Forest Soil Conservation and Rehabilitation in British Columbia

Opportunities, Challenges, and Techniques

… with Examples from Recent Research

Forest Science Program
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BRITISH COLUMBIA

This brochure highlights lessons learned from recent research on forest soils in British Columbia. The information will be of interest to operational staff who plan and carry out forest management activities that affect the soil, and to others who are interested in soil conservation. Results are presented in highlight form; more detailed results from several of the projects are available in scientific literature, or directly from the investigators.

Productive soils, along with clean water and air, are the foundation of productive forest ecosystems, but forest management has the potential to degrade soil productivity.

Soil degrading disturbance can include:

- **compaction**, which leads to wet soils with poor aeration, and increased soil strength that prevents root growth, and
- **loss of nutrient-rich surface soils**, causing plant roots to grow in inappropriate rooting media.

Soil conservation is needed to maintain forest soils in a productive condition, and to protect water.

Soil rehabilitation aims to restore productivity to degraded soils, and occurs either as part of ongoing field operations, or after identifying high-priority sites that were degraded in the past.

Site-specific management relies on risk rating of soil to identify cost-effective forest practices that protect the soil.

Monitoring and research are needed to evaluate current soil conservation strategies and techniques, and to identify new approaches to protect B.C.'s forest soils. The results presented here, along with information from other studies, are an important component of science-based management.

Examples from Research

Studies have been initiated in recent years to evaluate soil disturbance and tree growth on degraded and rehabilitated sites. Although long-term conclusions are still some way off, early results are starting to flow from these projects, indicating that:

- Effectively conserving and rehabilitating soil productivity requires identification of sites where soils are susceptible to damage, and those where restoring productivity is difficult.
- On many sites, favourable stocking and acceptable tree growth are observed after rehabilitation of degraded soils using a variety of techniques.
- New techniques that rely on a knowledge of local conditions and available equipment have the potential to reduce costs and improve results.
- Equipment operator training is key to success.
- Operationally focused trials and adaptive management can provide solutions for your area.

Be optimistic – plan ahead – avoid damaging sensitive soils

For restoration:

- establish drainage and control erosion,
- consider the need and techniques for:

Tillage … Topsoil … Trees

The end result can be a healthy forest on sites that would otherwise be unproductive.

The **pore system** consists of an interconnected system of channels and spaces that occur between mineral and organic soil particles. The size of pores approximately equals the size of the associated solid particles.

The pore system of productive soils includes large aeration pores to allow rapid movement of air and drainage of excess water, mid-sized pores where plant-available water is stored for use during periods of dry weather, and smaller pores that hold soil nutrients. Aeration pores have a minimum diameter about 0.005mm, and are the main channels for air to flow to growing root tips.

Soil texture describes the proportion of sand-, silt-, and clay-sized particles in the mineral fraction of soil. Soil texture, and the associated property, plasticity, largely determine the response to disturbance and rehabilitation.

Coarse-textured soils (rich in sand), those with low plasticity, and soils with many coarse fragments resist compaction because the aeration pores result simply from packing of the mineral grains.

In *fine-textured soils* (rich in clay), and other soils with high plasticity, large pores occur only when mineral particles are aggregated together. Development of stable structure in medium- and fine-textured soils is a long-term process mediated by plant roots, bacteria, fungi, and soil animals.

Soil organic matter is formed when leaves, dead trees, roots, and other materials are broken up and decomposed by soil animals, fungi, and bacteria. The final stage of decomposition is the formation of **humus**, which resists further decomposition, attaches to the surfaces of silt and clay particles, and facilitates soil water and nutrient retention. Humus also acts as the "glue" to bind soil aggregates, and is therefore an essential part of stable soil structure in a healthy soil.

Soil nutrients are present mostly in surface soils, especially in association with organic matter in the forest floor but also in the surface mineral soil layers. Productive soils have nutrient cycles that transfer nutrients from dead organic matter to available forms in the soil, and into growing plants. Nutrient cycling is carried out by millions of different organisms that make up the soil ecosystem.

