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Extension Note

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Forest Productivity and Soil Conditions on Rehabilitated Landings: Interior British Columbia

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Introduction

In British Columbia, soil rehabilitation aims to restore productivity to forest roads, landings, and trails that are no longer needed for access, and to areas that have suffered unavoidable or accidental damage as a result of forestry operations. Soil rehabilitation is an important component of management strategies to maintain or enhance timber supply in the working forest. Restoring productivity to degraded soils can also enhance other environmental values, and contribute to successful ecosystem or watershed restoration.

Soil rehabilitation research was initiated in British Columbia over two decades ago (e.g., Vyse and Mitchell 1977), and numerous contributions since that time have been reviewed by Bulmer (1998) and Sanborn et al. (1999a). In addition, a network of new research sites has been established to test new approaches to soil rehabilitation and to improve cost-effectiveness (Berch and Xiao 1998; Dykstra and Curran 1998; Inland Timber Management Ltd. 1998; Bulmer and Curran 1999a; Sanborn et al. 1999b; Venner 1999).

Despite significant progress in the past, and new information expected in the future, there is a need for information to guide operational projects that are currently under way. In particular, information is needed on the long-term effectiveness of soil rehabilitation efforts, and the extent to which operational soil rehabilitation can contribute to the timber supply. We examined tree growth and soil conditions on sites that were rehabilitated in 1991 in the British Columbia interior. The objectives of the work were (1) to document a minimum of 5 year's growth of lodgepole pine on rehabilitated landings, and compare it to growth on sites that were simply harvested, and (2) to document soil conditions affecting site productivity on the rehabilitated areas.

Operational Rehabilitation Projects

Boundary
George Delisle, Forestry Supervisor for Pope and Talbot, began using brush blades to till landings in 1988. By the mid 1990s, the winged subsoiler was used extensively in Pope and Talbot's soil rehabilitation program,

and more than 1000 landings had been tilled, seeded, and planted to lodgepole pine. The rehabilitated areas occur in several biogeoclimatic zones, but most of the sites we studied were in the Interior Cedar–Hemlock (ICH) and Montane Spruce (MS) zones.

Kispiox and Kalum

Two programs of landing rehabilitation were carried out in the Prince Rupert Region by the Ministry of Forests, beginning in 1990. Approximately 560 landings were rehabilitated and planted in the two forest districts by 1992 (Marsland 1994), and work continued in the Kalum District until 1995. The rehabilitation treatment consisted of tillage with a winged subsoiler, seeding for erosion control,[1] and planting to lodgepole pine. In the Kalum District, 200 kg/ha of 19-23-15 fertilizer was also applied to the rehabilitated areas. All of the landings we studied in the Kispiox and Kalum districts occurred in the ICH biogeoclimatic zone.

The operational projects in all three forest districts were suitable for retrospective study because:

- the landings were all tilled with a winged subsoiler, an implement still widely used for soil rehabilitation in British Columbia.
- there were plantations near the rehabilitated landings that were harvested but where soils had not been degraded. Tree growth in these plantations could be measured and compared with growth on the landings.
- there were sufficient potential replicates for our study. Pope and Talbot Ltd. (Midway) planted more than 150 rehabilitated landings in 1992. In Kispiox/Kalum, approximately 100 rehabilitated landings were planted in 1992.
- the treatments were well documented.

Study Sites

In three forest districts, we sampled a total of 98 randomly selected landings, and areas in the adjacent plantation. In the Boundary District, 41 landings were selected, 30 of them in the ICH and transition. In the Kispiox District, 32 landings in the ICH were selected. In the Kalum District, 25 landings in the ICH were selected.

