Best Management Practices for Improving Survival for Planted Douglas-fir in The Cariboo Natural Resource Region

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Contents

Establishing Interior Douglas-fir in the Cariboo Natural Resource Region has many challenges. The ecosystems present in the Cariboo experience considerable variability of drought and frost.

Climate change modelling indicates that the Cariboo Natural Resource Region will experience an increase in climate extremes. This can take the form of extended periods of drought and frost as well as extremes in temperature throughout each month of the year (MacKenzie and Mahony 2021). Douglas-fir is extremely difficult to establish and trends of increased exposure will make this more challenging. Once Douglas-fir is established it becomes increasingly resistant to these events.

Where Douglas-fir forests currently exist, it must be maintained and further recruited to support forest values. The best practices for harvesting in Douglas-fir forests are through silvicultural systems such as uniform shelterwoods, single tree or group selection (Newsome et al. 2016). However, because there have been such extensive catastrophic fires and a recent history of clearcut harvesting in the region, many of the strategies recommended in this paper focus on situations where thermal protection is limited. Forest professionals are planting Douglas-fir into areas that are challenging to establish. This report recommends best management strategies to increase Douglas-fir presence, through improving planted tree survival. It is not enough just to plant Douglas-fir, it must thrive to provide the conditions necessary to maintain our forest values.

This Best Management Practices document is intended to help silviculture practitioners identify and manage for the factors that cause planted Douglas-fir to succeed or fail.

For a more thorough discussion on the recommendations in this BMP a detailed companion report is available at the Forest Science, Planning and Practices Branch _FFT Website.

Best Managmement Practices for Douglas-fir on all sites

The following practices are Best Management Practices on all sites where Fdi mortality is considered likely.

Planning

- Increase mature retention to provide as much thermal protection and shade as possible for planted and natural Fdi regeneration,

- **BMP:** On sites where reforesting with Fdi is challenging, natural regeneration should be encouraged as much as possible through methods available such as: overstory Fdi retention (thermal cover, shade, and seed source) retention of other taller stems that can provide shade and thermal protection to provide both a seed source and increase in disturbance to reduce pinegrass competition. Preferably, these tools should be employed where they have the best chance of success such as on steeper slopes versus flat areas and where clumps of mature stems are present rather than scattered individual mature stems
- Silviculturists have the tools to adjust frost hazard through mature tree retention during harvest planning.

  Silvicultural systems that maintain significant overstory are:

  » Uneven-aged (group or single tree selection) and

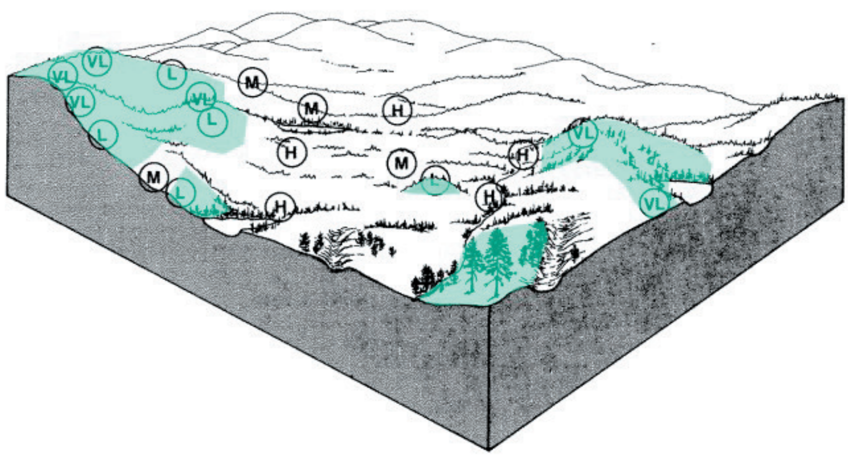
  » Even-aged: shelterwood

- **BMP:** A silviculture forester should have input and signoff on all Site Plans in order to review openings to help plan and prepare for reforesting sites prone to heat stress, drought and frost
- When planning for reforestation, increasing thermal cover (leaving overstory retention) is an important tool to reduce environmental impacts on seedlings.
- Where overstory thermal protection is not available; planting prescriptions, planting contracts, planting preworks, and planting inspection systems should be designed to place the Fdi seedlings in or adjacent to (by order of importance): MSP spots, aspen, taller brush, larger stumps, rocks, downed slash and shorter stumps.

Frost

- **BMP:** Silviculturists should review sites prior to-harvest through the lens of the frost hazard assessment worksheet, separating areas with different values. Sites should be stratified as thoroughly as possible to identify regimes that will work across strata. A field guide to forest site identification and interpretation for the Cariboo Forest Region (Steen and Coupé 1997) and Steen et al. 1990 for the frost hazard classification should be used to classify these sites.

- Track the frost hazard rating value for each site using the tables provided – make sure to adjust for thermal protection and other factors that will increase or decrease frost hazard. This will make it easier to quantify and summarize the area associated with increased risk,



Sample frost hazard rating for an imaginary opening within the IDFdk3. (Original drawing Steen et al. 1990)

Drought

- **BMP:** Silviculturists have a tool to ameliorate drought hazard through mature tree retention during harvest planning.

Reforesting Dry Sites in the Thompson Okanagan Natural Resource Region (2020) is a report completed for the Resource Practices Branch. That report focused exclusively on drought and how to apply appropriate treatment regimes to reduce mortality and damage caused by drought. Many of the findings from that report are applicable to the Cariboo Region, however, recommended regimes must be modified to minimize frost damage and mortality as well. The IDF subzones within the Cariboo region all have drought constraints though not to the extent of the Thompson Okanagan region. The Cariboo has reduced intensity of pinegrass and lower daytime temperature extremes than the Thompson Okanagan Region.

In the absence of frost as a limiting factor, the main tools for reforesting with Fdi in drought prone sites are overstory retention for shade; soil disturbance through mechanical site preparation; and prompt reforesting with large stock Fdi. In areas where frost is also a limiting factor, many of the same tools that allow Fdi to escape drought impacts also mitigate for frost damage; overstory thermal protection, soil disturbance through mechanical site preparation and prompt reforestation with large stock Fdi.

