January 1990 FRDA Memo No. 160

Synopsis

Topic Summary for the Operational Forester

Mechanical Site Preparation for Cold Site Management

INTRODUCTION

Cold sites cause reforestation problems over much of the interior of British Columbia. In southern B.C., cold site problems are mainly confined to high elevation areas, but in the central and northern Interior they are widespread. This leaflet identifies characteristics of cold sites and suggests mechanical site preparation (MSP) methods to help solve cold site problems.

Note that only MSP treatment options are presented here. The reader should always consider other, non-mechanical treatment options before preparing a prescription to alleviate a cold site problem.

WHAT ARE COLD SITES?

Cold sites are those where periodic or continuously low soil or air temperatures are a major limiting factor to successful conifer seedling establishment. This includes sites with:

- cold soils (mean rooting zone temperature below 10°C throughout the growing season).
- a high risk of summer frost.
- a high risk of winter damage (direct freezing or wind damage).

Although cold sites share similar characteristics, not all cold site symptoms occur on every site. For example, sites prone to summer frost will not necessarily have cold soils. Consequently, MSP prescriptions and their effectiveness in improving seedling performance will vary with each type of cold site.

WHERE ARE COLD SITES FOUND?

In the BWBS, ESSF, SBPS, and SBS biogeoclimatic zones, cold sites occur widely in the landscape because these zones have long cold winters and cool summers. In zones with warmer climates (ICH, IDF, MS, PP), cold sites are restricted to specific topographic situations. Cold sites are most common under the following conditions:

Cold Wet Sites

- imperfectly to poorly drained soils.
- areas with deep forest floors (10-15 cm or deeper).

Cold Dry Sites

- areas with cold summer temperatures.
- moderately to well-drained soils subject to summer drought.

Summer Frost-Prone Sites

- valley bottoms, depressions and other concave areas that accumulate cold air.
- areas subject to radiation frosts.

Sites Prone to Winter Damage

- areas with low winter snowfall.
- areas subject to wide fluctuations in winter temperature (chinooks).
- areas where the seedling is exposed while the soil remains frozen.

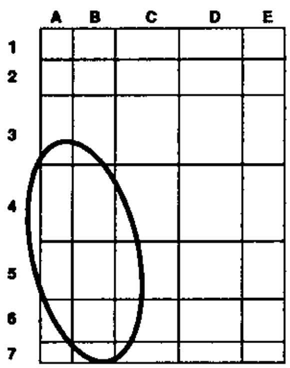
Note: *Dense vegetation can amplify cold site problems on both wet and dry sites.*

IDENTIFYING COLD SITES IN THE FIELD

The tips below may help you identify cold sites before a reforestation problem develops:

1. **Use the biogeoclimatic ecosystem classification for your area.** Ecosystem guides should help you pinpoint those site series (ecosystem associations) most prone to cold site problems. Note that within a subzone, the coldest soils are often, but not always, associated with oligotrophic A to submesotrophic B (or mesotrophic C) nutrient regimes.

2. **Study the topography.** Cold site problems are most severe on sites that receive little sunlight or are subject to cold air ponding. Watch for:
   - north aspects
   - shaded narrow valleys or draws
   - depressions or hollows
   - areas subject to cold air flow from nearby mountain tops or glaciers
   - flat high elevation plateaus exposed to clear, cold nights



Ecosystem guides can help you identify cold sites.

Refer to Stathers (1988) for more details.

3. **Use indicator vegetation.** In each zone or subzone, certain plant species are good indicators of cold or frost-prone sites; others indicate warmer, milder conditions. Get to know the indicator species for your local area. Some common examples from the SBS zone are shown in Table 1.

4. **Examine soil characteristics.** Look for:
   - thick, slowly decomposing (Mor type) forest floor layers (10-15 cm or greater).
   - shallow roots concentrated in the forest floor or upper-most mineral soil.
   - evidence of poor drainage: mottles, gleying, impermeable clay layers.
   - growing season soil temperatures below 4-8°C. Use a soil thermometer.

