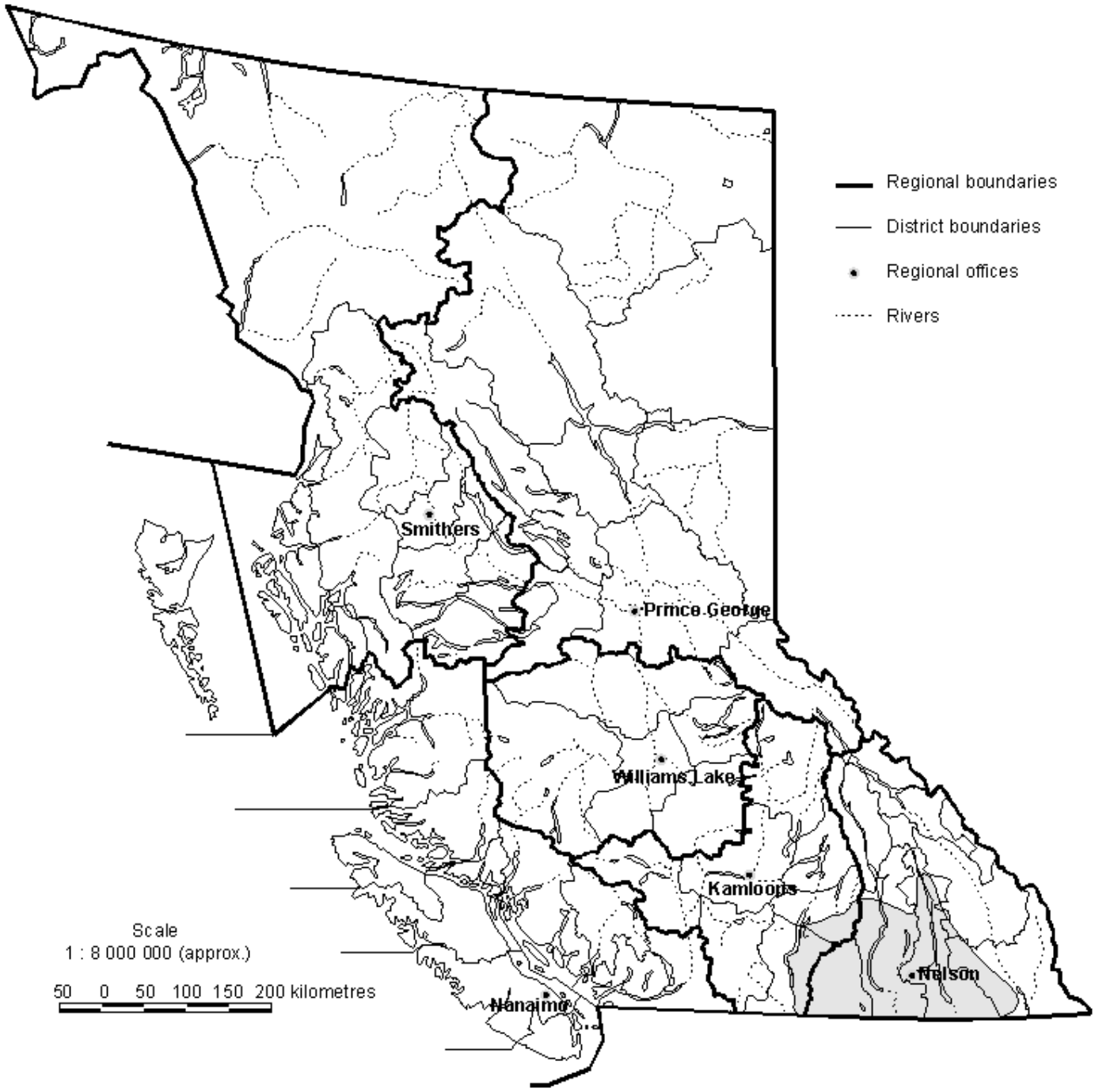