Mechanical Site Preparation (MSP)

- **BMP:** In situations where Fdi is planned for planting, Mechanically Site Prepare the site using ripper plow, or disc trencher where Bt restricting layer is absent. Mechanical Site Preparation can expand the area where Fdi is at lower risk for frost damage and mortality.

- Administer MSP with as much attention as planting programs, including increased communication at the viewing, contract, pre-work, and checking stages. Identify the level of disturbance required throughout the treatment area and indicate under what scenarios the area will need to be reworked until the acceptable treatment standard has been met throughout.

- Create or use approved variations in the stocking standards to reduce minimum inter-tree distances to address situations where mechanical site preparation is not possible due to machine limitations and safety concerns,

Treatment type	Treatment description	Effects on vegetation	Effects on risk of summer frost damage	Effects on drought	Effects on soil temperature
Untreated control	Seedlings were planted directly into surface soil with no screefing. There was no disturbance of soil or surrounding vegetation.	No effect	No effect	No effect	No effect
Hand screef	30 × 20 cm patches were created by shovel screefing, with the intention of removing surface vegetation and forest floor material. Minor exposure of mineral soil occurred, and the treatment created slight depressions, the depth of which depended on forest floor depth.	Vegetation was removed in small patches; root mat was slightly broken up	Limited effect	Minor reduction related to grass removal and creation of slight depression (IDF only)	Little effect
Leno	A Leno scarifier created very shallow, linear (40 × 100–150 cm) scarified patches. Little soil disturbance occurred and the Bt layer was not broken. Two seedlings were planted in each linear Leno patch, in the centre width-wise and ~10 cm from either end.	Vegetation was removed in strips; root mat was broken up	Slight reduction related to nighttime heat re-radiation and grass removal	Minor reduction related to grass removal	Reduced daytime surface temperature; release of heat during the night
Ripper tooth	A ripper tooth (not winged) was used to break through the Bt layer and create narrow, deep, continuous furrows that were up to 40 cm deep and 10–20 cm wide. The bottom of the furrow closed up, leaving a 5–10 cm deep trench with reduced bulk density. Seedlings were planted into the bottom of this trench.	The ripper tooth cut vertically through roots, but above-ground vegetation was only slightly pulled away from the furrow	Slight reduction related to nighttime heat re-radiation and grass removal	Reduction related to moisture collection in the furrow and access to soil moisture at greater depth	Reduced daytime surface temperature but less than in treatments with greater mineral soil exposure

Treatment descriptions and potential effects on vegetation, risk of summer frost damage, drought, and soil temperature (Newsome et al. 2016)

Treatment type	Treatment description	Effects on vegetation	Effects on risk of summer frost damage	Effects on drought	Effects on soil temperature
Ripper plow	A Merritt ripper plow was used to create a 30–40 cm deep and 40 cm wide continuous trench with large berms. Mineral soil was exposed over ~30% of the treated area and the Bt layer was broken, which reduced bulk density. Seedlings were planted in the trench bottoms.	Vegetation removed; root mat broken up	Reduction related to nighttime heat re-radiation and grass removal	Reduction related to moisture collection in the trench and access to soil moisture at greater depth	Reduced daytime surface temperature and release of heat during the night
Disc trench	An MM passive disc trencher created continuous shallow, scarified patches ~30 cm wide (different from trenching produced with a powered trencher), with an adjacent poorly defined berm of loosened soil. Surface soil was removed, but the Bt layer was not broken. Seedlings were planted in the trench bottoms at all sites.	Vegetation was removed in a narrow scarified strip; grass root mat broken up	Reduction related to nighttime heat re-radiation and grass removal	Slight reduction related to moisture collection in the shallow depression and removal of vegetation	Reduced daytime surface temperature; release of heat during the night
V-plow SBSdw1/2 only	A V-plow was used to create continuous plows that were 2.5–3 m wide, exposing mineral soil over ~50% of the treated area. Soil was disturbed to a depth of ~10 cm and the Bt layer was not broken. Seedlings were planted on either edge of the plow strip, which allowed them to access nutrient-rich material at edge.	Vegetation was removed in wide strips	Reduction related to nighttime heat re-radiation and grass removal	Reduction related to vegetation removal	Reduced daytime surface temperature; release of heat during the night; greater soil warming than in treatments with less mineral soil exposure

Planting prescriptions

- **BMP:** When planning tree species for planting, strongly consider that Fdi has improved long-term drought tolerance compared to other species. While it may be easier to establish Pli species initially, this does not create a stand that is resilient to future drought events. It is also important to note that establishing a stand of Pli where Fdi was harvested is species conversion and this is poor forest management practice.

- Target the majority of Fdi for low frost hazard strata within the opening, adjacent to timber edges and where adjacent thermal cover is present. Within moderate frost hazard areas, identify microtopographical steeper areas and residual cover for higher Fdi percentages. For the remaining area of moderate frost hazard prescribe much lower percentages of Fdi with the intent that these will be planted adjacent to obstacles for thermal protection,

BMP: Planting prescriptions must have maps that spatially identify the location where Fdi is expected to be planted.

- Avoid planting Douglas-fir too shallow, or too deep.
- For mechanically prepared sites, avoid planting into compacted medium as well as elevated microsites where frost and drought are the key considerations.

Sowing requests

- When choosing B class seed:
- Select provenances that are drier than the target planting site, example, for IDFdk3 site, the preference is to use seed sourced from IDFxm or drier as opposed to IDFdk3(although IDFdk3 would be acceptable).
- Select seed from similar subzones to the target planting site. Example, for an IDFdk3 site, the preference would be to select seedlots sourced from IDFdk3(local) as opposed to IDFdk5(Kootenays).
- Avoid selecting seedlots from considerably north or south of the target planting location. This will reduce exposure of the seedlings to early season frost (in the case of extremely northern seedlots) and late summer frosts (in the case of extremely southern seedlots),

- **BMP:** Trees intended for drought or frost prone sites must be sown at the earliest opportunity. It is not recommended to wait until harvesting is completed before sowing for trees.