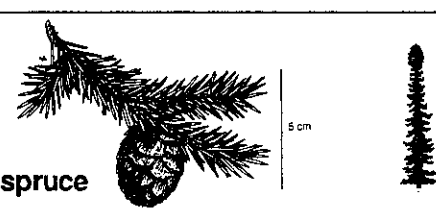
Some plant species are excellent indicators of cold site conditions.

TABLE 1. Examples of cold/warm site indicator species in the SBS zone*

Cold site indicators
black spruce (*Picea mariana*)
labrador tea (*Ledum groenlandicum*)
devil's-club (*Oplopanax horridus*) – north aspects
black twinberry (*Lonicera involucrata*) – dense and slow-growing
pink spirea (*Spiraea douglasii*)
Sitka burnet (*Sanguisorba canadensis*)
creeping snowberry (*Gaultheria hispidula*)
scrub birch (*Betula glandulosa*)
crowberry (*Empetrum nigrum*)
glow moss (*Aulacomium palustre*)
Warm site indicators
Douglas-fir (*Pseudotsuga menziesii*)
Saskatoon (*Amelanchier alnifolia*)
Douglas maple (*Acer glabrum*)
thimbleberry (*Rubus parviflorus*) – abundant and vigorous
Hooker's fairy bells (*Disporum hookeri*)
false sarsaparilla (*Aralia nudicaulis*)
peavine (*Lathyrus* spp.)
trailing raspberry (*Rubus pubescens*)
sweetcicely (*Osmorhiza chilensis*)
blue wild rye (*Elymus glaucus*)
electrified cat's-tail moss (*Rhytididelphus triquetrus*)

*Note: these plants may not be reliable indicators in all parts of the SBS. Always use local experience.

5. **Watch for seasonal changes.** Direct evidence of cold temperatures is all around you, especially in spring! When you are out in the woods, make a note of sites where:
   - the snow stays longest in spring or arrives first in autumn.
   - vegetation is frost-killed or frost-damaged.
   - plants are late to burst bud.
   - it remains shady most of the day.
   - ground frost is present on cold clear mornings.
   - the soil is still frozen or feels cold when nearby soils are already warm.



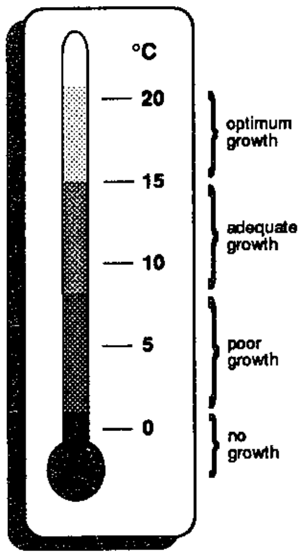
Black spruce

HOW DO COLD SITES AFFECT SEEDLING PERFORMANCE?

During the growing season, cold sites affect seedling performance through:

1. Low soil temperatures (less than 4-8°C). These:
   - reduce water and nutrient uptake.
   - slow root growth.
   - inhibit overall seedling growth by decreasing net photosynthesis.

   Note: *Optimal spruce growth occurs at a soil temperature of 20°C.*



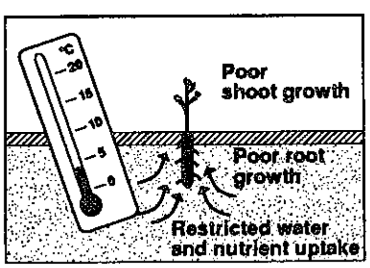
Soil temperature

2. Low air temperatures (not freezing).
   - Optimal growth of interior conifers is not achieved at air temperatures below 18-22°C.

   Note: *MSP treatments have little influence on these temperatures.*

3. Below-freezing air temperatures. These:
   - temporarily reduce photosynthetic rate.
   - retard or inhibit bud formation.
   - cause physical damage. New growth is especially sensitive.
   - cause seedling mortality if severe.

   Note: *Frost damage in the first growing season usually occurs because planted seedlings are poorly acclimated to the site. Ensuring that seedlings are properly conditioned is the best way to reduce frost damage problems.*



Cold soil temperatures inhibit root growth and restrict water and nutrient uptake.

