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Identification and  
management of summer  
frost-prone sites in the

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Reforestation Systems

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## Identification and Management of Summer Frost-prone Sites in the Cariboo Forest Region – Report 157

A guide (FRDA Report 157) has been prepared to help silviculturists in the Cariboo Forest Region identify and manage sites prone to summer frost. The guide presents a simple method for evaluating the risk of summer frost to young tree seedlings on clearcut sites in the Region, and summarizes some options for reducing the risks of summer frost damage in young forest plantations. Minimum temperature data have shown that some sites in the area may experience frost on more than 50% of summer nights.

The guide contains the following three major sections:

1. a summary of factors affecting the occurrence of summer frost;
2. a guide to identifying the frost hazard on clearcut sites in the region; and
3. a summary of silvicultural options for reducing the risk of summer frost damage.

This memo summarizes the approach described in the guide for rating the frost hazard at a site, and briefly describes some of the silvicultural options for reducing this hazard. Additional information on factors affecting summer frost is available in FRDA Report 073, "Summer Frost in Young Forest Plantations" (R.J. Stathers 1989).

### FROST HAZARD ASSESSMENTS

#### Frost Hazard Classes

Five frost hazard classes are defined for clearcut sites in the Cariboo Forest Region: very low, low, medium, high, and very high. Higher hazard classes are associated with a greater expected frequency of summer frost, and higher anticipated levels of seedling damage and mortality in young plantations in the region.

Of the three major commercial tree species in the region, Douglas-fir is the most frost-sensitive, and is at risk on low hazard sites (Figure 1). Interior spruce becomes at risk on medium hazard sites, and lodgepole pine, the most frost-hardy of these three species, is at risk only on high and very high hazard sites. These species represent the range of frost sensitivities among native tree species in the Cariboo Forest Region.

#### Site Assessments

Two steps should be completed to obtain the best assessment of frost hazard on a particular site:

- Step 1** First, a preliminary frost hazard rating should be determined from a key that considers three of the most important factors affecting frost occurrence:

regional climate (biogeoclimatic unit), mesoslope position, and slope gradient. Biogeoclimatic unit indicates the probability of large scale frosts, as well as the relative intensity of overnight radiation cooling. The mesoslope position of a site describes its relative position along a path of downslope air flow. For example, a convex site near the top of a slope will generally shed cold air, while a concave site near the base of the slope will receive cooled air from upper slopes, and consequently have a higher risk of frost. On level sites, cold air drainage is confined to short mesoslope transects, and as a result, small hollows or depressions only a few metres below the surrounding terrain can have a much higher frost hazard. Slope gradient influences the rate of cold air movement through a site and the amount of mixing of the cooled air with the warmer overlying air. As slope gradient increases, the amount of mixing increases and the risk of frost damage decreases. Slopes greater than 15% have a reduced frost risk.

The key used in the first step provides a preliminary frost hazard rating for all slope positions and slope gradients within each biogeoclimatic unit of the Cariboo Forest Region. For example, in the IDFdk3, mid-slope positions with greater than 15% slope gradient have a low hazard rating, while those with less than 15% slope gradient have a medium hazard rating. High hazard ratings are given to gentle lower and toe slope positions, and to depressions. Very high ratings do not occur on any sites of the IDFdk3, but do occur in other biogeoclimatic units, especially the ESSFwk1, ESSFvx, MSxc, and the SBPxc.

**Step 2** In the second step, the preliminary frost hazard for a site may be modified according to additional site-specific features affecting frost occurrence. These features include the size of the upslope cold air source area, barriers to downslope air flow (such as timber boundaries), vegetation cover, and microsite characteristics. For a site-specific frost hazard assessment, it is best to consider as many factors as possible that could contribute to the overall frost hazard at a site, and to evaluate their combined effects on the overall hazard.

Additional information on the importance of summer frost on a particular site may be obtained from vegetation indicators. The absence of frost-sensitive species, as well as low plant diversity and vigour, may indicate that the site experiences frequent summer frosts. Examples of potential indicator species for biogeoclimatic zones in the Cariboo Region are presented in the guide.

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Summer frost hazard class	Expected damage and mortality					
	Douglas-fir		Interior spruce		Lodgepole pine	
Expected incidence	Damage	Mortality	Damage	Mortality	Damage	Mortality
<b>Very Low VL</b> 0 in 10 years <-4°C 0 in 10 years <-8°C	None	None	None	None	None	None
<b>Low L</b> 1-2 in 10 years <-4°C 0 in 10 years <-8°C						
<b>Medium M</b> 3-6 in 10 years <-4°C 1-2 in 10 years <-8°C	Severe	Extensive	Moderate	Limited	Moderate	Limited
<b>High H</b> 7-10 in 10 years <-4°C 3-5 in 10 years <-8°C						
<b>Very High VH</b> 10 in 10 years <-4°C >5 in 10 years <-8°C			Severe	Extensive	Severe	Extensive

FIGURE 1. Mean number of days of frost between June 1 and August 31, 1988, in five frost hazard classes. Data were recorded on 35 cutover sites.

## MANAGEMENT OF FROST-PRONE SITES

Clearcuts are generally more prone to summer frosts than are partially cut sites. However, on sites where the original forest was closed-canopy, a residual canopy of at least 50% is usually required to reduce the frost hazard class significantly. Cutblock boundaries and leave-strips can also be oriented to minimize the obstruction of cold air flow away from a site and thus reduce the risks of frost.

Silvicultural treatments can reduce the risk of frost on frost-prone sites, but annual variation in summer weather conditions will affect the success of these treatments. For example, a treatment that is normally effective at reducing the frost hazard on a site may not work during a summer of particularly severe frost. However, site preparation treatments designed to reduce the frost hazard are likely to affect other environmental factors, such that seedling growth could be enhanced or hampered.

A number of mechanical site preparation treatments have been shown to reduce the risk of frost damage on low and medium frost hazard sites. Among these are trenching, blade scarification, and mounding.

Selection of frost-hardy species for planting on frost-prone sites may improve regeneration success, but acceptable survival and growth can still be difficult to achieve on high and very high hazard class sites. On low to medium hazard sites, a nurse crop of a relatively hardy species such as lodgepole pine may be used to protect a frost-sensitive species like Douglas-fir during the establishment phase. On medium to high hazard sites, a mixed plantation of interior spruce and lodgepole pine may be appropriate.

Finally, appropriate microsite selection during planting can decrease the potential for frost damage to seedlings. For example, microsites that trap cold air, such as shallow depressions near fallen logs, will have a higher frost hazard than those from which cold air readily drains, such as areas of raised mineral soil situated near a tree stump.

## CONCLUSIONS

**Understanding the factors that affect the occurrence of summer frost over the landscape makes it possible for the forester to predict which sites are most likely to experience summer frost. An assessment of the frost risk at a site can then be used to select appropriate reforestation strategies to minimize the damaging effects of frost.**

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