- As drought risk increases for a site, sow first and adjust the planting plans later. Planting must be initiated as quickly as possible. Identify when these openings are likely to be harvested and sow for these even if harvest completion is uncertain,

- **BMP:** grow the appropriate size stock for the drought and frost risk. Larger stock should be considered as risk increases.

Example Fdi stock size. Source BCTS recommended seedling stock type selection. Interior/Spring

	Large	Medium	Small
Fdi	512A	412A	412B

- **BMP:** In situations where the preferred reforestation scenario cannot be followed due to circumstances outside of the silviculturist's control choose the largest available stock size to improve chance of success. This includes scenarios such as, range issues, access constraints, or fire. There will be situations where this is not possible, such as extremely rocky or shallow soils.

- Do not use seedlots with less than 85% germination percentage to minimize transplant shock at the nursery. Seedlings exposed to additional transplant shock will have smaller roots and will be at increased risk of drought and frost damage and mortality.

- **BMP:** Fall planting is not recommended where there is higher risks of drought and late summer frosts,

Planting program and implementation

- **BMP:** Include language in planting contracts indicating where Fdi is expected to be planted. Communicate this clearly at planting viewings. Provide planting prescription maps with explicit language and locations where Fdi is expected to be planted. Keep these clear and simple.

- Prior to receiving quotes for planting pricing, an office viewing must discuss the expectations for planting Fdi. This must include: the location and microsite planting requirements, and the tools that will be made available to the planting contractor to achieve success.

- Planting prescriptions must have maps that spatially identify the location where Fdi is expected to be planted.

- Clearly communicate to the planting implementer what the process will be if the planters are not following the plan, or for instances where Fdi is planted in inappropriate locations,

- **BMP:** Plant as early as possible following snow and frozen ground free conditions. A larger plug size may help mitigate for spring frost damage. Larger trees are more likely to have their terminal bud out of the frost pool

- Create operational trials. This will allow increased learning opportunities. Root excavations should be incorporated into all stocking surveys for these units,

- **BMP:** Small operational trials are an extremely cost-effective way of testing for appropriate regimes most likely to work in an area. Silviculturists should engage with their local research silviculturist to improve trial design, expand questions worth testing, and to help drive research project ideas.

- There will be situations where mechanical site preparation does not adequately cover a site and there is one or two intervening growing seasons prior to planting. Reforestation to adequate levels may be very difficult or unachievable. In these situations, it is recommended to include direction in all treatment regime planting prescriptions to obstacle plant for shading purposes to increase the number of planted trees. Expect higher mortality of Fdi where MSP was not possible.
- Create informal trials to test new ideas and increase learning opportunities.

Brushing

- Vegetation control for woody species should be avoided on dry and frost prone sites. Most species, with the exception of pinegrass, will provide some level of shade and thermal protection which overrides most concerns related to competition for moisture and light.

- **BMP:** Avoid brushing treatments unless crop tree mortality is imminent. Brush and upland aspen can provide necessary thermal protection for Douglas-fir.

Monitoring and reporting

- Track replants separate from initial planting. This will make it easier to manage sites that have increased challenges. Adopt the coding PL-RP for sites that have been previously planted and failed due to drought or frost mortality. Track the cause for the re-plant activity "Drought", or "Frost",
- Surveys: identify a survey regime for at-risk sites. Sites where frost hazard is considerable, or drought concerns are considerable, should have summer and fall walkthroughs to better track plantation progress. Surveys should be completed within one year of planting and resurvey frequency should be no longer than two years until establishment is secure,
- **BMP:** Sites that are actively being managed for Fdi, in areas where frost or drought is anticipated, should have accelerated reviews or surveys of any planting treatments.
- Surveys: survey preworks should include education on where Fdi is suitable and indicate that detailed spatial direction on where to plant Fdi is a requirement for completed planting prescriptions,
- **BMP:** provide surveyors with access to silviculture extension such as courses, presentations and field trips focused on reforesting with Fdi. Further focus surveyors' attention on this issue by highlighting Fdi reforestation opportunities in survey contract documents and preworks with greater emphasis on where Fdi can survive and thrive.
- Surveys: review the treatment regimes recommended for frost prone and dry sites with survey crews. Outline the factors that surveyors need to address on dry sites. Surveyors should include comments about which microsites show increased mortality and survival,
- Surveys: templates provided to surveyors for planting prescriptions should include a section on where Fdi is suitable for planting – this should include spatial representation on the treatment map,

Identifying frost prone sites

Frost is a major limiting factor affecting Douglas-fir damage and mortality in the Cariboo Natural Resource Region. *The FRDA report #157 - Identification and management of summer frost-prone sites in the Cariboo Forest Region* (Steen 1990) has an excellent table which summarizes frost hazard within each biogeoclimatic subzone by mesoslope position – note this table assumes the site is clearcut.

Biogeoclimatic subzones/variants	Mesoslope position	Slope gradient	Frost hazard
Group 1:	Crest, Upper, Mid	> 5%	VL
BGxh3, xw2	Lower	> 15%	VL
IDFxw		< 15%	L
PPxh2	Toe, Depression, Level	< 5%	L
Group 2:	Crest	> 5%	VL
IDFdk1	Upper, Mid	> 15%	VL
IDFmw2		< 15%	L
IDFxm (Fraser R)	Lower	all slopes	L
SBSmh	Toe, Depression	< 5%	M
	Level	< 5%	L
Group 3:	Crest	> 5%	VL
ICHdk	Upper, Mid	> 15%	VL
ICHmk3		< 15%	L
ICHmw3	Lower	> 15%	L
ICHwk2,wk4		< 15%	M
SBSdw1	Toe, Depression	< 5%	H
	Level	< 5%	L
Group 4:	Crest	> 5%	VL
IDFdk3	Upper	> 15%	VL
IDFxm (Chilcotin)		< 15%	L
SBSdw2	Mid	> 15%	L
SBSmw		< 15%	M
	Lower	> 15%	L
		< 15%	M
	Toe, Depression	< 5%	H
	Level	< 5%	M