During the winter period, cold sites affect seedling performance through:

1. Freezing injury.
   - Stems, needles or buds may be damaged or killed.
   - Freeze-thaw cycles lead to poor vigour or death.
2. Wind damage.
   - Warm winter or spring weather can cause drought stress on exposed seedlings that are unable to take up water in near-freezing or frozen soil.
   - Ice crystals in the air can damage exposed needles.

Winter damaged spruce seedling.

Frost damaged spruce seedling.

WHAT ARE MANAGEMENT OBJECTIVES ON COLD SITES?

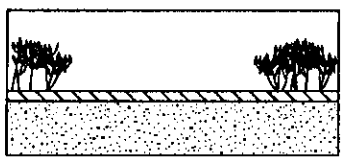
The main objective is to promote high rates of seedling survival, rapid seedling establishment, and early growth. This entails:

- increasing root growth.
- improving water and nutrient uptake.
- increasing photosynthetic rate.
- minimizing potential for growing season frost damage.
- minimizing potential for winter damage.

HOW DOES MSP HELP MEET MANAGEMENT OBJECTIVES ON COLD SITES?

It helps in several ways:

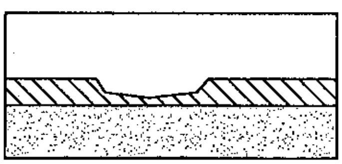
By removing shading vegetation or slash, which



- can increase soil temperature if the forest floor is less than 5-10 cm thick.
- improves air circulation.

Caution: *In low snowfall areas, removing vegetation and slash may increase winter damage by reducing snow accumulations around the seedlings*

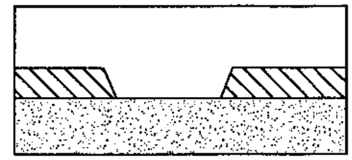
By reducing the depth of insulating forest floors, which



- is essential for increasing soil temperature if the forest floor is deeper than 5 -10 cm. The forest floor must be less than 5-8 cm thick after treatment for significant increases in soil temperature to occur.
- has little effect on soil temperature if the forest floor was less than 5 cm thick before treatment.

Note: *If the soil is imperfectly or poorly drained, the seedling must be elevated to improve aeration. Simply reducing forest floor depth and planting is not recommended.*

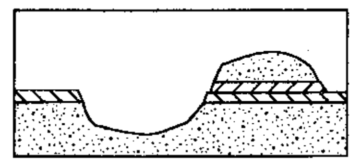
By exposing mineral soil, which



- is important for increasing soil temperature. Mineral soil absorbs heat during the day and re-radiates it at night. This can increase night time air temperature by 1-2°C near the ground surface.
- has little effect on day-time air temperature.

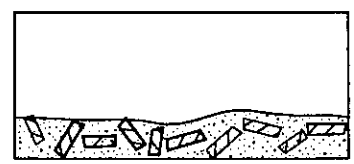
Caution: *Exposing large areas of mineral soil increases daily soil temperature fluctuations. Nutrient availability may also be reduced. A small patch of exposed mineral soil will have little effect on nighttime air temperature.*

By providing an elevated microsite, which



- improves soil drainage on wetter sites.
- increases soil temperatures and improves soil aeration.
- elevates seedlings above cold ground surface.
- can reduce frost damage.

By mixing mineral soil and organic matter, which



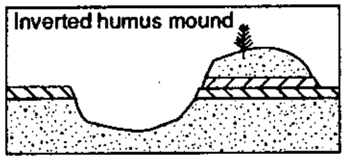
- can increase soil temperature through improved aeration and water relations.
- can increase nutrient availability.
- improves soil texture and tilth.

MSP OPTIONS FOR SITES WITH COLD WET SOILS

Objectives:

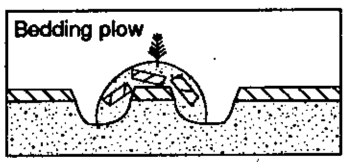
- to improve soil aeration and increase soil temperature.
- to create an elevated planting microsite.

Mounding



- Creates discrete, elevated planting sites.
- *Equipment for mounding:* excavators, Bräcke mounder, Sinkkilä, skidders with backhoe attachments, and the Ministry/Rivtow prototype.
- For a detailed discussion of mounding objectives, techniques, and equipment, see Haeussler (1989).

