Forest Site Management Section
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July 30, 1999

Silviculture Note 20

Natural regeneration of lodgepole pine on four types of seedbed:

The effects of harvesting systems that process at the stump versus at roadside and chain-dragging

Summary

One year after an SBS site near Fraser Lake was clearcut harvested, natural lodgepole pine germinants were present at a density of 13 000–32 000/ha. A further 500–2500 germinants/ha were counted the second year after harvesting, but there was no new germination in the three years following. Germination appeared to be heaviest on forest floor material that had been compacted by repeated passes of heavy equipment, perhaps because of better contact between substrate and seed. Five years after harvesting, >93% of first-year germinants and >70% of second-year germinants continued to survive. The high rates of germination and survival are attributed to wet weather in June of the two years after harvesting. The largest numbers of germinants were counted in areas that had **not** *been chain-dragged, but it made little difference whether processing during harvesting took place at the stump or at the roadside. The lowest germination rate (13 000 stems/ ha) occurred in areas that had been processed at the stump and later chain-dragged. Lower germination rates in chain-dragged areas are partly the result of cones opening during the three months between harvesting and site preparation.*

Introduction

Natural regeneration of lodgepole pine in British Columbia is most likely to be successful on sites where there is an abundant supply of viable seed, a suitable seedbed for germination, and conditions that are conducive to ongoing survival and growth of germinants (Bancroft 1996). The potential for success may be influenced by the harvesting system and site preparation techniques employed, particularly as they relate to mineral soil exposure, soil compaction, slash load and distribution, and cone distribution.

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Mitchell and von der Gönna (1994) speculated that harvesting systems that process at the roadside would be more likely to promote natural regeneration because of greater exposure of mineral soil by the former than those that process at the stump. However, processing at the stump would likely provide more even distribution of cones. Site preparation techniques such as chain-dragging can also enhance natural regeneration of lodgepole pine by exposing mineral soil and mixing mineral and organic materials together. Mitchell and von der Gönna (1994) expected that mechanical site preparation would be less effective following processing at the stump during harvesting, however, because of the large amount of slash left on site. In addition, conditions under slash piles were not likely to support the survival of germinants.

Relying on natural regeneration is generally a riskier option than planting, regardless of measures employed to improve the chances of success. It also involves a longer time delay before legislated stocking criteria can be met. For example, Crossley (1976) and Johnstone (1976) found that annual recruitment of lodgepole pine germinants peaked six to eight years after logging, and then continued at a slow rate for up to 14 years. It is difficult to know when stocking levels are stable and no longer subject to annual cycles of mortality and germination, and also difficult to control density. Planting may reduce the need for fill planting, but it can also compound density problems and increase the need for juvenile spacing.

In 1992, a research trial was established near Fraser Lake, BC to study harvesting systems that process at the stump versus at the roadside (Table 1) (Mitchell and von der Gönna 1994). Abundant natural pine regeneration was observed in the first spring after harvesting and site preparation, particularly in areas where heavy equipment had compacted forest floor materials. Plots were established in fall 1993 to monitor ingress and mortality of germinants on various substrates in the harvesting/site preparation treatments.

Table 1. Chronology of activities, 1992 to 1997

Activity	Date
Harvesting	June 2–July 24, 1992
Seedbed and cone surveys	August 10, 1992
Chain-dragging	November 3–5, 1992†
Germinant counts	Fall 1993, Fall 1994, Fall 1995, Fall 1996, Fall 1997

† Chain-dragging for seedbed enhancement should be carried out as soon as possible after harvesting (Bancroft 1996). The delay of four months between harvest and dragging is not optimal.

Site description

The Holy Cross study site is located in the Vanderhoof Forest District, 51 km south of Fraser Lake, on the Holy Cross FS Road. It is on a 59 ha west-facing cutblock, at 918 m elevation, and is transitional between the SBSdk (Dry Cool Sub-Boreal Spruce) and SBSmc2 (Babine Moist Cold Sub-Boreal Spruce) biogeoclimatic subzones. The moderately well-drained soils are loam to sandy clay-loam, with slightly more coarse fragments in blocks assigned to the process at the stump treatment than the process at the roadside treatment. The forest floor was 2–6 cm thick prior to harvesting. Following logging, vegetation consisted mainly of sparse distribution of rose, birch-leaved spirea, and fireweed.