Biogeoclimatic subzones/variants	Mesoslope position	Slope gradient	Frost hazard
Group 5:	Crest	> 5%	VL
IDFdk4	Upper	> 15%	VL
		< 15%	M
	Mid	> 15%	L
		< 15%	M
	Lower	> 15%	L
		< 15%	H
	Toe, Depression	< 5%	H
	Level	< 5%	M
Group 6:	Crest	> 5%	L
MSxk	Upper, Mid	> 15%	L
SBPSdc		< 15%	M
SBPSmc	Lower	> 15%	M
SBPSmk		< 15%	H
SBSmc1,mc2	Toe, Depression	< 5%	H
	Level	< 5%	M
Group 7:	Crest	> 5%	L
ESSFdc2	Upper, Mid	> 15%	M
ESSFwk1		< 15%	H
SBPSxc	Lower	> 15%	M
SBSwk1		< 15%	H
	Toe, Depression	< 5%	VH
	Level	< 5%	H
Group 8:	Crest	> 5%	M
ESSFwc3	Upper, Mid	> 15%	M
ESSFxv		< 15%	H
MSxv	Lower	> 15%	H
	Lower, Toe, Depression	< 15%	VH
	Level	< 5%	VH

Guide to Preliminary Frost Hazard Class Rating for Clearcuts in the Cariboo Forest Region (FRDA 157 Steen 1990)

Factors that may increase the hazard are: (bolded factors are more important) **(FRDA 157, Steen 1990)**

- **Large upslope source area,**
- **Impediment to downslope cold air flow,**
- **Microtopographic depression, especially on level terrain,**
- Cold air Channel, gently sloping (creek drainages),
- Grass dominated vegetation on level sites,
- North aspects.

Factors that may decrease the hazard are: (bolded factors are more important)

- **Tree or tall shrub canopy,**
- **Microtopographic crest or knoll, especially on level terrain,**
- Mineral soil exposure on upper, mid or level slope positions,
- Abundant slash,
- South or south-west aspect.

Once the site has been assessed and the additional factors considered to raise or lower frost hazard, the expectation of damage and mortality for Douglas-fir can been reviewed on the following table.

<table>
<tr><th rowspan="2">Summer frost hazard class</th><th colspan="6">Expected damage and mortality</th></tr>
<tr><th colspan="2">Douglas-fir</th><th colspan="2">Interior spruce</th><th colspan="2">Lodgepole pine</th></tr>
<tr><td>Expected incidence</td><td>Damage</td><td>Mortality</td><td>Damage</td><td>Mortality</td><td>Damage</td><td>Mortality</td></tr>
<tr><td>Very Low VL
0 in10 years <-4°C
0 in10 years <-8°C</td><td>None</td><td>None</td><td rowspan="2">None</td><td rowspan="2">None</td><td rowspan="3">None</td><td rowspan="3">None</td></tr>
<tr><td>Low L
1-2 in 10 years <-4°C
0 in10 years <-8°C</td><td>Moderate</td><td>Limited</td></tr>
<tr><td>Medium M
3-6 in 10 years <-4°C
1-2 in 10years <-8°C</td><td rowspan="3">Severe</td><td rowspan="3">Extensive</td><td>Moderate</td><td rowspan="2">Limited</td></tr>
<tr><td>High H
7-10 in10 years <-4°C
3-5 in 10years <-8°C</td><td rowspan="2">Severe</td><td>Moderate</td><td rowspan="2">Limited</td></tr>
<tr><td>Very High VH
10 in 10years <-4°C
>5 in 10years <-8°C</td><td>Extensive</td><td>Severe</td></tr>
</table>

Definition of Frost Hazard Classes for Cariboo Forest Region (FRDA 157, Steen 1990)

Planting Scenarios

Fdi planting treatments have been summarized into variations of four similar scenarios. Each scenario is described, with recommendations into three categories: Treatment Unit setup (organization), Planting treatment maps (spatial), and Planting treatment direction (text).