The first step in forest soil conservation is to ensure that harvested sites and access structures are stable and free of erosion. Where a road, landing, or trail is intended for re-use at some time in the future or soil conditions make rehabilitation of productivity impractical, deactivation of the site is all that is needed. For sites where access is no longer needed, additional measures such as **tillage (3)**, **topsoil recovery (4)**, and **site organic matter enhancement (5)** may be necessary to restore soil conditions so the site can support trees.

Deactivation techniques include:

- Recontouring over-steepened cuts, and pulling back unstable fills,
- Restoring surface and subsurface water flow patterns, and
- Revegetating to prevent surface soil erosion.

Restoring water flow patterns

An excavator has good control when excavating and placing materials, so it is often used for deactivation work.

Agronomic grasses and legumes are the most reliable means of preventing surface soil erosion in the short term, and may also provide benefits such as noxious weed control, improved soil structure, and water infiltration. However, when **cattle (7)** are present, they are attracted to agronomic species.

Consider the need for erosion control and other benefits of grasses and legumes, along with the potential for cattle damage to planted seedlings, when developing revegetation plans for degraded areas.

Revegetating

The goal of tillage is to restore the **pore system (1)** and reduce soil strength.

The **winged subsoiler** has been used throughout B.C. to decompact roads and landings. The specially designed wings allow self-drafting tillage that is effective for one-pass operation on a range of soil types. The shanks pivot to clear buried rocks and logs.

Rock rippers and modified rippers are generally less effective than the winged subsoiler for one-pass operation, but can be effective on medium- and coarse-textured soils if care is taken to ensure complete decompaction. Rock rippers are often used for small jobs where the expense of transporting a subsoiler cannot be justified. Crawler tractors can be effective for replacing topsoil on level to gently sloping ground.

Excavators are versatile and effective for **installing drainage (2)**, **recontouring unstable fills (2)**, and replacing **topsoil (4)**, as well as for soil decompaction, but they are less productive for tillage than implements pulled by crawlers. A variety of attachments are suitable for rehabilitation work, including buckets, site preparation rakes, single ripper teeth, and powered mixing heads.

For effective tillage, consider that:

- many options are available, and a careful operator can often do a good job even with less than ideal machinery,
- fine-textured soils need to be friable for effective decompaction,
- an appropriate tillage depth would be similar to the rooting depth of trees growing on undisturbed sites in the vicinity, and
- on erosion-prone sites, grasses and legumes survive best if seeded shortly after tillage.

Topsoil is operationally defined as the surface layers of soil, and in B.C. forests it typically occurs to a depth of about 20cm. Topsoil is often enriched in organic matter, nutrients, and soil organisms, has higher water storage capacity than subsoil, and may have beneficial soil structure that makes it better as a growing medium.

The main purpose of managing topsoil is to preserve and replace a valuable medium for root growth. Replacing topsoil is common practice in oilfield and mining rehabilitation, and is also necessary for effective rehabilitation of temporary forest roads and landings.

Replaced topsoil

Surface soil layers often end up mixed with stumps, rocks, and other debris in piles adjacent to landings and roads.

While considerable benefit to soil productivity could be expected from using this material in soil rehabilitation, the cost and logistics of respreading such piles are a challenge.

Results at **Aleza Lake (14)** show that respreading topsoil combined with shallow tillage using an excavator was 3 times as expensive as decompacting the site with a winged subsoiler. Although topsoil recovery was not attempted with the crawler tractor at Aleza Lake, in gentle terrain, topsoil recovery with a crawler may be cost-effective.

Topsoil piles

Benefits of topsoil replacement for forest soil rehabilitation in B.C. have not been quantified in detail, although early **research results (10)** suggest it is beneficial in some cases, and work is currently under way to further evaluate the effects on productivity.

Respreading piles

Strategies for restoring lost organic matter include (1) vegetation growth to contribute organic matter through decomposition, (2) redistributing organic matter in close proximity to the disturbed area, and (3) importing organic materials from elsewhere.

Over the long term, grasses and legumes are effective for enhancing soil organic matter through root decomposition, and many shrubs and deciduous trees accomplish similar objectives.

