ESTABLISHING DOUGLAS-FIR PLANTATIONS IN THE DRY BELT OF INTERIOR BRITISH COLUMBIA

Teresa A. Newsome, D. Craig Sutherland and Alan Vyse

ABSTRACT

Douglas-fir plantation failure has been extensive in the dry belt of Interior British Columbia. High seedling mortality may be attributed to: frost, mid-season drought, stock quality problems, cattle damage, and vegetation competition from native and domestic grasses.

Preliminary results are presented from field trials in the Cariboo and Kamloops Forest Regions. These trials were designed to test various treatments to improve seedling survival and growth such as: site preparation, fencing to exclude cattle, and pine nurse-cropping. Seedling survival, condition, height and diameter growth, and damage codes were assessed for a maximum of six growing seasons.

On the driest sites, Interior Douglas-fir zone (IDF), seedling survival and annual height growth improved when planted in a trench or a v-plow path. However, annual height growth was below 3 cm on all treatments. Cattle severely damaged seedlings planted in some of the untreated areas and on paths created by v-plows. Pine nurse-crops helped alleviate damage from frost and cattle.

On moister sites, Subboreal Spruce zone (SBS), seedling survival was better than in the IDF. Survival improved with any form of mechanical site preparation. Also in the SBS, container seedling performance was better than bareroot performance. Cattle damage was more prevalent on areas prepared by v-plows.

Keywords: *Pseudotsuga menziesii*, site preparation, cattle grazing, nurse crops

INTRODUCTION

Most Douglas-fir stands in the dry belt of interior British Columbia are logged by some form of partial cutting and restocked by natural regeneration (Vyse *et al.* 1990). However, wild fires and inappropriate past logging practices have created cleared areas that have and will require planting. Douglas-fir (Fd) is the preferred species for planting even though the alternative species lodgepole and/or ponderosa pine have better initial survival and growth. Douglas-fir has a superior timber value and planting Douglas-fir helps to maintain species diversity. However, Douglas-fir regeneration is poor in these clearings. Both seedling survival and growth are low which often results in plantation failure. This paper reviews information on the dry-belt environment to suggest reasons for the failures, and reports on the results of recent Douglas-fir establishment trials in the Cariboo and Kamloops Forest Regions.

British Columbia is divided into Biogeoclimatic zones. Most of the dry belt Douglas-fir area is situated in the Interior Douglas-fir (IDF) zone (Figure 1). It also includes small transition areas in the Subboreal Spruce (SBS) zone. The SBS is a slightly moister zone than the IDF zone. The dry belt Douglas-fir area follows the main valleys in the southwest part of the province and expands onto the adjacent plateau to an elevation of 1350 m. Precipitation ranges from 300-500 mm per year with less than half of that falling in the growing season. Mean growing season temperatures range from 11-15°C. Growing degree days (greater than 5°C) rise from 1100 to a high of 1700. Historically, Douglas-fir seedlings performed poorly on these dry ecosystems, because of such factors as frost, drought, vegetation competition, stock quality and cattle interaction.

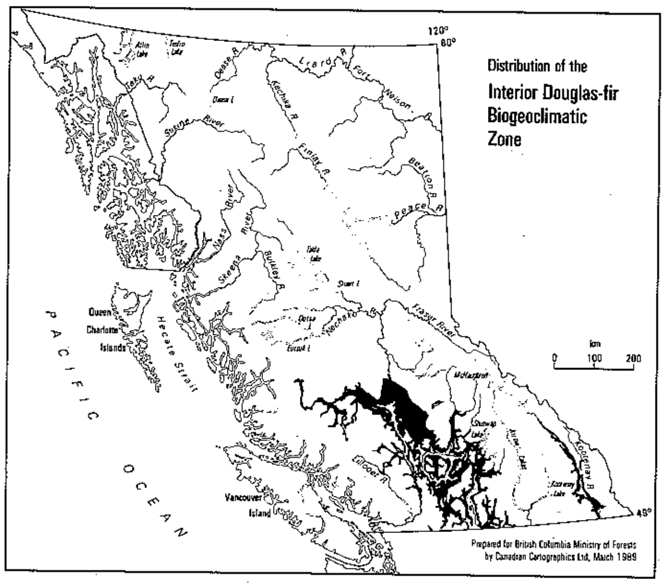

Figure 1.—The Interior Douglas-fir Zone.