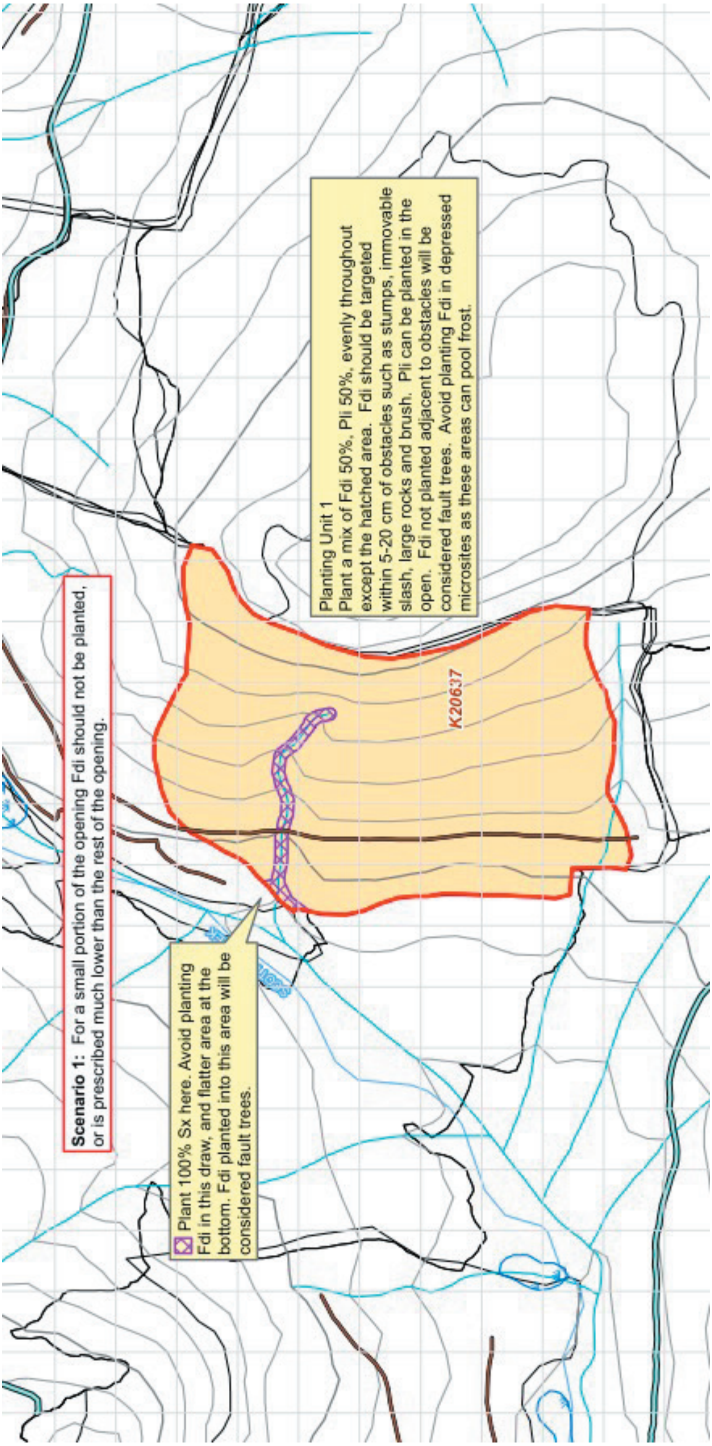
The planting units throughout the Cariboo Region can be managed using the following approach, regardless of BEC as the major driving forces are Frost Hazard, and Drought Hazard.

BMP: Frost hazard should be assessed, and the treatment area fully stratified using FRDA#157 Report (Steen et al 1990). The stratification must be adjusted based on additional considerations, such as overstory thermal cover, meso-scale topographic crests and depressions, increases in upslope frost source, and impediment to downslope cold air drainage. In addition, Drought hazard should be assessed and closely typed using A Field Guide to Forest Site Identification and Interpretation for the Cariboo Forest Region (Steen and Coupé 1997) – focusing on xeric sites, rocky eskers, obvious non-productive (NP), and steeper south facing slopes.

Scenario 1. This planting treatment is characterized by predominantly low frost hazard throughout. Small sections of ground exist that are not suitable for planting Fdi such as wet areas, and depressional terrain associated with draws or creeks. There are no obvious stratifiable areas of higher frost or drought hazard.

Planting treatment units: This scenario can remain as one planting unit with a defined species allocation. Increase the allocation of alternative species to reforest the areas that are not suitable for Fdi.

Planting treatment map: The planting map provided to the planters does not require stratification, however representation of the areas where Fdi should not be planted should be attempted wherever possible and Fdi must not be planted in these areas. This can be achieved using swamp symbols or hatching where there are obvious wet areas, and hatching in the vicinity of the depressional areas. Notes with arrows should be used to clearly identify the areas where Fdi should not be planted.


Scenario 1: For a small portion of the opening Fdi should not be planted, or is prescribed much lower than the rest of the opening.
Plant 100% Sx here. Avoid planting Fdi in this draw, and flatter area at the bottom. Fdi planted into this area will be considered fault trees.
Planting Unit 1
Plant a mix of Fdi 50%, Pli 50%, evenly throughout except the hatched area. Fdi should be targeted within 5-20 cm of obstacles such as stumps, immovable slash, large rocks and brush. Pli can be planted in the open. Fdi not planted adjacent to obstacles will be considered fault trees. Avoid planting Fdi in depressed microsites as these areas can pool frost.
K20637

Planting treatment prescription (example text please adjust as required).
Plant a mix of Fdi 50%, Pli 50%, evenly throughout except the hatched area. Fdi should be targeted within 5-20 cm of obstacles such as stumps, immovable slash, large rocks and brush. Pli can be planted in the open. Fdi not planted adjacent to obstacles will be considered fault trees. Avoid planting Fdi in depressed microsites as these areas can pool frost.

Sx must be planted in the wet area identified (see map). Avoid planting Fdi within 5m of wet areas and depressional areas identified on the map or elsewhere throughout the planting unit. Fdi planted into these scenarios will be considered fault trees.

Discussion for scenario 1: This scenario assumes considerably larger Fdi allocations that are mostly suitable throughout. These trees should have reduced risk of frost damage and frost mortality relative to Fdi planted into moderate frost hazard. There will always be areas where Fdi should not be planted at all such as draws, the lower timber edge, and swamps – these should be typed out as best as possible on the planting map.

Include language in planting contracts that indicate Fdi will be considered fault trees if the planters do not follow the prescribed direction. The contract should provide clear direction for planters and implementers that is relatively easy to follow. It is difficult for planting implementers to enforce general directions on how Fdi should be planted. Clear direction at the contract stage, fully described at the prework, and supported by quality maps should ensure implementers, contractors and planters all understand how the Fdi should be planted. The result is improved survival and performance of planted Fdi and less risk for the planting contractor.

MSP is recommended for all areas where Fdi is planted and significant drought or frost potential exists. MSP is recommended if there is doubt about whether the treatment unit is low frost hazard or if it is trending towards a moderate frost hazard. Acceptable MSP treatments are: ripper plow, excavator raised screefs, or disc trenching where restricting Bt layers are absent. MSP is not required for areas with very low frost hazard and low drought potential.

Scenario 2. This planting treatment area is characterized predominantly by moderate frost hazard throughout. Within the main treatment area small sections of ground suitable for planting Fdi are identified, such as meso-scale topographic steep slopes, meso-scale topographic crests or areas with significant thermal protection such as residual Fdi cover

Planting treatment units: This scenario can remain as one planting unit with a defined species allocation. Increase the Fdi allocation for the areas more suitable for Fdi.