For a faster response, redistributed debris piles and imported organic materials can provide a source of organic matter. Exploratory work has been initiated on the use of **sawmill waste (13)**, **fine woody materials from landing debris piles (14)**, livestock waste, and other organic materials in soil rehabilitation.

Tillage (3) of fine-textured subsoils can be ineffective because the tillage clods are easily destroyed by rain drops. Added organic materials can provide short-term stability to the **pore system (1)** while also contributing to the development of **humus (1)** for stable aggregates that provide long-term benefits.

Some organic amendments such as wood waste have very low nitrogen content. When microbes decompose such nutrient-poor amendments, available soil nutrients are transformed and become unavailable to growing trees. This nutrient "immobilization" is especially problematic when amendments are mixed into the soil, but it can be counteracted by adding fertilizer.

Although organic amendments are often expensive to prepare and transport, their use may be cost-effective where:

1. Wood waste presents an environmental hazard or disposal problem in mill yards or landfills. Beneficial re-use on degraded lands close to such facilities may be possible.
2. Landing debris piles need to be disposed of or reduced. Debris piles can offer a ready source of organic material.
   - Where finely divided material is present (e.g., leaves and fine twigs), simply spread it on the surface and/or mix it in.
   - For burned debris piles, spread ash and partly burned material over the surface and/or mix it with surface soil.
   - Spread stumps, waste logs, and branches to increase the amount of coarse woody debris on the rehabilitated soil.
   - Chip or grind unburned material, and either spread it as mulch or mix it into the **surface soil (14)**. Costs of chipping and spreading could be reduced if the work was combined with in-woods operations that may occur when there is a demand for wood chips.

Mulched amendments (12), **(13)** can affect soil temperature and moisture. To determine an appropriate application rate, consider the depth and character of forest floor on similar undisturbed sites.

Tree planting to lodgepole pine in the interior is a proven reforestation technique on rehabilitated sites. In coastal B.C., Douglas-fir often establishes successfully on roadsides and other disturbed sites.

Although soils on rehabilitated sites may have less organic matter and less favourable physical properties than adjacent plantation soils, **results (9)**, **(10)**, **(13)** show that forest establishment following planting of hardy pioneer species such as lodgepole pine, Douglas-fir, and western larch can be successful.

Early growth rates of tree seedlings planted on **rehabilitated sites (9)**, **(10)**, **(11)**, & **(15)** can be similar, greater than, or less than growth rates for trees in plantations.

Planted lodgepole pine

Natural regeneration of western hemlock

Soil disturbance and rehabilitation can have both positive and negative effects on growth-limiting factors such as soil physical properties, temperature, moisture and competing vegetation.

Where establishment problems occur, they may result from poor soil conditions, or a number of other factors, i.e., climatic extremes, planting stock quality, competition from seeded cover species, or cattle damage.

To establish a new forest, consider that:

- a variety of tree species and stock types could be used, and natural regeneration may also lead to successful establishment of a forest ecosystem,
- native plants could play a role in site restoration, and
- for small areas of soil disturbance, ingress of native vegetation may be a cost-effective strategy for revegetation.

The following challenges need to be addressed to ensure that soil rehabilitation opportunities are fully realized, without wasting effort on work that provides little benefit or where the economic and environmental costs outweigh the benefits:

1. **Cost-effectiveness of soil conservation** is an important goal of current research and operational work.
2. **Inaccessible sites** and small areas of dispersed soil disturbance require innovative approaches.
   - For dispersed disturbance, the best approach is usually to recognize problems and repair damage before finishing the harvest.
   - Although small areas are accepted as an inevitable result of harvesting operations, studies are needed to determine if/when small pockets of disturbance, areas of rutting, and short sections of heavily used trail have a measurable effect on productivity at the stand level.
3. **Timing and logistics** of harvesting, site preparation, debris disposal, deactivation, decompaction, topsoil replacement, and planting operations present a recurring challenge. In some situations, equipment costs, transport, limited access, and other challenges are insurmountable, and rehabilitation work is forgone. In other cases, thoughtful and flexible planning has allowed cost-effective integration of rehabilitation work into operations.
4. **Clay-rich soils, wet sites, and sites with unfavourable subsoils** are easily damaged and often difficult to restore.
   - The best approach is usually to prevent degradation by limiting machine traffic on these sites.
   - For clay-rich soils and wet sites, confine machine traffic to periods when the soil is strong enough to resist the compacting forces of machinery.
   - For sites with shallow soils and/or unfavourable subsoils, consider harvesting systems that do not rely on construction and rehabilitation of excavated trails. Careful separation of topsoil and unfavourable subsoil is necessary for successfully restoring soil productivity on such sites.
   - Innovative harvesting and rehabilitation techniques need to be developed and tested to expand the opportunities for cost-effective harvesting of these sensitive sites while protecting the soil.
5. **Cattle grazing** occurs in many parts of B.C.
   - Work with ranchers to plan rehabilitation work in areas that are also used for cattle grazing.
   - Try to limit cattle use for 3 years following planting.
   - Consider both the benefits of agronomic species (e.g., erosion control, organic matter enhancement, noxious weed control) and the potential risks (e.g., attracting cattle, increased competition for seedlings) when developing revegetation plans.
   - Use obstacles, tillage, or other means to guide cattle away from planted seedlings.
   - Monitoring efforts that focus on the interaction of cattle and planted seedlings on rehabilitated sites should be part of soil rehabilitation projects in cattle country.

B.C.'s long-term soil productivity study is evaluating the long-term effects of soil disturbance on forest productivity.

Objectives: To determine the rotation-length effects of different levels of organic matter (aboveground biomass and forest floor) retention and soil compaction on long-term forest soil productivity on a range of sites and ecological conditions.

Investigators: S. Berch; B. Chapman; M. Curran; G. Hope; R. Kabzems; M. Kranabetter; P. Sanborn

Location: Various locations throughout B.C. and internationally

Biogeoclimatic Units: BWBS; SBS; IDF; ICH

Design: Four fully replicated installations have been established, and sites in the ICH are being installed. Within each replicate site, nine treatment plots represent a factorial combination of three organic matter removal treatments:

- Stems (boles) only removed
- Stems and crowns removed (whole tree harvest)
- Stems, crowns and forest floor removed;

… and three soil compaction treatments:

- No compaction
- Intermediate compaction
- Heavy compaction.

Stems only removed

Stems, crowns, and forest floor removed

Short-term Results:

- Forest floor removal had the most significant effect on plant species and cover, as well as soil properties such as mineralizable nitrogen and temperature.
- Growth of lodgepole pine was affected less than white spruce.
- In the BWBS, removal of forest floor led to reduced height growth of aspen and white spruce on sites with 20–30cm of stone-free silt loam over clay loam. Compaction led to lower height increments on white spruce after 3 years.

Management Implications:

- Preliminary data suggest that some mesic sites with medium soil texture may be relatively resilient to disturbances typical to forest harvesting, yet detrimental effects are observed on other sites with similar moisture regime and texture. The effect of soil disturbance on productivity likely depends on climate, tree species, and coarse fragment content as well as texture and moisture.
- Detrimental effects of soil disturbance are more likely on sites with finer soil textures and possibly wetter moisture regimes.
- Longer-term effects of the treatments will be evaluated through continued monitoring in order to provide essential information to evaluate soil conservation in B.C.

Objectives: To determine the short- and long-term effects of hoe-forwarding on seedling survival and growth.
Investigators: M.-J. Douglas; P. Courtin

Site 1 (Holberg): CWH vh1 (silt loam)
Species (Planting Date): Western hemlock (1992)
Design: Three treatment blocks were established in harvested areas. For each treatment block, four 50 m lines were laid out in undisturbed areas, and assigned treatments including control, and one, two, and four passes with the hoe. This area was trafficked in summer under drier soil conditions with protective puncheon.
Results (Holberg):

- The most common type of soil disturbance was compression of organic matter and decayed wood. The two- and four-pass treatments had higher proportions of impressions greater than 25 cm deep than the one-pass treatment.
- Seedling survival ranged from 79 to 82% after 5 years.
- Seedling height growth varied between the blocks, and differences were attributed partly to the presence of salal.
- Where salal coverage was low, seedlings were smaller on the disturbed sites than on the undisturbed treatment. Where salal was abundant, the effect of traffic was to improve seedling growth compared to the control after nine growing seasons.