Damaging frosts can occur during every month of the growing season on these Douglas-fir sites (Environment Canada 1985). In fact, conditions on these sites are similar to desert conditions where the dry air heats and cools very quickly. As many as fifty radiation frosts have been recorded per growing season (Spittlehouse and Stathers 1990). High frequency of frost during the growing season is very detrimental to the survival and early growth of Douglas-fir since it has a low frost tolerance compared to other Northwest tree species (Minore 1979; Krajina *et al.* 1982).

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Drought is quite prevalent on these sites during the growing season, due to high temperatures and low precipitation (Environment Canada 1985). The droughty conditions are accentuated in openings created by fire or logging where maximum daytime temperatures and wind speeds are higher than in treed areas. Douglas-fir has a moderate drought tolerance compared to other Northwest species. However, it does not have the physiological capacity to exploit hot, dry environmental conditions as compared to pioneer species such as lodgepole pine (Edmonds 1975). This susceptibility to summer drought increases when root growth is suppressed by low soil temperatures (Lopushinsky and Karufmann 1983).

Even though these are not brushy sites, vegetation competition is also a problem. Native grasses such as pinegrass occupy the majority of these areas and clearcuts may also be seeded with more palatable, domestic grass species for cattle forage. Both native and domestic grasses remain physiologically active longer than Douglas-fir seedlings during drought conditions. As a result, these grasses transpire more water than Douglas-fir seedlings and become strong competitors for moisture (Nicholson 1989). The grass also reduces nighttime wind speeds resulting in a reduction in the mixing of cold air next to the surface with warmer air above. Therefore the risk of frost increases (Stathers 1989).

Improvement in Douglas-fir planting stock may help to increase plantation success. Stock quality is a difficult factor to measure. It can be compromised at any stage of reforestation from unsatisfactory nursery practices to inadequate shipping and handling, and finally to poor planting in the field.

Cattle are frequently grazed on Douglas-fir plantations in the dry belt since multiple use dictates that land must be shared by all users. Poor cattle management in these areas can result in serious damage to Douglas-fir seedlings and may become an attributing factor to plantation failure. This paper outlines the findings of research trials established to address the above mentioned operational problems. The trials are located in the dry belt Douglas-fir areas and deal with the following subjects:

1) nurse crops,
2) site preparation,
3) stock types, and
4) cattle damage.

METHODS USED TO ENHANCE REGENERATION AND SURVIVAL OF INTERIOR DOUGLAS-FIR SEEDLINGS

Nurse Crops

Douglas-fir growing in the interior of British Columbia is a climax species that naturally regenerates under itself. In partially cut stands the overstory of Douglas-fir provides a seed source and a protective cover for new seedlings. However, if these areas are clearcut or burned by wild fire, re-establishing Douglas-fir is very difficult. The pioneer species on these sites is lodgepole pine. Once a stand of pine is established it can be used as a nurse crop for young Douglas-fir seedlings.

A nurse crop must allow enough light and moisture to be available for the underplanted seedlings and provide protection from damaging environmental factors such as frost. Also, planter access and other operational issues must be considered.

Since lodgepole pine tends to regenerate into dense stands it is not usually suitable as a nurse crop. However, if these stands are properly spaced, light and moisture become more available. Planter access improves as the slash decomposes. The requirements for this nurse crop trial were as follows:

1) the stand had to have been previously spaced by approximately five years,
2) the nurse crop trees had to be evenly spaced,
3) the nurse crop trees had to be over 2 meters in height with good crown development to provide protection for the underplanted seedlings,
4) all Douglas-fir seedlings were planted near the north side of a pine nurse crop tree just inside the edge of the crown to provide maximum shade and protection from frost but allow adequate light and moisture for the seedling, and
5) a clearcut had to be adjacent to each nurse crop stand to compare seedling survival and growth under the two different growing conditions.