Planting treatment map: The planting map provided to the planters does not require stratification into separate planting units. Attempt to represent the areas where Fdi is to be planted wherever possible. Fdi must be planted in these areas at significantly increased percentage, preferably 100%. This can be achieved by hatching obvious steeper slope areas, and hatching in the vicinity of increased mature Fdi retention. Text boxes with arrows should be used to clearly identify the areas where Fdi percentage should be increased.

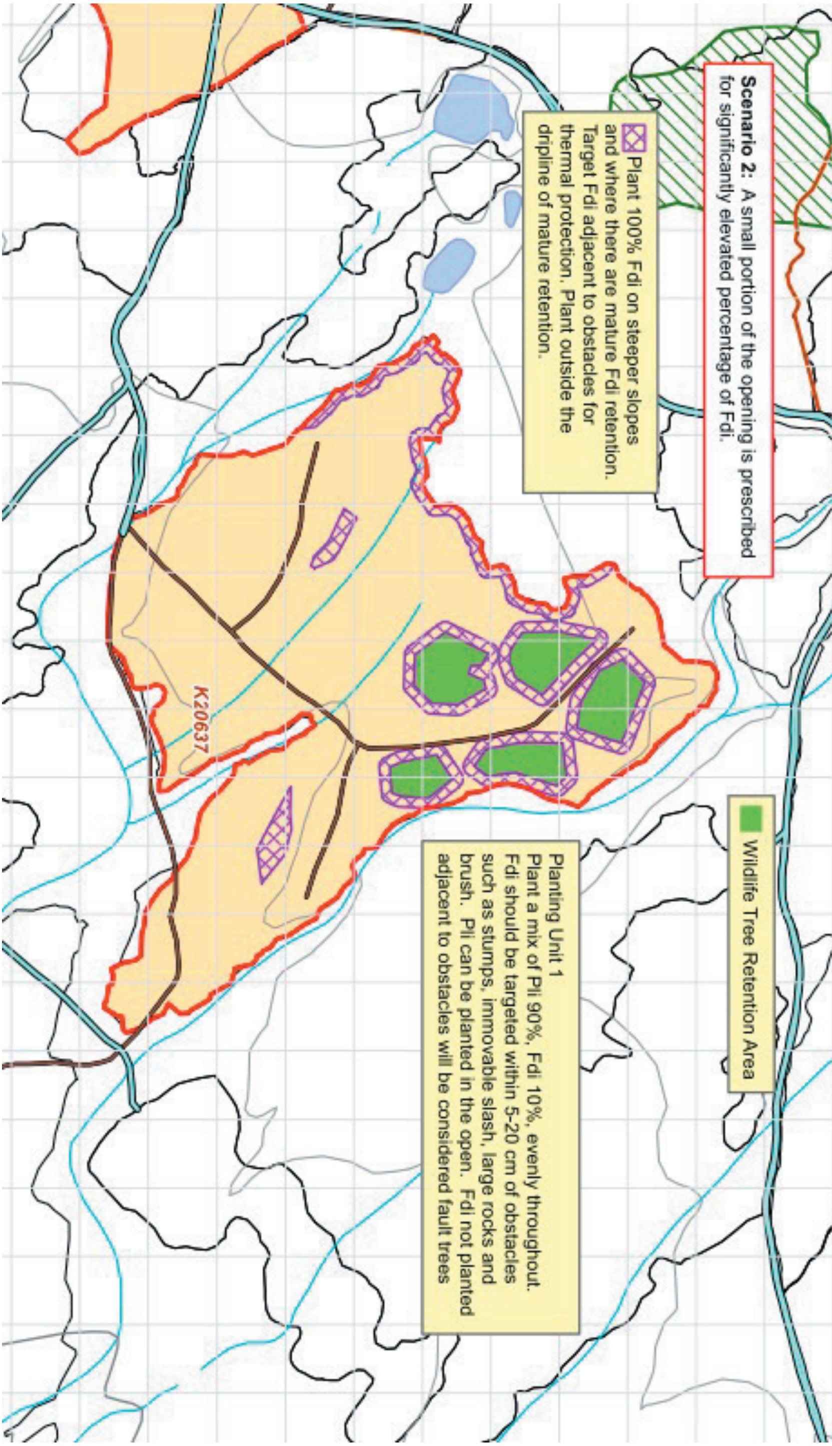
Planting treatment prescription (example text, please adjust as required).
Plant a mix of Pli 90%, Fdi 10%, evenly throughout. Fdi should be targeted within 5-20 cm of obstacles such as stumps, immovable slash, large rocks and brush. Pli can be planted in the open. Fdi not planted adjacent to obstacles will be considered fault trees.

Plant 100% Fdi on steeper slopes and areas with mature Fdi retention (see map).

Discussion for scenario 2: This scenario allows for a considerable increase in planting of Fdi in preferred locations within the planting unit. These trees should have reduced frost damage and mortality relative to Fdi planted into moderate frost hazard.

Fdi planted into moderate frost hazard should be targeted into microsites adjacent to minor thermal protection such as brush, stumps and large rocks. These trees are still likely to have frost damage but may release once the surrounding Pli overtop them and begin to provide thermal protection. These Fdi are likely to have increase chances for frost shake but, if they survive, will contribute thermal protection and a reduction in frost hazard for the next rotation. Frost shake occurs with late summer frost damage when the late wood lignin is not laid down for the year leaving a gap in the tree rings – this gap can act as an entry path for pathogens, causing further damage. Outward visible signs of frost shake can appear as the outer bark covered in sap that has exited these wounds.

Mechanical site preparation is recommended to mitigate drought in areas that have lower frost hazard and higher Fdi percentages in the planting prescription. Targeted MSP is recommended for these areas –resulting in a higher cost/ha but a lower total cost than treating the entire opening.