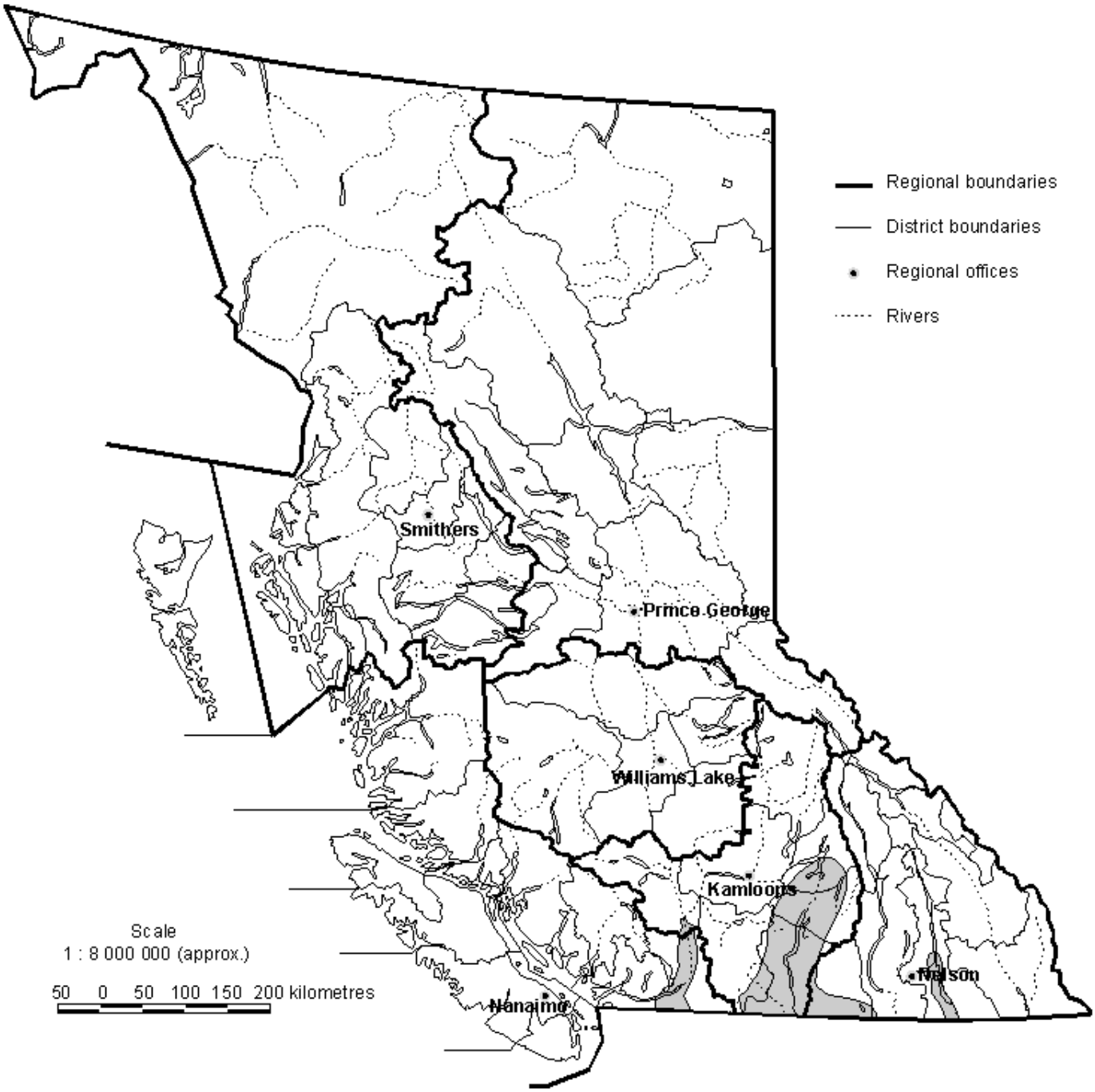