Sampling Methods

1. Three .005 ha circular plots were randomly located on each landing, and three were located in the adjacent logged plantation.
2. Total height and all internode increments above 15 cm of all lodgepole pine (including naturally regenerated trees) were measured. We considered an established tree to be 15 cm tall, and recorded growth as a function of years since establishment. Abundance of other naturally regenerated tree species was also recorded.
3. Soil temperature was measured 15 cm below the mineral soil surface. Volumetric water content, also at 15 cm, was determined with a theta probe. Forest floor depth and penetration depth of a steel probe were recorded.
4. On all landings, composite surface (0–20 cm) soil samples were collected for determination of texture, total C, total N, mineralizable (available) N, and pH. On a subset of 10 landings per forest district, bulk density was determined for

1 In the Kalum District, the seed mix consisted of birdsfoot trefoil (15%), annual rye grass (10%), white clover (37.5%), and alsike clover (37.5%). It was spread at 25 kg/ha. In the Kispiox District, the seed mix consisted of chewings fescue (40%), alsike clover (25%), birdsfoot trefoil (25%), and white clover (10%).

surface (0–20 cm) soil using the excavation method, and foliage samples were collected for nutrient determination.

Stocking

Figure 1 shows that from 63% (Boundary) to 95% (Kispiox) of the time, the plots we sampled on landings had greater than 1000 stems/ha, 6 years after planting. The average stocking levels (lodgepole pine trees greater than 15 cm tall) were all higher than 1450 stems/ha. Because we did not sample landings that had not been rehabilitated, the effect of the soil rehabilitation treatments on seedling establishment is not known. However, the results indicate that a new forest usually established on these landings that were tilled with a winged subsoiler and planted to pine.

Growth

In the Boundary District (Figure 2), trees growing on rehabilitated landings

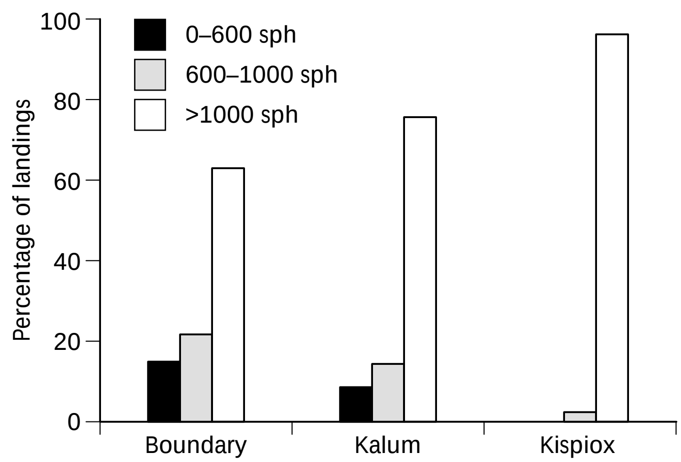

FIGURE 1 *Stocking density. Average densities were lower in the Boundary District (1450 sph), and higher in the Kalum (1800 sph) and Kispiox (1950 sph) districts.*

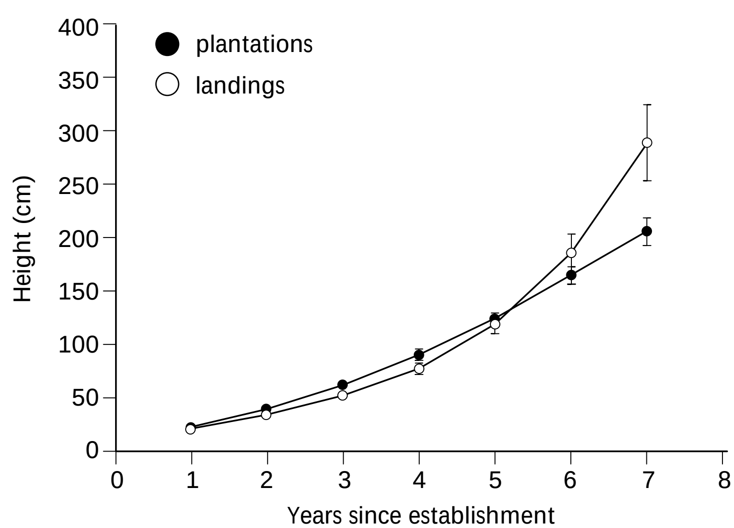

FIGURE 2 *Tree growth on landings and plantations in the Boundary District. Error bars represent pointwise 95% confidence intervals. n = 30 sites (ICH and transition only).*

in the ICH were growing as well or better than trees in the adjacent plantations 5 years after establishment. In the Kalum District (Figure 3), trees growing on landings were approximately 66% as tall as those on adjacent plantations 5 years after establishment, although growth rates appeared similar at that time. In the Kispiox District (Figure 4), trees on landings were about 51% as tall as trees on the adjacent plantation, 5 years after establishment, and growth rates were lower on the landings than on the plantations.