Soil and air temperatures were monitored to determine the number and severity of damaging frosts under the spaced pine stands and in the clearcuts. Minimum air temperatures at seedling height (15 cm) indicated frosts were more intense and frequent in the clearcut than under the nurse crop (Figure 2). The pine stand acting as a nurse crop provided protection from detrimental environmental factors.

Severe frost damage on newly established seedlings can indicate future mortality problems. Therefore, frost damage was assessed after the first growing season. Figure 3 shows that two of the four clearcut areas suffered intense frost damage whereas seedlings planted under adjacent nurse crops of pine received minimal damage. These results carried into the second year seedling survival. On the two clearcuts with heavy first year frost damage, survival was very poor but survival was excellent under all of the nurse crops (Figure 4).

This study was established as a pilot trial. Other factors must be considered before this method

1) Optimal stand spacing for the nurse crop.
2) Optimal location for planting Douglas-fir seedlings.
3) Harvesting system for a two crop stand.

Mechanical Site Preparation

Mechanical site preparation can be used to modify the seedling micro-environment. It can reduce frost occurrence, vegetation competition, soil density, and increase available moisture.

Many types of site preparation expose mineral soil which reduces potential frost damage. The exposed mineral soil around a seedling absorbs incoming radiation during the day and reradiates it back at night. This warms the air around the seedling and reduces the risk of frost. Conversely, a duff layer acts like insulation. It does not allow the soil to heat up during the day and consequently provides minimal warming of the seedling at night.

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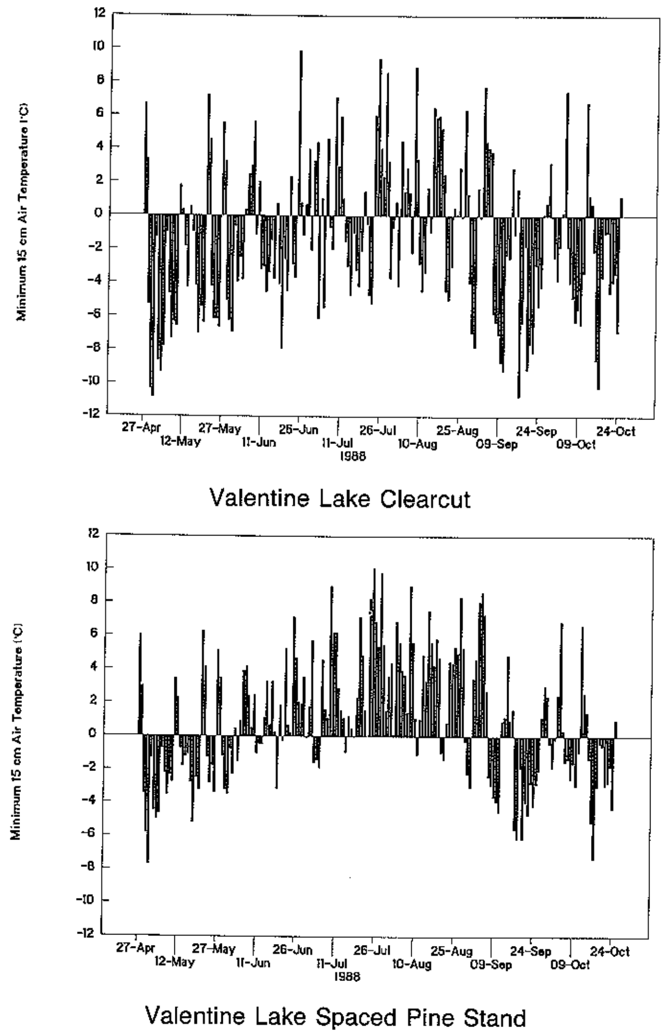

Figure 2.—The minimum air temperature at seedling height (15 cm) in the Interior Douglas-fir Zone.