Harvesting/site preparation treatments (Mitchell and von der Gönna 1994)

Four harvesting/site preparation treatments were established in 1992:

1. Process-at-stump/Untreated
2. Process-at-stump/Chain-dragged
3. Process-at-roadside/Untreated
4. Process-at-roadside/Chain-dragged.

A feller-processor was used to cut and process stems at the stump, and pieces were skidded to the landing by grapple skidder. Where processing took place at the road, stems were cut using a high-speed disc-saw felling head mounted on a carrier, and skidded to the road by grapple skidder, where they were processed with the same type of feller-processor that had been used at the stump. Chain-dragging was carried out in designated areas with a John Deere 740 skidder fitted with a V-rake with retractable teeth.

Post-harvest summary (Mitchell and von der Gönna 1994)

1. More slash remained in areas processed-at-stump than processed-at-roadside. Processing at the stump aligned slash in piles running parallel to the line of skidder travel (Figure 1).
2. Seedbed surveys showed that the distribution of different seedbed types was virtually identical in the two harvesting treatments. Organic material occupied 90–91% of the area, mixed organic/mineral occupied 6–7%, and exposed mineral soil occupied 3%. This contradicts expectations that more mineral soil would be exposed by processing-at-roadside than processing-at-stump. These surveys did not assess compacted organic material as a separate substrate.

Figure 1. Linear slash alignment following process at the stump harvesting *(photo courtesy of FERIC).*

3. About 6% more lodgepole pine cones were counted in plots processed-at-stump than processed-at-roadside. Across all ages of cones, 69–75% of cones were open three weeks after logging was completed.
4. Chain dragging resulted in greater amounts of exposed mineral soil and mixed organic/mineral soil in areas processed-at-roadside than those processed-at-stump. Slash accumulations in areas processed-at-stump limited the ability of chain-dragging equipment to expose mineral soil.

Germinant counts (1993–1997)

Germinants were counted in the four harvesting/site preparation treatments described above, on four types of seedbed:

1. Organic (undisturbed forest floor)
2. Pressed organic (forest floor material that had remained in place during harvesting, but was compacted by repeated passes with heavy equipment)
3. Mixed organic/mineral
4. Exposed mineral.

To be counted, germinants had to be alive at the time of assessment, or have survived long enough to leave a discernible 'corpse.' Assessors were able to count dead germinants that had survived only to the cotyledon stage, but it cannot be guaranteed that all ephemeral germinants were caught. Counts were made in early September of each year from 1993 to 1997. Germinants were not counted in spring 1993, but the number was assumed to be the sum of live and dead germinants counted in fall 1993. Little germination likely occurred immediately following harvesting in late-summer of 1992 because seed were not yet stratified and August was a dry month. The majority of germinants counted in 1993 likely originated in the spring of that year. Groups of germinants were marked with small stakes to differentiate between surviving individuals and new germinants.

Germination results

Timing of germination and mortality

In spring 1993, mean germination rates across all seedbed types were between 14 400 and 31 800 stems/ha in the four harvest method/site preparation treatments (Figure 2). Initial germination was highest in the process-at-roadside/untreated treatment, and lowest in the process-at-stump/chain-dragged treatment. Mortality among those original germinants was low between spring and fall 1993, ranging from 1.3% (process-at-roadside/untreated) to 6.9% (process-at-stump/chain-dragged). From fall 1993 to fall 1997, the only further mortality among those original germinants occurred in the process-at-stump/chain-drag treatment, where 400 stems/ha died between fall 1994 and fall 1995.