Landings in the Kalum District produced the largest trees for rehabilitated sites by a wide margin, even though the area has a climatic regime similar to that of the Kispiox District. The reasons for the better performance on rehabilitated landings in the Kalum District are not known at this time, but several factors could be

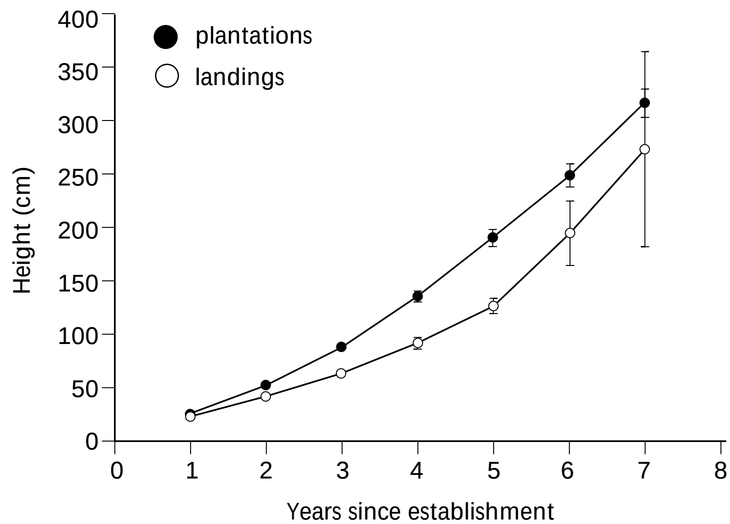

FIGURE 3 *Tree growth on landings and plantations in the Kalum District. Error bars represent pointwise 95% confidence intervals. n = 25 sites.*

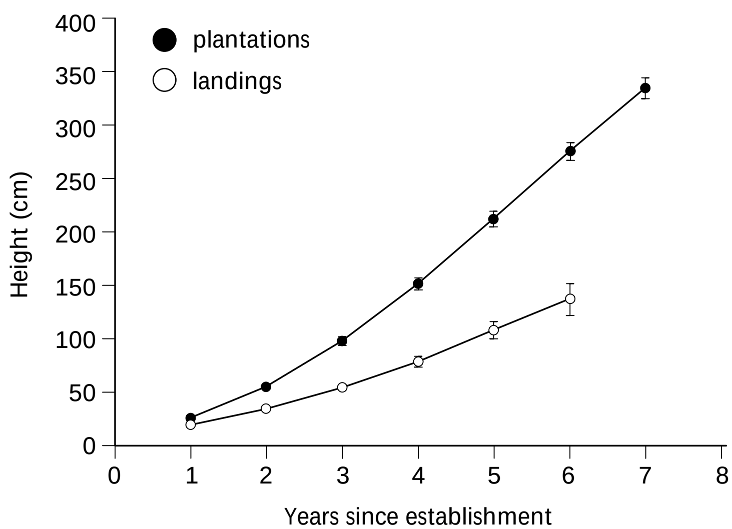

FIGURE 4 *Tree growth on landings and plantations in the Kispiox District. Error bars represent pointwise 95% confidence intervals. n = 32 sites.*

involved, including (1) use of bigger seedlings and copper-coated styroblocks in the Kalum District, (2) use of fertilizer in the Kalum District, and (3) different effectiveness of the subsoiling (there is a perception among the operational staff that the subsoiling in the Kispiox District resulted in less effective decompaction than the work in the Kalum District).

Pollack et al. (1985) suggested that acceptable performance of pine plantations in the ICH in the Prince Rupert Region was indicated if pine trees were 118 cm tall 5 years after planting. All of our rehabilitated landings met this expectation, and the plantation trees we measured were growing approximately twice as fast as this standard, which was developed only 15 years ago.