Figure 4. Douglas-fir dwarf mistletoe (Arceuthobium douglasii).



Hosts and symptoms

Trees of all ages can be parasitized and affected by dwarf mistletoes. In British Columbia, there are four dwarf mistletoe species of concern (Table 1). For detailed information on their field identification, refer to the *Field Guide to Pests of Managed Forests in British Columbia* or other suitable field identification reference.

Table 1. Important dwarf mistletoes and host tree species in British Columbia

Dwarf Mistletoe	Major Host(s)	Secondary Host(s)
Lodgepole pine dwarf mistletoe	lodgepole pine	ponderosa pine
Western hemlock dwarf mistletoe	western hemlock	anabilis fir, grand fir, sitka spruce
Western larch dwarf mistletoe	western larch	lodgepole pine (commonly infected), western white pine, grand fir
Douglas-fir dwarf mistletoe	Douglas-fir	grand fir

Other dwarf mistletoes in British Columbia include a subspecies on shore pine in coastal areas, and a subspecies on mountain hemlock in a few south-coastal, subalpine localities. Procedures outlined in this guide will also apply to these limited situations.

Secondary host tree species are often infected by dwarf mistletoe when growing near infected, major host tree species. Where such trees are infected, they should be treated the same as major tree species. **Any species not listed in Table 1 as susceptible to dwarf mistletoe are potentially useful for regenerating infected stands or for retention as future crop trees, and for leave trees for wildlife or biodiversity purposes.**

Dwarf mistletoes are readily identified in ground surveys during the data collection phase of forest development plans or any prescriptions. Symptoms of infection such as brooming and stem or branch swellings should be verified by identifying the dwarf mistletoe shoots on affected bark. Low-level aerial observations, although useful to indicate general areas of severe occurrence, must be verified by ground-level detection.

Dwarf mistletoes and stand dynamics

Dwarf mistletoe biology and behavior

Dwarf mistletoes grow in tree bark and wood, absorbing water and nutrients of the host tree that otherwise are used for growth. The parasite induces a localized swelling of bark and wood and, often, nearby buds and branches are stimulated to grow excessively, resulting in abnormal clumps of branches called “brooms” or “witches’ brooms.”

Parasitic and pathogenic effects of dwarf mistletoes include reduced growth rates and decreased strength and quality of infected wood. Individual small trees can be killed, and, in time, growth of infected, living trees can become completely stagnated. Statistically, growth losses caused by dwarf mistletoes become clearly evident (i.e., differences in growth rates are significantly different than those expected by chance variation alone) after 50% or more of tree branches become infected with mistletoe plants, generally when trees are 15 to 20 years of age or older. Very large stem swellings caused by hemlock dwarf mistletoe drastically affect wood quality. Severely infected trees are also more susceptible to other damaging agents.

Several features of dwarf mistletoe influence stand dynamics, and should be kept in mind when assessing pest risks or developing silvicultural or stand management presciptions:

- Dwarf mistletoes are obligate parasites that survive only on live branches or stems of living trees. They die as soon as a branch or stem dies.
- In forests disturbed by logging or fire, dwarf mistletoes survive on residual overstorey trees, and eventually spread to nearby young regeneration. Birds or squirrels occasionally carry dwarf mistletoe seeds, but they are not considered important sources of spread.
- Dwarf mistletoe seeds are explosively ejected from plants to horizontal distances of up to 15 m, and land on tree branches or stems with needles to cause a new infection.
- Depending on the species and other conditions, three to five years (or more) elapse before new infections produce seeds, two to three years for visible swelling in the host bark, and one to two years for shoots and flowers. Seeds mature one year later, and are dispersed in late summer or autumn.
- Initial spread of dwarf mistletoe from infected residual trees to susceptible regenerating trees depends on several factors, including:
  – age and size of young target trees
  – amount of dwarf mistletoe seed spreading to the target trees
  – stand density and distribution of both residual and target trees.
- Trees can be infected at any age but generally must be 2 to 3 m in height (10 years or older) before appreciable new infections are visible. Lodgepole pine regeneration as small as 30 cm tall can be visibly infected.
- In lodgepole pine stands, spread of dwarf mistletoe into young trees is more extensive from single, isolated residual trees than from relatively uniform, dense, even-aged stands of residual trees. Spread appears to be accelerated when dense infected residual stands are partially disturbed by cutting or wildfire.

