A summary of several “northern” site preparation trials

Abstracts and references of articles published on sites noted inTable 1

Bedford, L. and Sutton, R.F. 2000. Site preparation for establishing lodgepole pine in the sub-boreal spruce zone of interior British Columbia: the Bednesti trial, 10-year results. Forest Ecology and Management 126(2):227-238.

Abstract
Nine site preparation techniques for re-establishing productive lodgepole pine (*Pinus contorta* Dougl. var. *latifolia* Engelm.) forest in the Stuart Dry Warm Sub-Zone of the Sub-Boreal Spruce Zone (SBSdw3) of interior British Columbia on “NSR backlog” (i.e., by provincial criteria, not-sufficiently-regenerated) sites are compared in a randomized block experiment, with one 48-tree, 750-m^2 plot of each treatment in each of 5 blocks. Low fertility, compact subsoil, and low water-holding capacity in a rooting zone as thin as 10 cm in lower slope and level positions are the main limiting factors. After 10 growing seasons, pine survival was 90-97%; mean stem volumes in 7 treatments were 41-235% higher than the control, and one treatment gave 29% less volume. Results from mounding and patch scarification were virtually identical. While site preparation can increase early growth of lodgepole pine, especially on the more poorly drained parts of sites such as Bednesti, planting directly into sheared, windrowed ground will give satisfactory survival and growth.

Bedford, L., Sutton, R.F., Stordeur, L., and Grismer, M. 2000. Establishing white spruce in the Boreal White and Black Spruce Zone: site preparation trials at Wonowon and Iron Creek, British Columbia. New Forests 20(3):213-233.

Abstract
Two trials ("Wonowon" and "Iron Creek") in the Prince George Forest Region of interior British Columbia were begun in the mid 1980s to evaluate site preparation treatments for establishing white spruce (*Picea glauca* [Moench] Voss) in the Boreal White and Black Spruce biogeoclimatic zone. The 14 treatments (9 or 10 per trial) were: [B.C.] Ministry, Sinkkila, and Bracke mounds; Bracke mounds manually supplemented with 20-, 14-, or 6-cm cappings of mineral soil; fertilized Sinkkila mounds; Bracke patches; fertilized Bracke patches; bladed strips; plowed ground; herbicide; and untreated controls, separately with both standard and nominally superior "alternate" planting stock. With minor aberrations, each trial consists of 5 randomized complete blocks each with one 80-tree plot per treatment; planting was in spring, 1984 at Wonowon, 1987 at Iron Creek. All trees in mounding treatments and the inner 48 trees in other plots were monitored for performance through 1998 at Wonowon, 1996 at Iron Creek. The herbicide and plowing treatments, and mounds capped thickly enough with mineral soil to inhibit weed regrowth, were clearly superior to others. Survival rate increased with capping thickness at Wonowon, but while the 14 and 20 cm cappings were the best of the mounding treatments significant differences among them were few after 15 growing seasons. In both trials, patch scarification gave poorer results than did planting without site preparation.

Bedford, L. and Sutton, R.F. 2000. White spruce establishment after various mechanical site preparation treatments at Inga Lake, British Columbia: 12-year trial results. Submitted to Western Journal of Applied Forestry October 2000.

Abstract
A trial at Inga Lake in the Prince George Forest Region of British Columbia was initiated in 1987 to evaluate site preparation techniques for establishing white spruce (*Picea glauca* [Moench] Voss) on not-sufficiently-regenerated ("NSR") sites in the BWBSmw1 biogeoclimatic subzone. After winter-shearing and piling in 1986/87, nine treatments were applied in 1987 in a randomized block design with five replications: untreated control, vegetation controlled (tending), burned windrow, disk trenching (with plantings in hinge, furrow, and mound-in-furrow positions as three separate treatments), breaking plow, bedding plow, and Madge Rotoclear mixing. Contemporary standard stock (2+0 PSB313) was spring-planted in 1988, 48 trees per plot, and annually monitored for performance and condition through 1999. On the basis of 12-year performance, neither high survival rates (> 90% in all treatments) nor mechanical site preparation (msp) guaranteed good growth; greatest growth occurred in the burned windrow and maintained-vegetation- control treatments, which did not involve msp, but the breaking plow and Madge Rotoclear treatments were not significantly inferior. The disk-trenching treatments facilitated browsing, did not control competition, and resulted in growth significantly poorer than did any treatment except the untreated control.