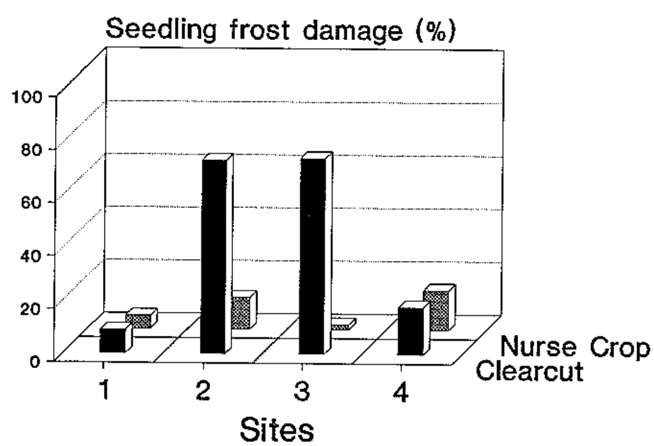

Figure 3.—Percent Douglas-fir seedling frost damage after the first growing season.

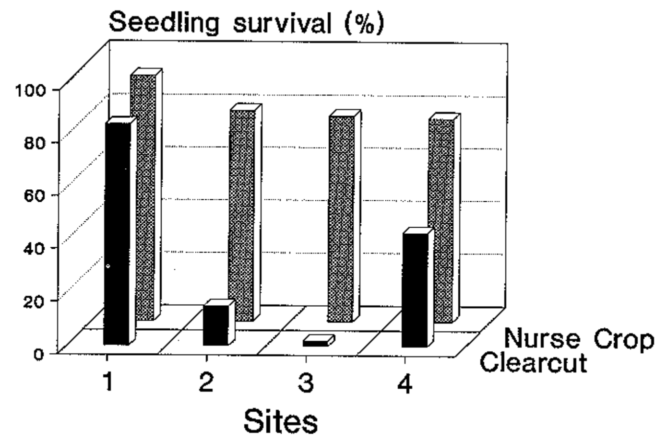

Figure 4.—Percent Douglas-fir seedling survival after two years.

Each mechanical site preparation treatment involves one or more of the following: ripping, trenching, and/or screefing. Ripping reduces soil density which increases the infiltration rate of water into the seedling root zone. Trenching reduces vegetation competition, captures moisture, and exposes mineral soil. Screefing exposes mineral soil and reduces vegetation competition. Micro-site conditions can be altered in a variety of ways depending on the form of site preparation chosen.

Trials were established in these dry belt areas to test many forms of site preparation. The site preparation methods referred to in this paper are listed below.

1) No Treatment (Control)
   - Seedlings are planted directly into existing vegetation and duff.
2) Hand Screef (Scr)
   - A small patch of mineral soil is exposed. The size of the patch varies from 15 cm x 15 cm to 30 cm x 30 cm. A small depression is often created with this method.
3) Patch Scarifier (Leno)
   - Creates continuous patches of exposed mineral soil approximately 60 cm x 100 cm.
4) Disc Trencher (Disc Trench)
   - Creates a continuous trench exposing mineral soil.
5) Ripper Tooth (Rip)
   - Rips the soil to approximately 40 cm depth creating a narrow deep trench.
6) Winged Ripper Tooth
   - Similar in depth to the ripper tooth but the trench is wider with a small berm.
7) V-plow or Scalp
   - Removes surface organic material and vegetation leaving a continuous swath of mineral soil. The small one meter wide blade is used in both the IDF zone and the SBS zone. The larger three meter wide blade is only used in the SBS zone.
8) V-plow & Winged Ripper Tooth (V-plow & Ripper)
   - A winged ripper tooth is run down the middle of the one meter wide v-plow path producing a combination of both treatments.

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9) Ripper Plow (Rip plow)
   - Creates a deep and wide trench. Large berms are formed exposing more mineral soil than the winged ripper tooth.

10) Hand Dug Trench (Trench)
   - A continuous trench approximately 20 cm deep and 15 cm wide made by a ripper plow and improved by hand digging for trial purposes.