Trees in the plantations in the Boundary District were growing more slowly than trees in the plantations of the northern districts, but were meeting expectations for lodgepole pine in the Nelson Forest Region (Thompson 1996). Using these plantations as the standard, the rehabilitated landings in the Boundary District have achieved or exceeded their expected productivity. Measured trees on the landings in the Boundary District tended to be younger than those in the other districts, which reflects fill planting associated with some initial establishment problems, and the presence of a greater number of naturally established trees on the landings.

In summary, our results show that, in all three forest districts, planting trees on tilled landings resulted mainly in the establishment of a new forest on sites that were considered nonproductive. Growth rates, and therefore productivity, of trees growing on the rehabilitated landings were sometimes higher (Boundary) and sometimes lower (Kispiox and Kalum) than those for nearby plantations.

Soil Conditions and Foliar Nutrients

Average clay content for the landings in the Boundary District was 5%, and the average soil texture for landings and plantations was sandy loam. In the Kalum District, clay content of landings was about 8% higher than on the plantation sites, and average soil texture for landings was sandy clay loam. In the Kispiox District, average soil texture was sandy loam for landings and plantations.

In all three forest districts, landings were warmer and drier than plantation sites (Figure 5). Although the values in Figure 5 were obtained on several days, and at different times during the day, each landing and its associated plantation was usually measured within 2 hours. Lower soil moisture and higher temperature on landings may reflect the loss of forest floor materials during landing construction and use. Forest floor acts as a mulch, which prevents evaporative losses of water, and slows the rate of soil warming.

For the Boundary District, bulk density of surface soils was higher for landings than for plantations (Figure 6), though the values were not in the range expected to be growth-limiting.

Landings tended to have less C and less mineralizable N in all three forest districts (Figure 7), but the differences were small and non-significant for the Kalum District. For the Kispiox District, mineralizable N values on landings were substantially lower than the values for plantation sites. Differences in C and nutrients likely reflect the absence of topsoil on the rehabilitated landings.

Despite depleted levels of soil C and N on rehabilitated landings in the Boundary District, trees were growing at the same rate as those in the plantations. In the Kispiox District, reduced

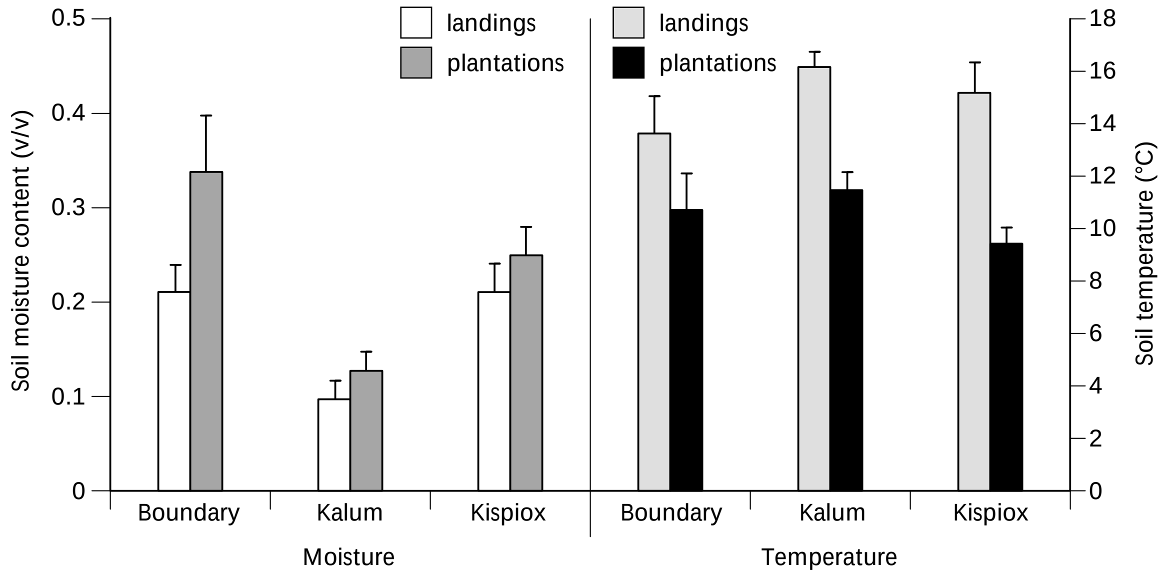

FIGURE 5 *Soil moisture and temperature. Error bars represent 95% confidence interval.*