- Within even-aged stands, dwarf mistletoes spread slowly (approximately 1 m to 1.5 m per year), with faster spread in less dense stands.

Natural stands and dwarf mistletoe

Dwarf mistletoe survival depends on the continuous presence of host trees from one forest generation to the next, and is significantly affected by stand age, vertical and horizontal height structure, and species composition.

In the past, the age of most natural stands in British Columbia, and the relationship between dwarf mistletoe and its common host, were determined primarily by wildfire. Large, intense wildfires effectively eliminated host trees along with their dwarf mistletoes. These burned areas then regenerated with even-aged stands of dwarf-mistletoe-free seedlings. Less intense wildfires left infected, live overstorey trees, allowing dwarf mistletoe to rapidly establish and intensify in the understorey stand. Dwarf mistletoe spread, intensification and impact are greatest in these situations.

Tree species composition and succession influence the impact of dwarf mistletoe in natural stands. Species-diverse stands are less affected than single-species stands. In many instances, periodic wildfires have maintained single-species stands of lodgepole pine and western larch, thus ensuring long-term survival of dwarf mistletoe. In other stands, forest succession in the absence of fire results in stands of non-susceptible tree species, such as spruce replacing lodgepole pine, and western redcedar and western hemlock replacing western larch. On the other hand, western hemlock and Douglas-fir dwarf mistletoes are common in all-aged, climax stands of their respective hosts and, in these instances, cause severe damage.

Managed stands and dwarf mistletoe

Clearcut harvesting

Clearcut harvesting, coupled with eradication of all host-tree residual stems, successfully eradicates dwarf mistletoe from a stand. After, dwarf mistletoe may spread from adjacent infected trees along cutblock boundaries to infect newly regenerated trees.

Partial cut harvesting

Partial cut harvesting in stands infested with dwarf mistletoe can greatly enhance the impact of dwarf mistletoe because latent infections are activated by increased light in tree crowns. It is virtually impossible to ensure that all remaining overstorey trees are free of dwarf mistletoe unless all host species are cut. Scattered infected overstorey trees produce a barrage of dwarf mistletoe seed that can rapidly infect regeneration.

Single tree or group selection systems—usually considered for Douglas-fir, western larch, or western hemlock, but not lodgepole pine—will likely result in intensified spread and damage by dwarf mistletoe. Therefore, such systems are not recommended for infected stands. However, detrimental effects can be ameliorated by a cutting cycle of 10 to 15 years with removal of moderately to severely infested trees at each cutting entry (see the section on “Dwarf mistletoe infection rating” for definition of severity ratings). Non-host tree species must be favoured for regeneration or leave tree purposes. Cutting cycles

of 20 years or more will result in severe damage. Where dwarf mistletoe is present, use of susceptible advanced regeneration is inadvisable.

Pre-commercial and commercial thinning

Both pre-commercial and commercial thinning increase the light available in stands and, therefore, can increase the activity of dwarf mistletoe. However, in commercial thinning, trees are of merchantable size and the time to final harvest usually does not allow substantial further impact. Fully-stocked stands have lower rates of spread and intensification of dwarf mistletoes. Dense stands suppress seed production of dwarf mistletoes, and shade out lower branches that are often the most heavily infected.

Intermediate cuts in stands infested with dwarf mistletoe should be undertaken with caution. It should be recognized that this type of disturbance can greatly exacerbate the spread and damage caused by dwarf mistletoe, often negating any potential benefits of thinning and other stand management treatments. It is virtually impossible to ensure that leave trees are free of dwarf mistletoe due to the three- to five-year life cycle of the parasite. With age, existing infections usually lose their aerial shoots, and become quiescent. However, a disturbance that increases available sunlight often reactivates these infections to produce new shoots. Thus, apparently disease-free trees may be infected, and quickly produce new aerial shoots and seed.