Site 2 (Woss): CWHmm1 (sandy loam)
Species (Planting Date): Douglas-fir (1993)
Design: Fifteen lines were laid out on tracked areas, each receiving one or two passes with the hoe, and 15 lines were laid out in adjacent undisturbed areas. This area was trafficked in winter under wet soil conditions without protective puncheon.
Results (Woss):

- Deep impressions into the forest floor and mineral soil were the most common types of disturbance.
- Preliminary analysis showed reduced growth and performance of Douglas-fir on tracked areas after 9 years.

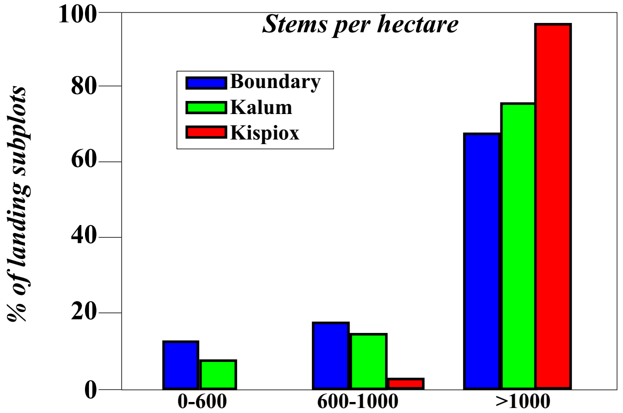
Overall Management Implications:

- Thick forest floor and the use of puncheon protect the soil from detrimental effects of machine traffic.
- On some sites, light disturbance caused by machine traffic can hamper the growth of competing species such as salal, and result in improved tree growth. Caution is advised, however, to ensure that levels of disturbance remain below thresholds that would affect tree growth.
- Sites with sandy loam soils may have constraints for season of harvest, particularly if puncheon is not prescribed. Wetter soil conditions may result in increased site disturbance, leading to reduced growth and performance of Douglas-fir.

Objectives: To evaluate soil conditions and lodgepole pine growth on rehabilitated sites compared to undisturbed areas.
Investigators: C. Bulmer; M. Schmidt; M. Plotnikoff; M. Curran; G. Hope; M. Kranabetter
Biogeoclimatic Units: ICH; BWBS; MS; SBS
Design: A retrospective sampling program established plots in areas that were treated as part of operational soil rehabilitation programs in the 1980's and 90's. Three subplots per landing or road segment were established, along with three in the adjacent plantation. Rehabilitated sites were evaluated in several areas:

District	Plant Date	Disturbance	Technique	Proponent
Pr. George	1984	landings	subsoiler	Min Forests
Kamloops	1990+/-	roads/ldgs	ripper	Weyerhaeuser
Boundary	1993	landings	subsoiler	Min Forests
Kalum	1993	landings	subsoiler	Min Forests
Kispiox	1993	landings	subsoiler	Min Forests
Kamloops	1995	landings	excavator	Interfor
Dawson Cr.	1996	landings	subsoiler	Min Forests

Results:
- Winged subsoiling and grass/legume seeding, followed by planting of pine, generally resulted in successful forest establishment.
- Trees on reclaimed sites were shorter than plantations in two areas, equalled plantations in three areas, and were taller in one area.
- In one case (Kispiox), shorter trees on landings were attributed partly to configuration problems with the subsoiler, which did not break up compacted and rocky soils below about 13 cm.
- In Kalum and Kispiox, reclamation was less successful on landings where the soils had more than 20% clay.
- Restored sites generally had no forest floor and reduced cover of non-coniferous vegetation compared to adjacent plantations.
- Landing soils often had lower concentrations of organic matter and nutrients, but foliar nutrients generally were not deficient.
- Respreading topsoil/ash piles appeared to be effective for replenishing organic matter and nutrients (Kalum) and appeared to correspond with improved tree growth (Kamloops).