soil C and N on landings was associated with slower tree growth than on plantations.

Foliar nutrient concentrations (Figure 8), determined on a subset of 10 landings and plantations in each forest district, were generally adequate for most nutrients (Carter 1992) with the exception of S, which appeared to be less than adequate for all sites. Foliar N levels were below adequate only for trees growing on the plantations in the Kalum District, indicating that N deficiency did not appear to be limiting growth on the landings. Similar values of foliar N were observed for trees growing on landings in the Kalum and Kispiox districts, suggesting that fertilizer application in the Kalum District had not significantly affected tree nutrition.

Implications of the Research for Current Rehabilitation Efforts

In general, the results for stocking in all three forest districts, and for growth in the Boundary and Kalum districts, indicate that soil productivity on the rehabilitated landings is similar to productivity levels of non-degraded soils. This finding is in agreement with other recent studies of soil rehabilitation (e.g., Bulmer and Curran 1999b).

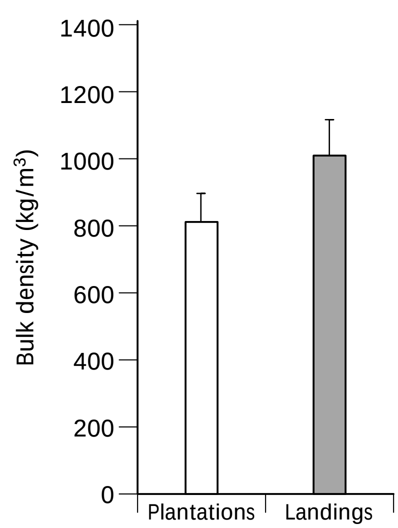

FIGURE 6 *Bulk density for soils of the Boundary District. Error bars represent 95% confidence interval.*

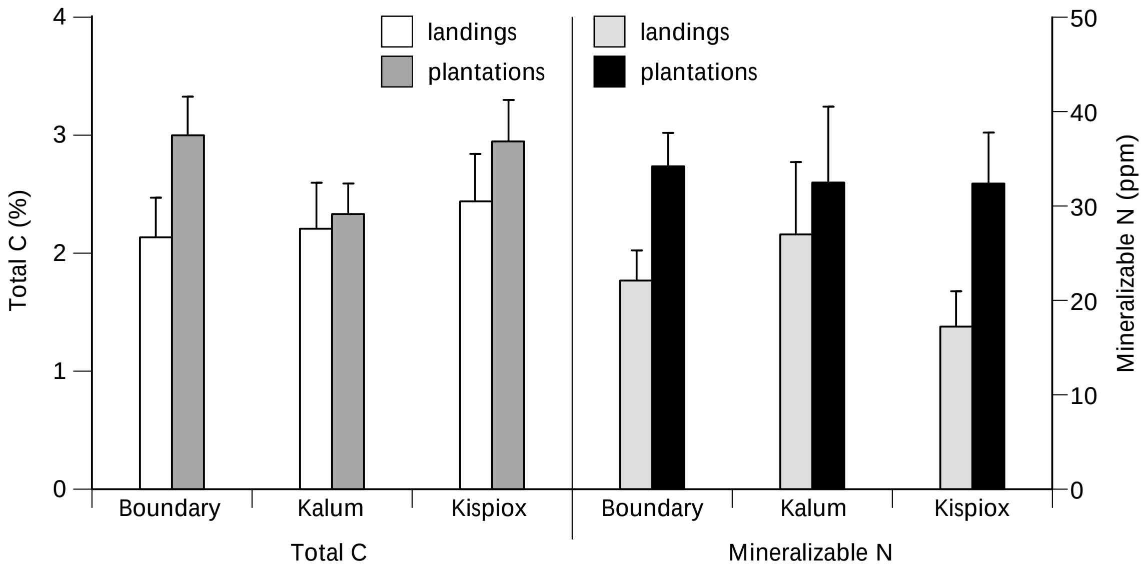

FIGURE 7 *Total C and mineralizable N for surface soils in all districts. Error bars represent 95% confidence interval.*