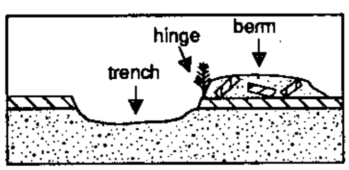
Plowing



- Creates continuous elevated planting berms.
- *Equipment for plowing:* bedding plow, ripper plow, agriculture breaking plow.
- Seedlings should be planted on the elevated microsites.
- Requires a large area of uniform and relatively clean ground to be effective.
- For a detailed discussion of plowing equipment, see Coates *et al.* (1987).

Note: *V-blades (also known as V-plows) are not considered to be plowing equipment.*

Power trenching



- Creates continuous or intermittent furrows or trenches.
- Seedlings should be planted on the hinge or slightly above the hinge.
- Seedlings should not be planted in the trench on cold, wet sites.
- Trenching is most suitable for moist (not wet) conditions or where cold wet patches are interspersed with areas of better drainage.
- For a detailed discussion of trenching objectives, techniques, and equipment, see Beaudry (1989).

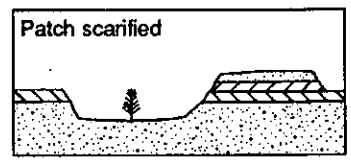
Caution: *Screefing, patch scarification, and blade scarification are not recommended for cold, wet sites.*

MSP OPTIONS FOR SITES WITH COLD DRY SOILS

Objectives:

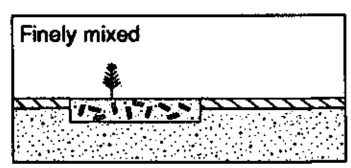
- to increase soil temperature and nighttime reradiation of heat by exposing mineral soil.
- to improve moisture availability for seedlings.
- to improve nutrient availability for seedlings.

Trenching, blade, or patch scarification



- Creates a flat or depressed planting spot with exposed mineral soil.
- Seedlings are planted in the lowest spot of the scalp or trench to provide shelter and maximum moisture availability (avoid planting in compacted or clayey subsoil).
- Wide, continuous scalps or trenches provide greater increases in soil temperature and moisture than do small patches or narrow trenches, but displace soil nutrients.
- Small patches or trenches retain soil nutrients near the seedling.
- A wide array of equipment is available for varying site conditions.
- For detailed equipment descriptions, see Coates *et al.* (1987).

Mixing



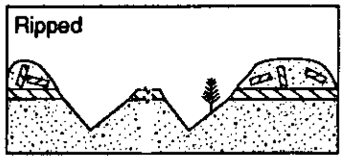
- Creates mixed mineral soil and organic matter planting spots with enough mineral soil exposed to raise soil temperature.
- Can increase nutrient availability on nutrient-

poor sites where trenching or scalping is undesirable.

- Availability of specialized mixing equipment (e.g., Madge Rotoclear) is limited; other equipment can be used for rough mixing, but is less effective.

Deep ripping

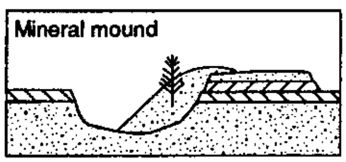
- Creates a deep trench that collects soil moisture and loosens subsurface soil layers.



- Seedlings are planted in the trench for frost protection and maximum moisture availability.
- Suitable for extremely droughty sites.
- Suitable for soils with a compacted or impermeable layer that inhibits penetration reach of seedling roots.
- *Equipment for deep ripping:* Ripper plow, Sanders-Araki deep tilling plow, subsoiler. See Coates *et al.* (1987).

Mounding

- Small mineral mounds are effective for increasing soil temperature on cold, well-drained sites.



- Seedlings must be planted deep, with roots well into the mineral soil below the mound.
- For more information refer to Haeussler (1989).

Caution: *Mounding must be used with caution on well-drained sites and should never be used on truly droughty sites. Avoid inverted humus mounds.*

MSP OPTIONS FOR SITES PRONE TO SUMMER FROST

Objectives:

– to increase air movement.

– to increase nighttime re-radiation of heat.