When thinning an infected stand, it is recommended that all infected stems should be removed, even if it creates a temporary void in the stand. Failing this, any overtopping diseased stems must be removed or girdled. If it is essential that infected trees be left, leave those with the least amount of infection. Any young trees with stem infections, particularly western hemlock, are not desirable because of the pronounced stem swelling that results.

Management of dwarf mistletoes

Dwarf mistletoes significantly affect the health of forests and the success of silvicultural systems and treatments. Information is required in forest development plans for managing dwarf mistletoes at the landscape level, including occurrence and general levels of incidence. In stands infected by dwarf mistletoe, a risk assessment and appropriate treatments must be documented in any silvicultural or stand management prescription.

High hazard biogeoclimatic units for dwarf mistletoe

Dwarf mistletoes are widespread in British Columbia. Forest ecosystem biogeoclimatic units in British Columbia which have a high probability of dwarf mistletoe damage—for at least one forest region—are listed in Table 2. Stands within these units should only be considered at high hazard when a susceptible host forms a major component of the stand. Any high hazard area requires evaluation as part of the planning or prescriptive process.

For more specific information by region, see Forest Health Charts (Appendix 6) in the appropriate *Establishment to Free Growing guidebook*.

Table 2. Biogeoclimatic units with high hazard of dwarf mistletoe damage

Dwarf Mistletoe	Biogeoclimatic Units
Lodgepole pine dwarf mistletoe	**ESSF** dc1, dc2, dk, mc, mk, wc1, wm, xc, xv
	ICH dk, dw, mc1, mc1a, mc2, mk1, mk3, mm, mw1, mw2, mw3, vk, wk3, wk4, xw
	IDF dk1, dk2, dk3, dk4, dm1, dm2, un, xh1, mw1, mw2, ww, xm, xw
	MS dc, dk, dm1, dm2, xk, xv
	SBPS dc, mc, mc2, mk, xc
	SBS dh, dk, dw1, dw2, dw3, mc, mc1, mc2, mc3, mh, mk, mk1, mk2, mw, wk, wk2, wk3
	PP dh1, dh2, xh1, xh2
Western hemlock dwarf mistletoe	**CWH** – all units
	ICH mc1, mc1a, mc2
Western larch dwarf mistletoe	**ESSF** wc1
	ICH dw, mk1, mk2, mw1,mw2, mw3, xw
	IDF dm1, dm2, mw1, un
	MS dk,dm1
	PP dh
Douglas-fir dwarf mistletoe	**IDF** dk1, dk2, dm1, mw1, xh1, xh2
	PP dh, xh1, xh2
	ICH xw

Detection surveys

Silviculture prescription walkthroughs

The presence of any dwarf mistletoe should be noted by host species.

Where a seed tree silviculture system is being considered, it is recommended that the percentage of potential seed trees infected and the severity of infection be recorded (see method in section on “Dwarf mistletoe infection rating”).

For the purpose of designing cutblocks that will reduce infection of regeneration, note distribution of infected trees and any natural barriers to spread such as rock outcrops, roads, patches of non-host tree species, and any other similar features which might be incorporated into the prescription.

Stand management assessments

Where dwarf mistletoe has been noted in the Integrated Silviculture Information System (ISIS), the Management Licensee Silviculture Information System (MLSIS) or found during a stand management assessment, or where there is a high probability of occurrence based on Table 2, record the following information:

- percentage of trees infected and severity of infection (see method in section on “Dwarf mistletoe infection rating”) in the current stand; or
- incidence and severity of infection on proposed residual crop trees (after treatment); and

- proportion of any non-host tree species.

Infection rating of potential residual crop trees is highly recommended.

Carefully consider the free growing criteria for dwarf mistletoes (see section on "Free growing criteria and assessment") before making recommendations for stand management activities.