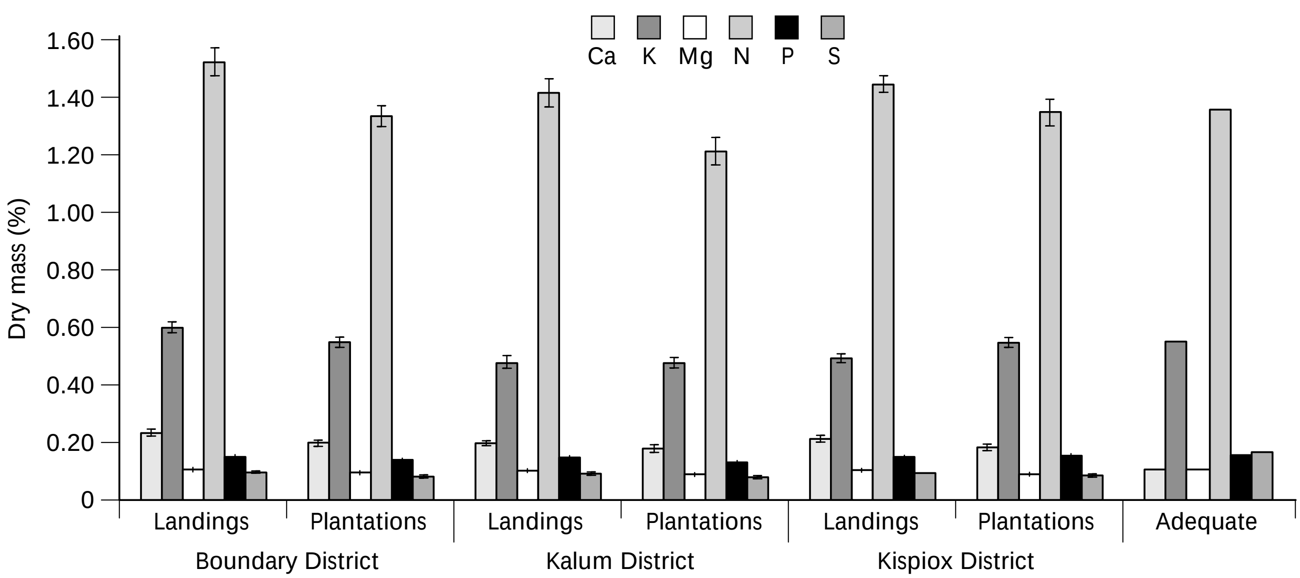

FIGURE 8 *Foliar nutrient concentrations by district. Error bars represent 95% confidence interval. n = 10/district.*

If topsoil had been retrieved during rehabilitation, higher soil C and N levels would be expected in the rehabilitated soils. Higher levels of soil C and N are expected to lead to improved tree growth on many sites, but likely not all sites.

Although we were not able to evaluate the extent to which the winged subsoiler improved soil conditions, results from the Boundary District indicate that soil bulk density is in a favourable range for root growth 7 years after subsoiling.

For these reasons, our results strengthen arguments that landings, and probably other disturbed sites, can be returned to the working forest area, and produce substantial benefits.

Conclusions

- Early indications are that, even without spreading topsoil, rehabilitating these landings has resulted in good stocking.
- Our results indicate that a forest is developing on these rehabilitated sites, and, in many cases, growth rates and productivity levels appear to be compatible with a commercial tree crop.
- Modern rehabilitation techniques with topsoil spreading may result in even better growth than we have found in our study.

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