Frost was identified as a principle cause of seedling damage. On one trial, frost damage was assessed after the first growing season. Frost damaged 31% of the seedlings in the control and only 15% of the seedlings in the v-plow and the v-plow & ripper tooth treatments (Figure 5). These treatments have exposed mineral soil and reduced the amount of frost damage.

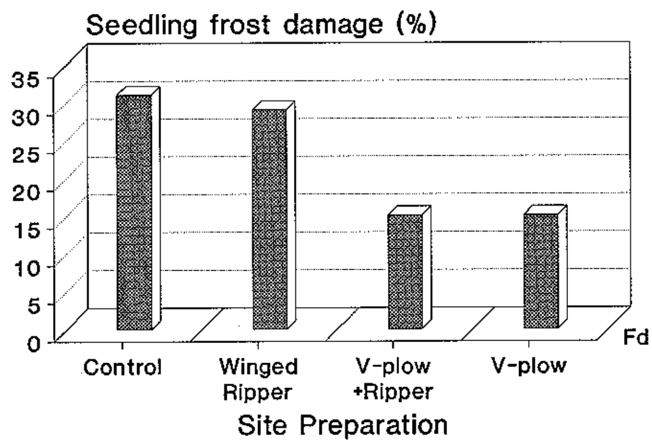

Figure 5.—Percent Douglas-fir seedling frost damage after one growing season (IDF).

In another five year old trial, site preparation treatments affected seedling survival. Survival was poor in all treatments with the highest seedling survival reaching only 52%. While this low survival was probably caused by poor stock quality, any form of trenching increased seedling survival substantially (Figure 6). Seedling survival was generally much higher on the moister SBS zone ranging from 5-76%. In contrast to the IDF site, seedling survival on the patch scarified treatment was similar to survival on the disc trencher and the ripper tooth treatments. The highest seedling survival was found on the ripper plow and v-plow treatments (Figure 6). Hand screefing did not improve seedling survival.

Site preparation did not have a strong effect on seedling growth. Seedling height growth was poor in all treatments with the tallest mean seedling height only 30 cm after five years (Figure 7). This poor growth can be attributed to the frequent frosts throughout the growing season affecting terminal bud development. Up to 80% of the seedlings had dead terminals in 1989 (Figure 8). The percentage of dead terminals decreased as the intensity of site preparation increased. Although there were no differences in growth, there were differences in seedling condition and general appearance (Figure 9 and 10). The seedlings that look more vigorous now may eventually produce more height growth.

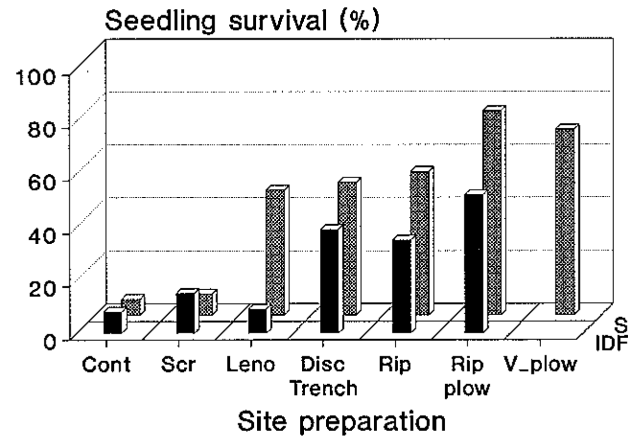

Figure 6.—Percent Douglas-fir seedling survival after five years.

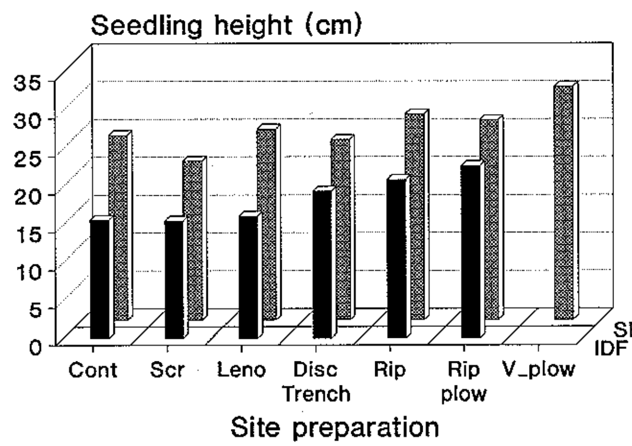

Figure 7.—Douglas-fir seedling height after five years.