Dwarf mistletoe infection rating

For the purpose of describing the severity of dwarf mistletoe infection on a tree, use the Hawksworth six-class rating system as described on the following page.

Figure 5. The Hawksworth six-class dwarf mistletoe rating system.

	Instructions		Example
Step 1	Divide live crown into thirds.		If this third has no visible infections, its rating is (0).
Step 2	Rate each third separately. Each third should be given a rating of 0, 1, or 2 as described below: (0) no visible infections (1) light infection (1/2 or less of total number of branches in the third infected (2) heavy infection (more than 1/2 total number of branches in the third infected).		If this third is lightly infected, its rating is (1). If this third is heavily infected, its rating is (2).
Step 3	Add ratings of thirds to obtain rating for total tree.		The tree in this example gets a rating of: 0 + 1 + 2 = 3.

Note: for coastal western hemlock, a descriptor for stem swellings can be added after the numerical rating using:

N = minor stem swelling (25% of the stem circumference affected)
M = major stem swelling (>25% of the stem circumference affected).

Only a major stem swelling is recorded if there are both major and minor swellings.

For example, a hemlock with a mistletoe rating of 4 and one or more major stem infections would be coded 4M.

On a tree or stand basis, light infection is a rating of 1 to 2; moderate is 3 to 4; and severe is 5 to 6. For a stand, the rating is calculated as the average rating of all infected trees. Incidence is the percentage of susceptible trees infected by dwarf mistletoe.

Management and treatment considerations

Management of dwarf mistletoe is relatively simple where susceptible tree species grow in even-aged stands, and an even-aged stand is desired. Although control might be less certain or even problematic in other situations, some management or treatment options are available to reduce dwarf mistletoe impacts under almost any silviculture system (Table 3).

All cutblocks should be designed to minimize spread of dwarf mistletoe into the young stand by leaving residual non-host species as border trees, and incorporating natural barriers wherever possible. Non-host tree species should be planted or used for natural regeneration as much as possible.

Shelterwood and selection systems are **not recommended** in stands where susceptible tree species comprise more than 50% of the total stems, and more than 20% of the susceptible overstorey trees are visibly infected.

Table 3. Management options for dwarf mistletoes in silvicultural systems

Silvicultural system	Management considerations
Even-aged, clearcut	▪ for DMP, DML, or DMF, cut all residual host species ▪ for DMH, cut all residuals over 2 m tall
Even-aged, seed-tree	▪ leave non-host tree species, if possible ▪ prefer seed trees with no infection (trees with a dwarf mistletoe rating of 4 or more are not suitable seed trees) ▪ if infected seed trees are used, girdle or remove seed trees as soon as regeneration established
Even-aged, shelterwood	▪ prefer non-host tree species as residuals ▪ prefer residual overstorey trees with little or no infection ▪ for DMH, consider removing all susceptible advanced regeneration over 2 m tall if overstorey canopy infected
Uneven-aged, selection	▪ prefer non-host tree species as residuals ▪ prefer residual overstorey trees with little or no infection ▪ multiple entries recommended to minimize damage
All systems with reserves	▪ prefer uninfected or non-host tree species as residuals ▪ layout reserves ("islands") to minimize spread of dwarf mistletoe into the young stand

Other resource management considerations

In certain instances, management of infected stands might be desirable to fulfill resource management objectives other than timber production. Infected trees with large witches 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 explicitly consider expected impacts of dwarf mistletoes. Any strata managed under such regimes should be assessed, and expectations for growth and yield adjusted accordingly.

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, increasing the fire hazard, and large brooms are prone to breakage. Pruning can be used to remove large brooms and maintain tree vigour.

Free growing guidelines

The provincial damage criteria for dwarf mistletoes used to determine if a tree is free growing are:

1. For all tree species,
   (a) any infected tree that has any infection on the bole is unacceptable
   (b) any infected tree that is 3 m tall or less and has any branch infection is unacceptable.