Boateng, J.O., Haeussler, S., and Bedford, L. 2000. Boreal plant community diversity ten years after glyphosate treatment. Western Journal of Applied Forestry 15(1):15-26.

Abstract
This study examined 10-year and 12-year post-treatment effects of broadcast and spot application of glyphosate for site preparation on structural diversity, species richness and diversity, and crop tree growth in two boreal forest plant communities in north-eastern British Columbia. At the broadcast-sprayed site, reduced dominance of the tall shrub layer was associated with increased structural diversity and increased richness of the herb layer 10 years after treatment. At the spot-sprayed site, no significant differences in plant community structure or diversity could be detected after 12 years. At both sites, glyphosate application increased the growth of planted white spruce (*Picea glauc*a) seedlings without eliminating deciduous trees and shrubs. The results indicate that a single application of glyphosate to prepare sites for reforestation can improve crop tree performance without adversely affecting vascular plant community diversity.

Burton, P., Bedford, L., Goldstein, M., and Osberg, M. 2000. Effects of disk trench orientation and planting spot position on the ten-year performance of lodgepole pine. New Forests 20(1):23-44.

Abstract
A disk-trenching experiment in the sub-boreal spruce zone of British Columbia, Canada, established three plots (0.12 to 0.26 ha each) with trenches running east-west, and another three plots with north-south trenches. Approximately 200 *Pinus contorta* Dougl. seedlings were planted in each of 13 microsites: berm, hinge, and trench positions in each of north, south, east, and west aspects, and in untreated locations between furrows. Soil temperature and soil moisture of representative microsites were monitored for 3 years; seedling diameter, height, and vigour were monitored annually for ten growing seasons. Based on tenth-year stem volumes, performance on south-, east-, and west-facing microsites was significantly greater than on north-facing or untreated microsites. Superior growth was noted on all berm and hinge positions other than those facing north. Microsites identified as best in year 5 were also best in year 10. On east-, south-, or west-facing berm positions, stem volume averaged 47% to 54% greater than that of control seedlings in year 5, but had suffered greater mortality. Seedlings on east-, south-, or west-facing hinges were 46% to 61% (year 5), or 36% to 47% (year 10) larger than control seedlings. Both east-west and north-south disk-trenching treatments are useful for increasing seedling growth, with planting spot selection being more important overall than trench orientation. The stand-level effectiveness of north-south disk trenching was greatest, because the creation of cool north-facing microsites was avoided.

Hauessler, S., Bedford, L., Boateng, J.O., and MacKinnon, A. 1999. Plant community responses to mechanical site preparation in northern interior British Columbia. Can. J. For. Res. 29:1084-1100.

Abstract
Abstract: Ten-year response of plant communities to disk trenching, plowing, rotoclearing and windrow burning was studied on two contrasting sites to address concerns that mechanical site preparation reduces structural and species diversity. Cover and height of all species on randomly located subplots within 0.05- to 0.075-ha treatment plots were used to develop indices of volume, structural diversity, and species diversity; to ordinate the plots; and to correlate species diversity with crop-tree performance. At both sites, community response was strongly influenced by the severity of site preparation. On a boreal site dominated by willow (Salix L. spp.), green alder (*Alnus crispa*(Ait.) Pursh ssp. crispa) and trembling aspen (Populus tremuloides Michx.), sitepreparation increased structural diversity and had little effect on species diversity. High-severity treatments increased non-native species abundance 10-to 16-fold while only marginally enhancing growth of planted white spruce(*Picea glauca* (Moench) Voss) over medium-severity treatments. On a nutrient-poor sub-boreal site, species diversity declined with increasing treatment severity and with increasing lodgepole pine (*Pinus contorta* var.*latifolia* Engelm.) stem volume. Velvet-leaved blueberry (*Vaccinium myrtilloides*Michx.) was highly sensitive to mechanical disturbance. Moderate

mechanical treatments appear to improve conifer performance while causing little change to plant communities, but high severity treatments can cause substantial change.

Heineman, J.L., Bedford, L., and Sword, D. 1999. Root system development of 12-year-old white spruce (*Picea glauca* [Moench] Voss) on a mounded subhygric-mesic site in northern interior British Columbia. For. Ecol. Manage. 123(2/3):167-177.