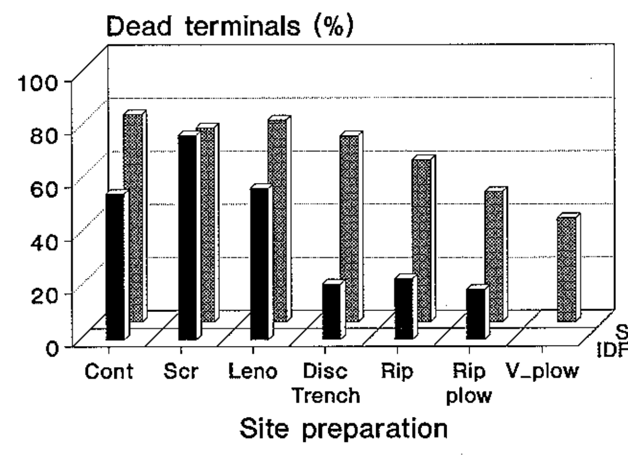

Figure 8.—Percent dead terminals on Douglas-fir seedlings after the 1989 growing season.

Another three year old trial in the IDF zone confirms these results. Site preparation treatments that created some form of trenching increased seedling survival (Figure 11). Seedling height growth was minimal and increased slightly on site prepared areas (Figure 12).

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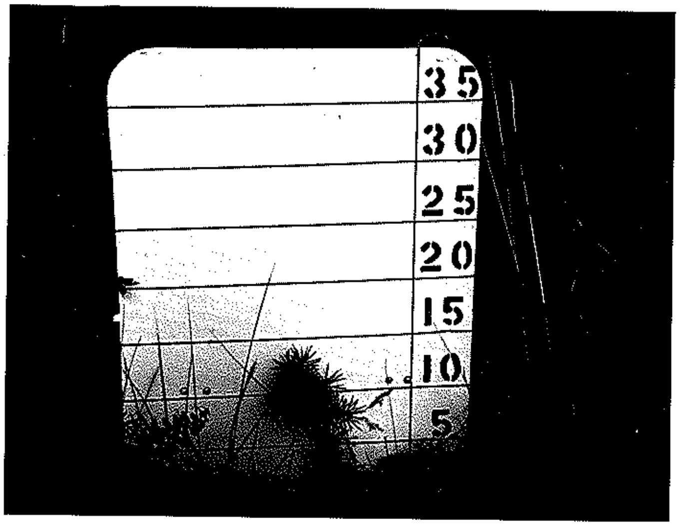

Figure 9.—Five year old. . .hand screefed treatment (IDF).

Figure 10.—Five year old. . .ripper tooth treatment (IDF).

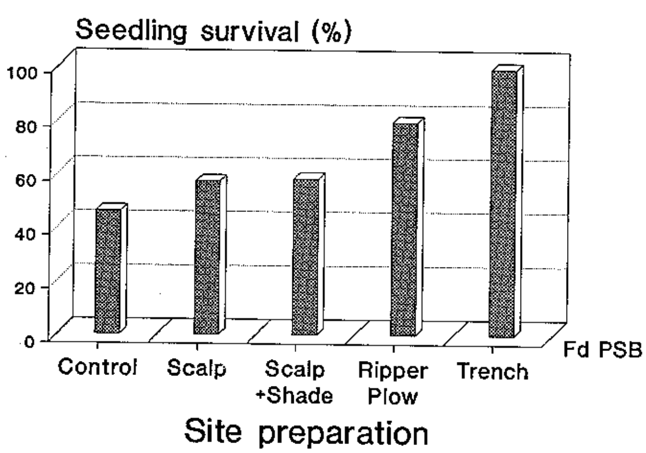

Figure 11.—Third year Douglas-fir seedling survival (IDF) (Black *et al.* 1989).