2. For coastal areas with western hemlock,
   (a) any western hemlock situated 15 m distance or less from an infected, overstorey residual western hemlock is unacceptable
   (b) any infected tree greater than 3 m tall growing on a low or poor site is unacceptable.

Note that infected western hemlock trees greater than 3 m tall on good and medium sites are acceptable only if they are more than 15 m distance from any infected, overstorey residual Hw.

3. For interior areas with lodgepole pine, western larch, or Douglas-fir,
   (a) any tree more than 3 m tall and infected in the top one-half of the crown is unacceptable
   (b) any infected tree or susceptible tree situated 15 m distance or less from any infected, overstorey residual tree of the same tree species is unacceptable.

Free growing criteria and assessment

With respect to stands infested with dwarf mistletoe and the associated treatment of infected strata, the following procedures define the criteria for assessing and determining if free growing obligations have been met. **If the parasite is absent from the strata then the prescription must explicitly state so.**

Assessing strata managed for timber production

If a stratum has an approved prescription for treatment of dwarf mistletoe, and if dwarf mistletoe resulted in a non-free growing stand, then **the district manager may choose** to accept stocking levels of preferred or acceptable species below the minimum stocking standards, provided all approved prescribed operations intended to abate the risk of dwarf mistletoe were fully implemented.

If the approved prescribed operations in the above case were not conducted, or were conducted improperly, the approved free growing obligations, as well as the costs associated with achieving these obligations, will remain the responsibility of the licensee.

Assessing strata not treated for dwarf mistletoe due to other resource management objectives

If a stratum has an approved prescription which does not prescribe active treatment for dwarf mistletoe in a stratum due to other resource issues, and the presence of dwarf mistletoe results in the non-

achievement of a free growing stand, then **the district manager may choose** to accept stocking levels of preferred or acceptable species below the minimum stocking standards.

If the approved prescribed operations for the above case were not conducted, or were conducted improperly, the approved free growing obligations, as well as the costs associated with achieving these obligations, will remain the responsibility of the licensee.

Assessing strata identified as not requiring treatment

If a stratum has been identified as having dwarf mistletoe present but not requiring treatment, and if the stratum has an approved prescription which prescribes no treatment as being required, and the presence of dwarf mistletoe results in the non-achievement of a free growing stand, then **the district manager may choose** accept stocking levels of preferred or acceptable species below the minimum stocking standards.

Assessing strata not identified as infected

If a stratum has not been identified as being infested with dwarf mistletoe, or if the licensee explicitly stated that the stratum is not infested with dwarf mistletoe, and if dwarf mistletoe resulted in a non-free growing stand, then the approved free growing obligations, as well as the costs associated with achieving those obligations, will remain the responsibility of the licensee.

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Glossary

Advanced regeneration: seedlings or young trees that have developed in the understorey of the forest.

Even-aged silvicultural system: a silvicultural system that is designed to regenerate and maintain an even-aged stand. Clearcutting, seed tree, and shelterwood are even-aged systems.

Hazard: the degree to which the characteristics of a tree or stand make it vulnerable to damage. It is equivalent to susceptibility.

Incidence: the proportion of damaged or affected trees within a stand or area.

Risk: the probability and expected severity of damage as determined by a function composed of host susceptibility; suitable environmental conditions (both combined equate to hazard); plus pathogen proximity, abundance, and virulence.

Reserves: the retention of live or standing dead trees, pole size or larger, on site following harvest for purposes other than regeneration. Reserves can be uniformly distributed as single trees or left in small groups, and they can be used with any silvicultural system.

Residuals (residual trees): trees left standing after harvesting.

Seed trees: trees left standing to provide seed sources for natural regeneration. Selection is usually on the basis of good form and vigour, the absence of serious damage by disease, evidence of the ability to produce seed, and wind firmness.

Stand dynamics: the study of changes in forest stand structure over time, including stand behavior during and after disturbance.

Uneven-aged silvicultural system: a silvicultural system designed to create or maintain and regenerate an uneven-aged stand structure. Single-tree and group selection are uneven-aged silvicultural systems.