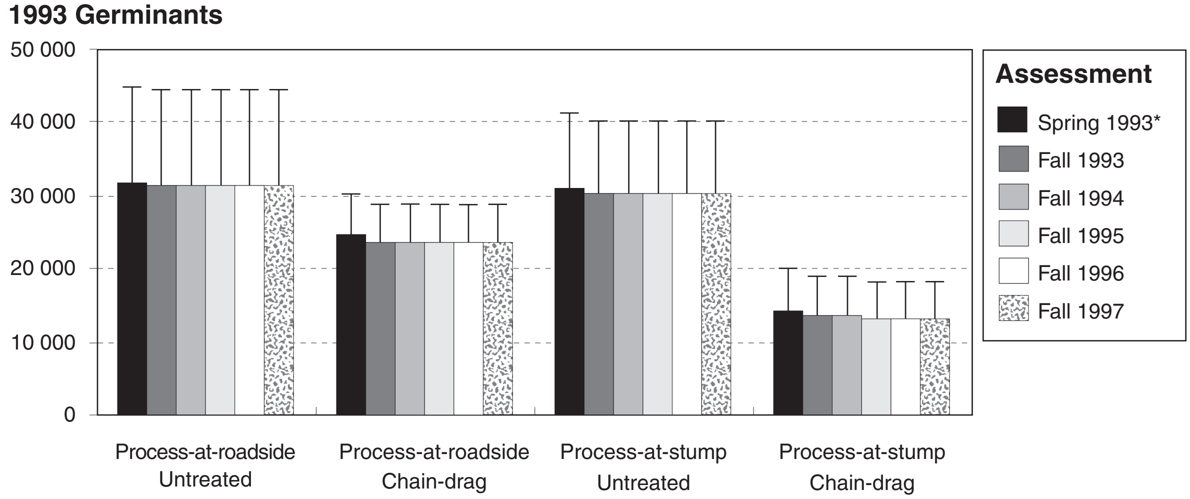
A second flush of germination took place in spring 1994, ranging from 600 to 2600 stems/ha in the four treatments (Figure 3). There was up to 30% mortality among this second flush of germinants between 1994 and 1997, which had little effect on overall numbers. There was no germination after 1994.

Effects of harvesting technique

In areas that were harvested but not chain-dragged, total numbers of germinants were similar, regardless of whether processing had taken place at the roadside or at the stump. After five years, numbers of surviving germinants differed by less than 4% (32 400 versus 31 200 stems/ha) in these two treatments. More germinants were counted in mineral soil where processing had been at-the-roadside than at-the-stump (Figure 4). This is difficult to explain, since seedbed surveys indicated that the proportion of exposed mineral soil was identical in the two areas.

Processing at the stump left linear piles of slash that accumulated along the path of travel of the processor (Figure 1). Areas between slash piles were dominated by 'pressed organic' material that had been compacted by harvesting machinery, explaining the large proportion of germinants found on that substrate in the process-at-stump/untreated area (Figure 4c). Germination and/or survival under the slash piles is likely to have been poor for three reasons:

1. Serotinous cones that were elevated above the ground did not tend to release their seed, probably because they did not encounter the necessary high temperatures or mechanical stress.



* *The number of spring 1993 germinants was calculated by adding the numbers of live and dead germinants counted in fall 1993.*

Figure 2. Survival of 1993 germinants, from 1993 to 1997. *Error bars represent one standard error.*

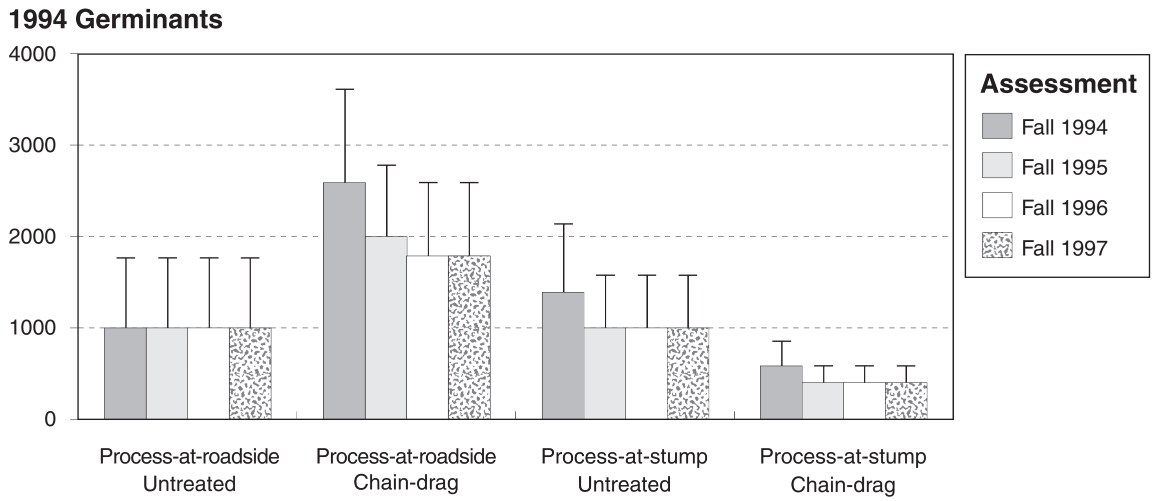


Figure 3. Survival of 1994 germinants, from 1994 to 1997. *Error bars represent 1 standard error.*

2. Seed that was released within the slash piles would have been in a dark environment unsuitable for germination and/or survival of germinants.
3. Predation was likely higher under slash piles.