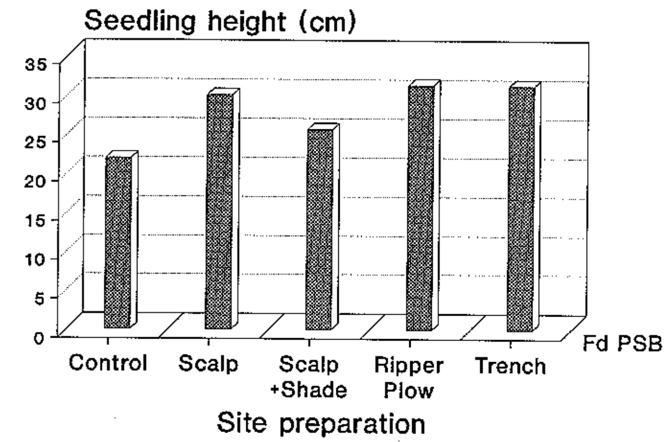

Figure 12.—Third year Douglas-fir seedling height (IDF) (Black *et al.* 1989).

Chemical Site Preparation

Herbicides were tested on these dry sites to control grass competition. Although herbicides were effective at controlling grasses, this controversial treatment has not improved seedling survival (Black *et al.* 1989). Herbicides do not expose mineral soil or disturb the soil profile. Even without grass competition other factors such as frost are still affecting seedling survival.

Stock Types

Both container (1+0 PSB 313) and bareroot (2+0) Douglas-fir stock were planted on IDF and SBS sites. Bareroot seedlings performed slightly better than the container stock on two trials in the IDF zone. The reverse trend was found on a moister SBS site. Container stock had a higher survival rate than the bareroot stock after six years. Other factors need to be considered and tested before any stock recommendations can be made for these dry sites.

Species

Very little Douglas-fir has been planted operationally on dry belt sites because of continuous plantation failure. Lodgepole pine is a pioneer species and therefore is better adapted to regenerating on clearings. It's survival and early growth surpasses that of Douglas-fir on clearcut areas. If some form of site preparation is used, pine survival is usually between 75-100% and it can reach a height of 50 cm on dry sites and over one meter on moister sites after five years.

CATTLE PLANTATION INTERACTIONS

Cattle are commonly grazed in young dry belt fir plantations. Seedlings can be trampled and occasionally browsed. For cattle and seedlings to co-exist proper cattle management techniques must be used. Seedling damage can be minimized if the cattle are properly herded on site and moved to other sites throughout the growing season. Differences in cattle damage on the SBS and IDF sites are a result of variations in cattle management techniques (Figure 13). On the IDF site, a large number of cattle spent approximately two months continually grazing in the same

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spot. Whereas on the SBS site the cattle were spread over a larger area for a shorter time span. Therefore, the grazing intensity was much lower on the SBS area minimizing seedling cattle damage.

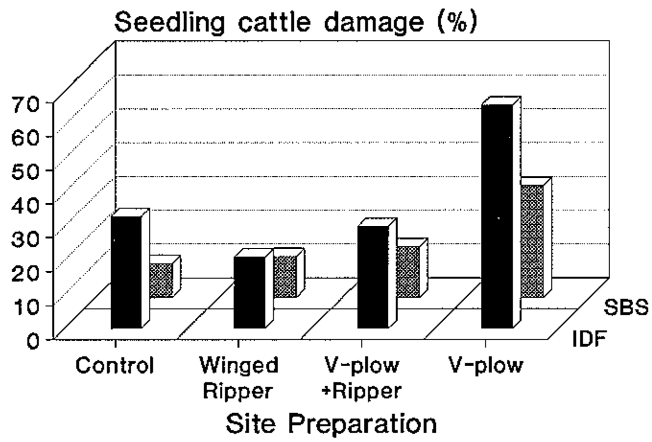

Figure 13.—Percent Douglas-fir seedling damage by cattle after two years.