Scenario 2: A small portion of the opening is prescribed for significantly elevated percentage of Fdi.
Plant 100% Fdi on steeper slopes and where there are mature Fdi retention. Target Fdi adjacent to obstacles for thermal protection. Plant outside the dripline of mature retention.
Wildlife Tree Retention Area
Planting Unit 1
Plant a mix of Pli 90%, Fdi 10%, evenly throughout. Fdi should be targeted within 5-20 cm of obstacles such as stumps, immovable slash, large rocks and brush. Pli can be planted in the open. Fdi not planted adjacent to obstacles will be considered fault trees
K20637

Scenario 3. This planting treatment is a mix of Scenario 1 and 2 and requires stratification into different planting units (PU). A mappable portion of the planting area is very suitable for Fdi (in this case PU 1), and the remaining area is not well suited for Fdi (in this example PU 2). With different prescriptions for these two strata, it is best to create and manage as two planting units.

Planting treatment units: This scenario is characterized by two distinct planting units with a defined species allocation for each.

Planting treatment map: The planting map provided to the planters Includes two clearly mapped and described planting units.

Planting treatment prescription (example text, please adjust as required).
PU 1. Plant a mix of Fdi 60%, Pli 40%, evenly throughout. Avoid planting Fdi into micro depressions where cold air can linger.

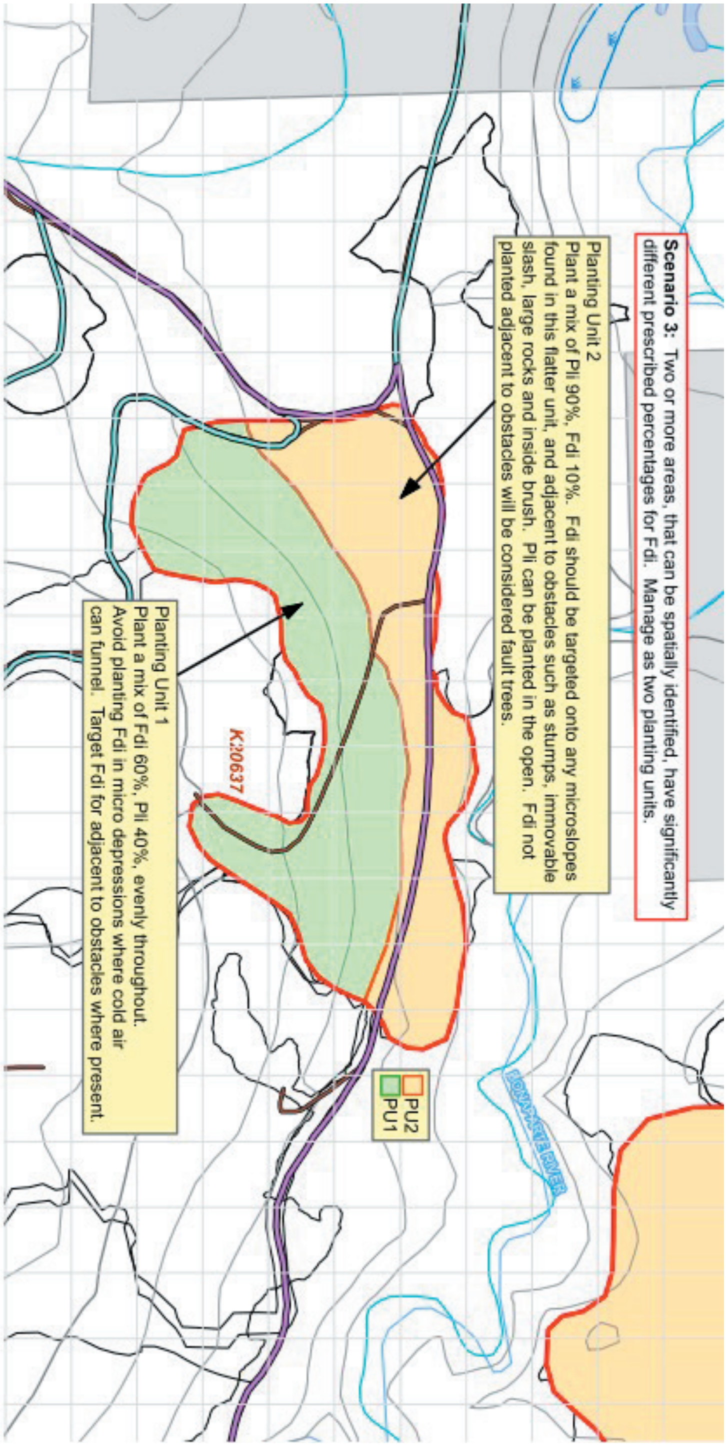
PU 2. Plant a mix of Pli 90%, Fdi 10%. Fdi should be targeted adjacent to obstacles such as stumps, immovable slash, large rocks and inside brush. Pli can be planted in the open. Fdi not planted adjacent to obstacles will be considered fault trees.

Discussion for scenario 3: This scenario allows for a considerably higher percentage of Fdi in one of the planting units. There is a history in the Cariboo of directing planters at prework meetings to plant Fdi in the steeper areas and avoid depressional areas. This scenario clearly defines where a higher percentage of Fdi can be planted to ensure the prescription is achieved.

(PU 1 example) Targeting the Fdi for this area allows for a considerable increase in planting of Fdi in the best locations within this planting unit. These trees should have reduced frost damage and frost mortality relative to Fdi planted into the moderate frost hazard planting unit (PU2). Prescriptions up to 100% Fdi should be considered for areas that have low frost risk.

(PU2 example) For the Fdi planted into moderate frost hazard all Fdi should be targeted for adjacent to minor thermal protection such as brush, stumps and large rocks. These trees are likely to have frost damage but may release once the surrounding Pli overtop them and begin to provide thermal protection. Frost shake damaged Fdi will contribute thermal protection for the next rotation, reducing frost hazard in the future.

Mechanical site preparation is recommended to mitigate drought in areas that have lower frost hazard and higher Fdi percentages in the planting prescription. Targeted MSP is recommended for these areas – resulting in a higher cost/ha but a lower total cost than treating the entire opening.