Three of 10 plots in the process-at-stump/untreated area fell at least partially in slash piles.

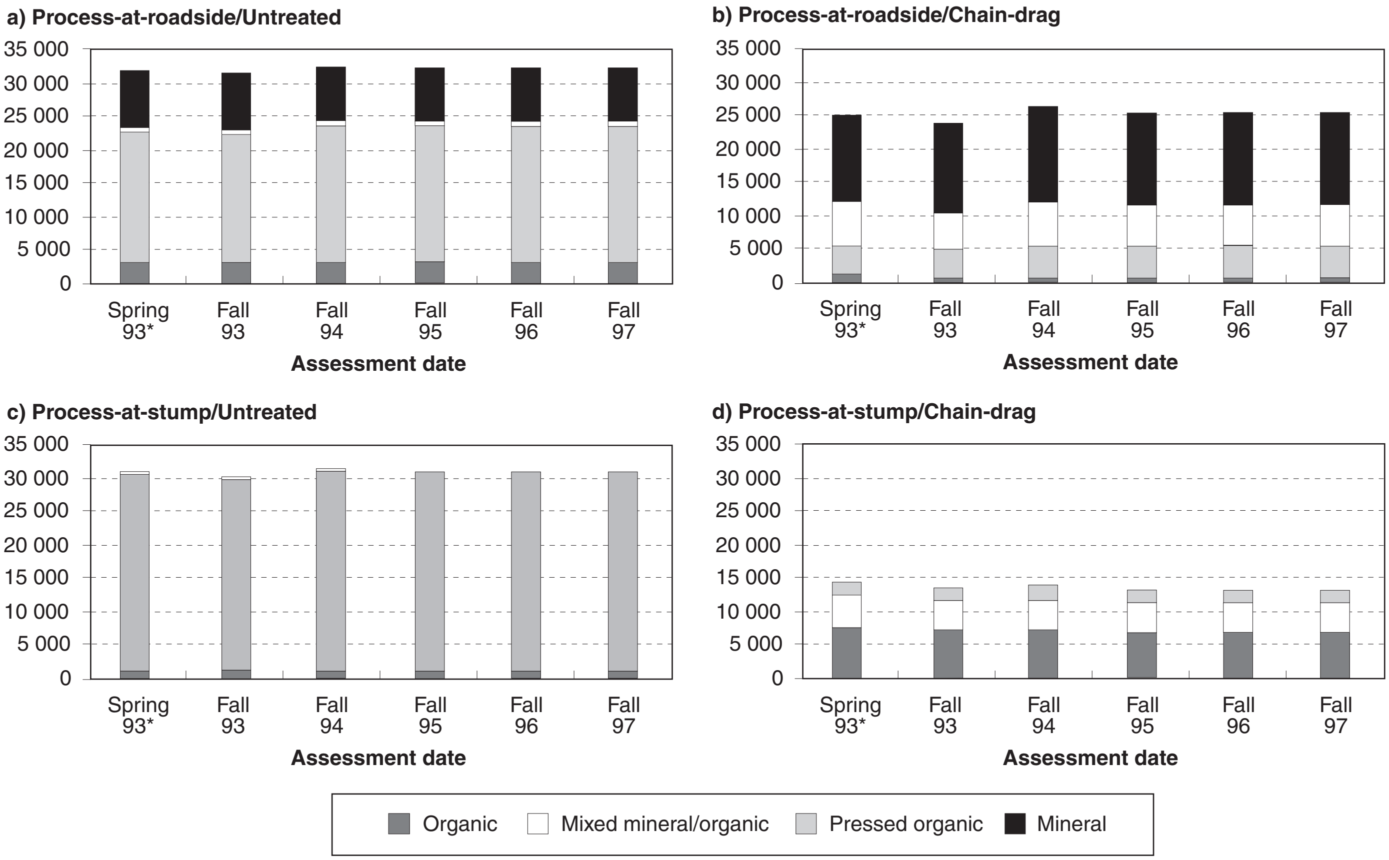
Effects of chain-dragging

Chain-dragging is often prescribed to improve the seedbed for natural regeneration, but on the Holy Cross site, more germination occurred in blocks that were left untreated (Figure 4). Chain-dragging likely had a negative effect on this site because it was not carried out until after the majority of cones had opened. Surveys indicated that most cones had opened by mid-August, whereas chain-dragging did not take place until November. Chain-dragging would also have mixed and decompacted the pressed organic substrate, which was favourable to germination in untreated areas.