Note:

- MSP does little to increase air flow. This is best accomplished through cutblock design and layout.
- Frost-prone sites may or may not have cold soils.
- Properly acclimated seedlings will greatly reduce the risk of frost damage.
- Effects of MSP on frost damage have been extremely variable. It is not recommended that MSP be prescribed solely to minimize the risk of frost damage.

Exposing mineral soil

- Offers some protection against ground frost by absorbing heat during the day and re-radiating it at night.

Creating an elevated planting spot

- Mounds or berms with mineral soil cappings elevate the seedling above the cold ground surface, increase air circulation, and provide the benefits of mineral soil exposure.
- Planting on mounds or berms can reduce frost damage in areas subject to shallow ground frosts, but will be of little value in areas subject to deep cold air ponding.

Caution: *Mounding occasionally increases frost damage by causing seedlings to flush early, before the risk of spring frost is past.*

Reducing vegetation density

- Reduced vegetation density can improve near-surface mixing of air, resulting in lower risk of frost.

For a detailed discussion of how to identify and manage frost-prone sites, refer to Stathers (1988).

MSP OPTIONS FOR SITES PRONE TO WINTER DAMAGE

Objectives:

- to minimize the risk of winter freezing injury or wind damage.

Note: *Winter injury occurs primarily because newly planted seedlings are poorly acclimated to severe winter conditions in clearcut openings. Properly acclimated seedlings will greatly reduce the risk of winter injury.*

MSP options

At present, no specific MSP techniques can be recommended for reducing winter damage to seedlings. Site preparation methods that increase the depth of snow around seedlings or decrease exposure to wind may afford some protection, for example, using vegetation or berms of slash or soil to create a "snowfence", or providing depressional microsites for seedlings. These techniques, however, may not be beneficial to seedlings because they decrease soil and air temperatures during the growing season.

Microsite selection

On sites where winter injury is the primary hazard:

- Avoid planting seedlings on top of exposed, raised microsites (mounds or berms).
- Plant on the sheltered side of berms or mounds, away from prevailing or chinook winds, and avoid south aspects subject to rapid snowmelt.

REFERENCES

Beaudry, L. (compiler). 1989. Trenching. For. Can. and B.C. Min. For., FRDA Memo No. 099.

Coates, D., S. Haeussler, A. MacKinnon, L. Bedford, and J. Maxwell. 1987. A guide to the use of mechanical site preparation equipment in British Columbia. 2nd ed. For. Can. and B.C. Min. For., FRDA Handbook No. 002.

Haeussler, S. (compiler). 1989. Mounding for site preparation. For. Can. and B.C. Min. For., FRDA Memo No. 100.

Herring, L.J. 1987. Winter injury of white spruce in the boreal forest of B.C. Unpublished manuscript. Available from B.C. Min. For., For. Sci. Section, Prince George, B.C.

Maxwell, J. 1989. Silvicultural site preparation equipment study. Unpublished report. Available from B.C. Min. For., Silv. Branch, Victoria, B.C.

Spittlehouse, D.L. and R.J. Stathers. 1990. Seedling microclimate. B.C. Min. For. Land Manage. Rep. No. 65.

Stathers, R.J. 1988. Summer frost in young plantations. For. Can. and B.C. Min. For., FRDA Report No. 073.

Stathers, R.J., D.L. Spittlehouse and J.D. Lousier. (compilers). 1989. The effects of forest plantation microclimate on conifer seedlings. For. Can. and B.C. Min. For., FRDA Memo No. 152. In press.

Sutherland, D.C. and A. Vyse. 1989. Site preparation options for improving plantation performance in low precipitation areas of the Cariboo Region (EP 841.06). Unpublished report. Available from B.C. Min. For., For. Sci. Section, Williams Lake, B.C.

Örlander, G., P. Gemmel, and J. Hunt. 1990. Site preparation: a Swedish overview. For. Can. and B.C. Min. For., FRDA Report No. 105.

Information compiled by:

Dave Coates
B.C. Forest Service
Forest Science Section
Bag 5000, Smithers, B.C.
V0J 2N0
(604) 847-7436

Sybille Haeussler
Skeena Forestry Consultants
RR#2 Site 81 C-2
Smithers, B.C.
V0J 2N0
(604) 847-9451