Site preparation techniques can also affect the amount of cattle damage to seedlings. Figure 13 shows the differences in seedling damage on four different types of site preparation on one trial. The v-plow created walking paths for the cattle resulting in excessive damage especially on the IDF site (66%) where the grazing intensity was higher. However on the same site, damage dropped to 30% when a winged ripper tooth was run down the middle of the v- plow path. Cattle damage on the winged ripper tooth treatment was less than the control on the IDF site. The decrease in damage was probably due to the uneven footing created by the ripper tooth which the cattle avoided. The nurse crop trial seedlings planted in the clearing had 52% cattle damage while the seedlings planted under the pine trees received only 1% damage (Figure 14). Cattle do not like to move through spaced pine stands. They tend to stay in the shade on the edge of a clearcut and then feed in the openings.

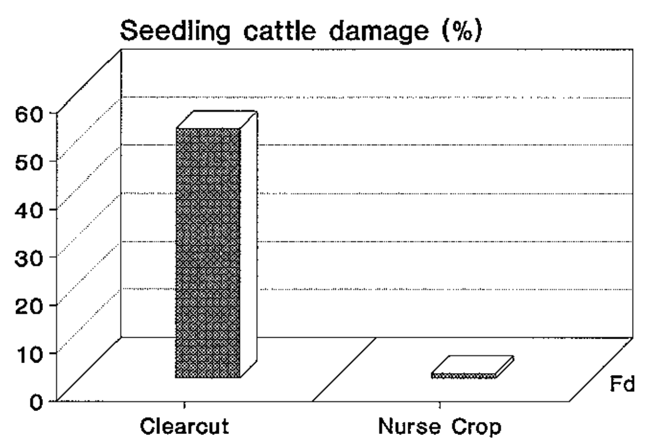

Figure 14.—Percent Douglas-fir seedling damage by cattle after two years.

CONCLUSIONS

These research trials have provided some insight on how to regenerate Douglas-fir on the dry belt Douglas-fir sites. Frost is a critical factor that must be considered. Treatments that did not alleviate frost damage such as herbicides did not improve seedling survival. Very dry sites may require treatments with more soil disturbance compared to slightly moister areas. Each site needs to be assessed individually to determine the optimal treatment. Treatments that improved seedling survival included:

1) Nurse Crops

   The nurse crop altered the micro-site climate conditions primarily by reducing frost damage. Cattle damage was also minimized by this treatment.

2) Mechanical Site Preparation

   On the driest sites some form of trenching is recommended. As moisture availability increases trenching is less critical and mechanical screefing may be adequate. However, trenching still produces the highest seedling survival.

Cattle damage can be decreased by fencing plantations, by not creating paths for cows to walk on and by using appropriate cattle management techniques. Cattle movement should be frequent and the number of cows on a site should be minimized. Do not let them graze continually on one site for a long period of time!

Seedlings must be vigorous to exist in the harsh climate of the dry belt. However, which stock type is most suitable for these sites is unknown. Other factors affecting seedling performance such as nursery practices and storage techniques require further investigation.

Seedling growth was generally very poor even after five years. Some seedlings did have good form and appeared vigorous. Growth differences between treatments may occur over the next five years.

Species diversity is important to a forest's health. A mix of lodgepole pine and Douglas-fir is more desirable than a monoculture of lodgepole pine. Therefore it is important to make a special effort to re-establish Douglas-fir on these dry belt sites. Artificial regeneration of Douglas-fir seedlings is difficult in the harsh climate of the dry belt, but new silviculture techniques may improve seedling performance.

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Authors

Teresa A. Newsome
B.C. Ministry of Forests
Cariboo Forest Region
540 Borland Street
Williams Lake, B.C. V2G 1R8
Canada

D. Craig Sutherland
B.C. Ministry of Forests
Cariboo Forest Region
540 Borland Street
Williams Lake, B.C. V2G 1R8
Canada

Alan Vyse
B.C. Ministry of Forests
Kamloops Forest Region
515 Columbia Street
Kamloops, B.C. V2C 2T7
Canada

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