Better chain-dragging coverage occurred in areas that had been processed at the roadside than at the stump because of lesser slash loads in the former. This likely resulted in greater exposure of mineral soil in the process-at-roadside/chain-drag treatment, and hence a greater proportion of germinants in that substrate. In the process-at-stump/chain drag treatment, the greatest proportion of germinants were found on undisturbed organic material.

Seedbed effects

Although seedbed type was recorded for each germinant, the proportion of plot area occupied by each type of substrate was not estimated at the



** The number of spring 1993 germinants was calculated by adding the numbers of live and dead germinants counted in fall 1993.*

Figure 4 a–d. Number of live germinants/ha in four harvesting/site preparation treatments, on six assessment dates from 1993 to 1997.

beginning of the study. This makes it impossible to conclude that germination was more likely to occur on the pressed organic substrate even though numbers appear to have been greater on that material. Cones that dropped during harvesting were apparently pressed into the compacted surface of the forest floor, which may have improved contact between substrate and seed.

Precipitation

Weather information was not collected on the research site after 1992, but records from climate stations within a range of 75 km indicate that June was wetter in 1993 and 1994 than in 1995 or 1996 (Figure 5). Greater than 100 mm of precipitation fell in each of June 1993 and June 1994, compared to only 17 mm in 1995 and 44 mm in 1996.

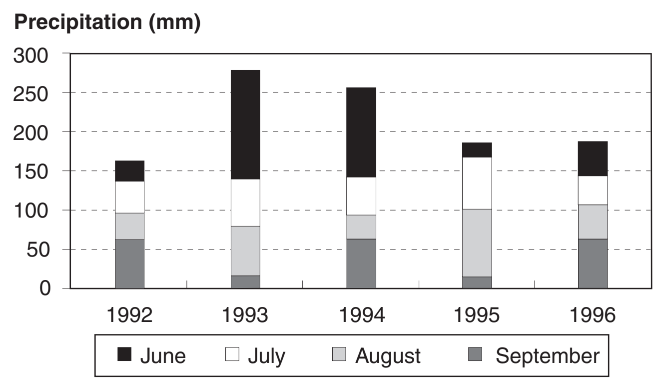


Figure 5. Cumulative precipitation, June through September (1992–1996).

(1992 data collected at the Holy Cross site; 1993 data at Vanderhoof; 1994–1996 data at Kenny Dam.)

Conclusions

Germination of lodgepole pine seed at the Holy Cross study site occurred in the first two springs following harvest, with the large majority of germination occurring in the first spring. This is likely related to wet weather in June of both those years. After 1994, no new germination occurred, contradicting other studies in which germination continued for up to 14 years (Crossley 1976; Johnstone 1976). Germinants were abundant where forest floor material had been compacted by heavy equipment, and it is speculated that improved contact between substrate and seed increased the availability of moisture to the germinating seed. A similar phenomenon has been observed for sown seed of jack pine, where tamping the soil surface, either before or after seed was sown, resulted in a 30% increase in the number of germinants after one season (Van Damme *et al.* 1988).

Mortality of germinants was surprisingly low on the Holy Cross site, which may also be related to the wet June weather in 1993 and 1994. It was particularly low among the spring 1993 germinants (<7%). Nearly all mortality occurred within a year of germination, regardless of whether germination had taken place in 1993 or 1994. However, mortality was higher (up to 30%) among the 1994 germinants than the 1993 germinants. Five years after harvest, regardless of harvesting method and the application of chain-dragging, large numbers of lodgepole pine germinants survived. The highest survival occurred where processing had taken place at the roadside and the area was not chain-dragged (32 400 stems/ha) and the lowest where processing had taken place at the stump and the area was then chain-dragged (13 200 stems/ha). This study was not intended to fulfil the requirements of a stocking survey, however, and it provides no information about the distribution of germinants across the cutblock or about the anticipated time to reach free growing.

By 1997, surviving seedlings were variable in size, and if they had not been tagged for identification in the year of germination, would have been assumed to be younger than their five years, and more variable in age (Figure 6).

Figure 6. 1993 germinants, all five years old, ranging in height from approximately 10 to 40 cm.

Acknowledgements

The Ministry of Forests expresses appreciation to Brian Walker of West Fraser Mills and Marvin Grismer for assistance with this project, FERIC for establishing the original study, Forest Renewal BC for contributing to funding, and to Jean Heineman for preparing this note.

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Editing, design and layout by TM Communications.