Abstract
On a silt-loam soil in the boreal white and black spruce (BWBS) zone in northern interior B.C., 50 root systems of 12-year-old planted white spruce *(Picea glauca* [Moench] Voss) seedlings were excavated; 25 from mounds (14 cm of mineral soil over inverted organic matter) and 25 from untreated ground. Diameter, depth, and substrate of main structural roots were assessed at 10 cm intervals from the stem. The total number of roots and the aggregate cross-sectional root area (CSA) exiting the mound or a 50-cm control radius in untreated ground were also determined. Seedlings on mounds had well-developed root systems that were equally as symmetric as those in untreated ground. Roots extended well beyond the mound, excepting those few that were surrounded by saturated soil conditions. Mound seedlings had more, and thicker, main lateral roots than seedlings in untreated ground. CSA of mound seedlings was approximately five times greater than for seedlings in untreated ground, and the total number of roots was 2.5 times greater. Beyond the mound, depth and substrate of main lateral roots was similar to that of seedlings in untreated ground. It was concluded that the potential for long-term mechanical stability of white spruce on such mounds would be no less than that of seedlings planted without site preparation.

Macadam, A. and Bedford, L. 1998. Mounding in the Sub-boreal Spruce Zone of west-central British Columbia: 8-year results. Forestry Chronicle 74(3):421-427.

Abstract
Results are presented from two site preparation trials involving mounding on a moist to wet site with a medium soil nutrient regime (5-6/C) located in a lower slope to toe of slope position and on a near-level area upslope from the first site with medium soil moisture and nutrient regimes (4/C). Both trials compared the performance of long-rooted hybrid white spruce (*Picea glauca* *P. engelmannii* [Parry ex Engelm.]) (Sxw) container stock (PSB 323) to that of a standard-sized stock (PSB 313) planted in inverted mounds and untreated spots. The trial on the first site also tested the effectiveness of two mound capping depths and of planting the 313 stock to two different depths in mounded spots. After eight seasons, there were no significant differences between 313s and 323s in terms of height growth or proportions of free growing trees. Although diameter growth was significantly greater among 323s in mounds compared to 313s this relatively small difference is unlikely to justify the higher cost of the larger stock. Height and diameter growth among 313s were 17 and 22% greater, respectively, for trees planted in mounds with 20 cm of capping compared to 12 cm of capping. Deep-planting in mounds consistently resulted in slight increases in height growth and survival relative to planting to the standard depth, though differences were not statistically significant. Rates of

growth were substantially greater among trees planted in mounds compared with those in untreated spots. The greatest relative differences were noted on the first site where height growth among 313s was 43 to 74% greater in mounded treatments depending on planting depth and capping thickness, with similar improvements in diameter growth.

Macadam, A., Sutton, R.F and. Bedford, L 2001. Site Preparation for Establishing Lodgepole Pine on Backlog Sites in the Sub-Boreal Spruce Zone [the Doris Lake and Kluskus trials] B.C. Min. For. Note 27. Jan. 2001 (available at: http://www.for.gov.bc.ca/hfp/pubssilvnotes.htm

At Kluskus, a fertilizer treatment applied to the soil surface at the time of planting had no effect on the survival or growth of lodgepole pine.
While mounding treatments resulted in superior tree height and diameter during the early years of plantation establishment, the high cost of the treatment and relatively low rates of survival make it a poor choice on these sites with average and drier moisture regimes. Newly planted seedlings are particularly vulnerable to moisture stress until roots have become established, and since both Kluskus and Doris Lake are seasonally rather dry sites and mounding tends to aggravate existing soil moisture deficits, the high rates of mortality were not surprising.
Though seasonal moisture deficits occur at both sites, there are important ecological differences between them that affected response to treatments. While soils at Doris Lake are relatively porous and well drained, at Kluskus soil drainage and rooting are severely restricted by a dense layer of basal till close to the soil surface. Consequently, although treatments that created depressed microsites (Bräcke patch and V-blade) consistently improved survival and growth at Doris Lake, this was not the case at Kluskus.
The Sinkkilä patch treatment improved tree survival at Kluskus, but it failed to improve growth significantly relative to untreated controls. While the depressed microsite created by the patch scarifier mitigated drought conditions, and thereby decreased mortality during the first growing season, it also aggravated seasonal flooding, particularly during snowmelt. The placement of tree roots closer to dense root-restricting layers in the soil would also have contributed to slower growth relative to other mechanical treatments.
The shallow, intermittent disk trenched furrows and very light blading treatments at Kluskus resulted in some degree of mineral soil exposure without creating significant depressions. Both treatments resulted in superior growth relative to either patch scarification or untreated controls.
At Doris Lake, site preparation significantly improved survival for bareroot stock. However, the survival of plug stock on untreated ground was greater than for any site preparation treatment planted with bareroot stock. By year 14, the annual height growth of bareroot and plug stock planted in the control was equal to the annual height growth on the 14 cm mound (the best treatment at year 10). If this trend persists, the difference in height growth between the bareroot stock planted on the untreated ground and the bareroot stock planted on the best site prepared ground will be approximately 1 m. The absolute gain in growth from site preparation on drier ecosystems such as Doris Lake, where the vegetation competition poses no serious threat, is generally less than on sites