Scenario 3: Two or more areas, that can be spatially identified, have significantly different prescribed percentages for Fdi. Manage as two planting units.
Planting Unit 2
Plant a mix of Pli 90%, Fdi 10%. Fdi should be targeted onto any microslopes found in this flatter unit, and adjacent to obstacles such as stumps, immovable slash, large rocks and inside brush. Pli can be planted in the open. Fdi not planted adjacent to obstacles will be considered fault trees.
Planting Unit 1
Plant a mix of Fdi 60%, Pli 40%, evenly throughout. Avoid planting Fdi in micro depressions where cold air can funnel. Target Fdi for adjacent to obstacles where present.
K20637
PU2
PU1

Scenario 4. This scenario is a combination of Scenario 1 and 2 but is not conducive to stratification into planting units because the low and moderate frost hazard areas are dispersed throughout.

Planting treatment units: this scenario should be one planting unit, with an approximation of how much area is suitable for Fdi and how much is poorly suited to Fdi.

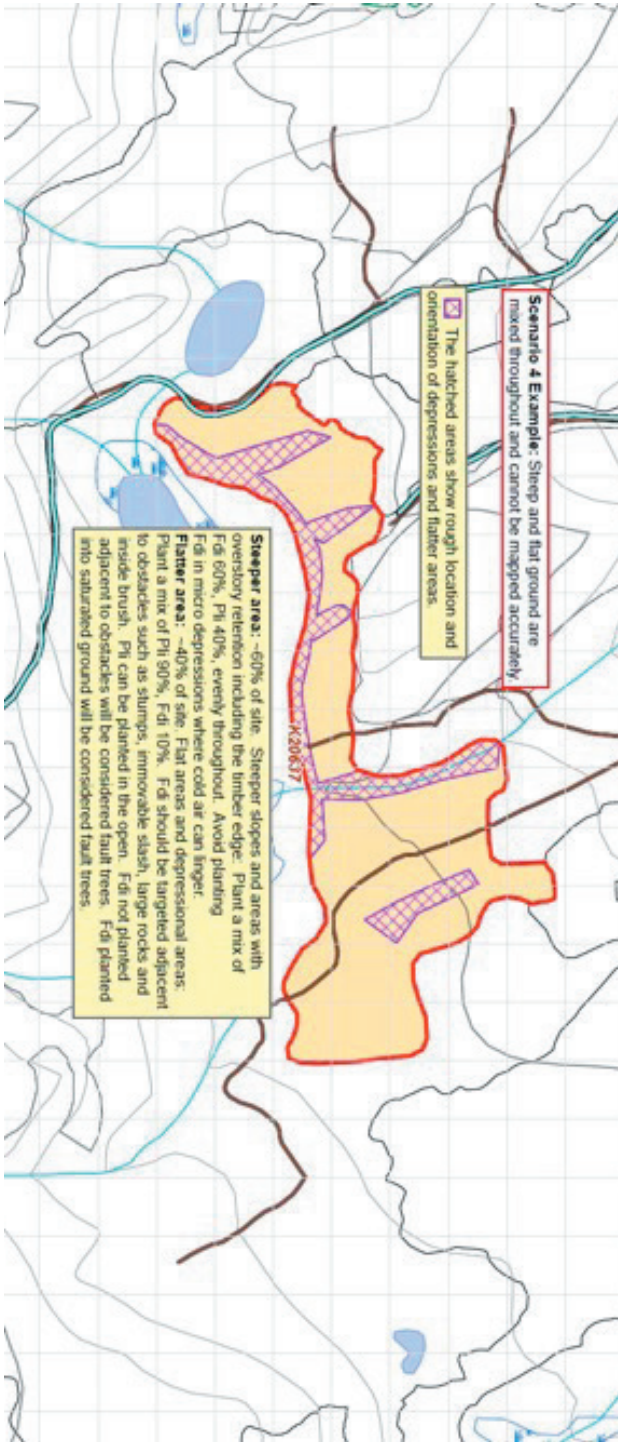
Planting treatment map: The planting map provided to the planters does not require stratification, however an attempt to describe the areas suitable for planting more Fdi is warranted.

Planting treatment prescription (example text, please adjust as required). Steeper slopes and areas with overstory retention including the timber edge: Plant a mix of Fdi 60%, Pli 40%, evenly throughout. Avoid planting Fdi in micro depressions where cold air can linger.

Flat areas and depressional areas: Plant a mix of Pli 90%, Fdi 10%. Fdi should be targeted adjacent to obstacles such as stumps, immovable slash, large rocks and inside brush. Pli can be planted in the open. Fdi not planted adjacent to obstacles will be considered fault trees. Fdi planted into saturated ground will be considered fault trees.

Discussion for scenario 4: This scenario allows for a considerable increase in the Fdi percentage in one part of the planting unit, however it is dispersed, making it difficult to describe spatially and map. This scenario requires considerable direction to the planters at the prework as well as in the field by implementation staff or the contract coordinator. Consequences of planting Fdi into unacceptable areas require very strong communication and language in the contract, at the prework and during the first days of planting in order to be enforceable.

Mechanical site preparation is very difficult to target for the most suitable sites. Two options are available as best practices: broadcast treatment of the entire planting area, and targeted MSP.



Scenario 4 Example: Steep and flat ground are mixed throughout and cannot be mapped accurately.
The hatched areas show rough location and orientation of depressions and flatter areas.
K20637
Steeper area: ~60% of site. Steeper slopes and areas with overstory retention including the timber edge: Plant a mix of Fdi 60%, Pli 40%, evenly throughout. Avoid planting Fdi in micro depressions where cold air can linger.
Flatter area: ~40% of site. Flat areas and depressional areas: Plant a mix of Pli 90%, Fdi 10%. Fdi should be targeted adjacent to obstacles such as stumps, immovable slash, large rocks and inside brush. Pli can be planted in the open. Fdi not planted adjacent to obstacles will be considered fault trees. Fdi planted into saturated ground will be considered fault trees.

Notes

British Columbia