with a vegetation problem. On such sites, the manager needs to weigh the benefits of accelerated early growth against treatment costs.

MacKenzie, D.M. 1999. THE EFFECT OF MECHANICAL SITE PREAPRATION ON SOIL PROPERTIES, NUTRIENT DYNAMICS AND TREE GROWTH: Tenth Year Results for Two Sites in Northern British Columbia. M.Sc. Thesis, Simon Fraser University, 117 p.

Abstract
Tenth year comparisons of soil physical and chemical properties were made between eight MSP treatments at two study sites in the northern interior of British Columbia. The Bednesti site, located in the SBS, was planted to lodgepole Pine. The Inga Lake site, located in the BWBS, was planted to Spruce. The bedding plow, breaking plow, fire and madge all had statistically higher crop tree growth compared to control treatments. In many cases the bedding plow had significantly higher concentrations of soil nutrients than the control, while the breaking plow, fire and madge treatments were not significantly different from the control indicating that chemical fertility had not been effected.
Foliar analysis did not show many significant differences between the foliar element concentrations and when compared to acceptable foliar nutrient levels for these species, treatments had either adequate supplies or slight deficiencies. In many cases, the bedding plow, madge and fire treatments increased foliar nutrients and needle weight relative to the control. This may be related to better soil climate, nutrient availability and nutrient uptake on these treatments.

Sutton, R.F., Bedford, L., Stordeur, Linda, and Grismer, Marvin. 2001. Site preparation for establishing interior spruce in British Columbia: trials at Upper Coalmine and Mackenzie. Western Journal of Applied Forestry *in press* "ready for Jan 2001 issue".

Abstract
Two trials ("Upper Coalmine" and "Mackenzie") were begun in the 1980s in the Prince George Forest Region, B.C., to evaluate a total of 13 site preparation treatments for establishing interior spruce (*Picea glauca* *engelmannii*) in the Engelmann Spruce-Subalpine Fir and Sub-Boreal Spruce biogeoclimatic zones. Treatments included mounding (with various thicknesses of mineral soil "capping"), patch scarification, blading, disk trenching, and herbiciding. In each trial, five blocks each contained one 48- or 80-tree plot/treatment. Trees were monitored for 10 yr at Mackenzie and 15 yr at Upper Coalmine. Large mounds have had consistent biological success. Tree seedling response to blading was site specific; blading at Mackenzie was not significantly inferior to the best (Ministry mound) treatment, but at Upper Coalmine was no better than the untreated control.

von der Gönna, M.A. 1989. First year performance and root egress of white spruce (*Picea glauca* [Moench] Voss) and lodgepole pine (*Pinus contorta* Dougl.) seedlings in mechanically prepared and untreated planting spots in north central British Columbia. M.Sc. Thesis, Univ. B.C., 130 p.

Abstract
Root zone temperature and root egress were studied during the first growing season on white spruce and lodgepole pine seedlings planted in various forms of mechanically prepared microsites. Mounded microsites had higher summer soil temperatures and greater diurnal ranges, at a depth of 10 cm, than the patch and control treatments. Mounded microsites, however, showed the greatest response to changes in weather and decreasing solar radiation inputs in the fall, being the first to record soil temperatures below freezing. Seedlings planted in the deep mineral soil over inverted humus mounds created by the Ministry Mounder had significantly greater numbers of new roots greater than 1 cm long than did seedlings planted in patch and control treatments at 45 and 70 days after planting. Seedlings planted in other mound and plowing treatments had high to intermediate numbers of new roots. At 95 days after planting, seedlings planted on all mounded treatments generally had higher root area indices, root dry weights and total dry weights than did seedlings on other treatments. Variation in treatment results over the three spruce sites studied reflect differences in site conditions, primarily soil moisture regimes. High and fluctuating water tables negatively effected seedlings planted in patch and control treatments.