Management Implications:
- The results support the conclusion that soil rehabilitation is a useful strategy for enhancing productivity of B.C.'s forests.
- Some rehabilitated sites had shallow soils, or were depleted in organic matter, so these short-term results need to be confirmed with long-term monitoring.

Objectives: To quantify tree growth on rehabilitated skid trails and make recommendations to improve rehabilitation techniques.
Investigator: M. Curran
Location: The Rocky and Purcell Mountains of southeast B.C.
Biogeoclimatic Units: ICH; MS; ESSF
Tree Species and Planting Date: Various
Methods: Both retrospective studies and designed experiments were used. Initially, trails were rehabilitated simply by recontouring the sidecast. More recently, installations have been established on sites where more complete rehabilitation was carried out.

Sections of rehabilitated trail were identified, and

(1) operationally planted trees were selected for measurement, or

(2) trees were planted on specific parts of the trail cross-section (inner track, mid trail, berm, and undisturbed).

Results:

- Where rehabilitation consisted of simple recontouring, trees growing on the undisturbed and berm portions of the trail were taller than those growing on the inner track or mid trail.
- Better growth on the berm was attributed to a more favourable rooting environment resulting from accumulation of the original "topsoil" and forest floor. Soils on the inner track tended to be shallow because the running surface was not decompacted, and recontouring simply filled these areas with subsoil.

Management Implications and Recommendations:
- Drainage control is a priority when working on sloping ground.
- Maintain an outslope trail profile when decompacting the running surface.
- Topsoil should be kept separate from subsoil, and soil layers should be replaced in their original sequence.
- Choose operational techniques and species that compensate for site-specific growth-limiting factors.
- Machine operators play a major role in success.

Objectives: To evaluate the use of excavator tillage and organic amendments on survival and growth of lodgepole pine.
Investigators: C. Bulmer; P. Sanborn
Location: Vama Vama Creek; 44 km east of Prince George
Biogeoclimatic Unit (Soil Texture): SBS (silt loam)
Planting Date: 1995
Methods: Nine treatment combinations were established on small plots. Treatments consisted of tillage to 50 cm in combination with amendments (wood chips or old sawdust) that were either tilled in or left on the surface as a mulch.

Results:

- After 5 years, survival was high for all treatments, except where frost-heaving had damaged seedling root systems.
- The best growth was obtained for plots that were simply tilled, and where rotten sawdust was used as a soil amendment.
- Poor tree growth on areas receiving wood chips as a mulch was attributed partly to cold soils. The effect of soil chemical conditions associated with wood chip decomposition could not be evaluated in detail, but may also have affected growth.

Management Implications:

- For these medium-textured soils (rich in silt), simple tillage appeared effective for restoring the pore system.
- Physical and chemical characteristics of soil amendments need to be considered for successful rehabilitation. Application rates should be planned to approximate the amount and nature of surface organic layers in undisturbed soil.

Objectives: To evaluate the use of wood waste for rehabilitating productivity on disused forest roads and landings.
Investigators: C. Prescott; K. Venner; C. Bulmer; M.-J. Douglas
Location: Dutton Creek (16 km west of Okanagan Falls); Tofino
Biogeoclimatic Units (Soil Texture): IDF (sandy loam); CWH (loamy sand)
Species (Planting Date): Lodgepole pine, western larch, Douglas-fir (1998)
Methods: Replicated plots were installed on landings (interior site) and roads (coastal site). In the interior, 10 treatments included excavator tillage in combination with topsoil, hog fuel, sort yard waste, and biosolids–wood waste compost. On the coast, five treatments included excavator tillage, cedar wood waste, and compost. Amendments were either tilled in or applied as a surface mulch.

Results – Interior Trial:
- After 3 years, survival was high for pine on sites treated with decompaction alone, or decompaction and either sort yard waste or hog fuel.
- Poor survival on plots receiving biosolids–wood waste compost may have been related to excess nitrogen, soluble salts from the compost, or severe weed problems.
- Soils on plots receiving amendments had lower bulk density and lower soil strength compared to plots with no amendment. Soils receiving the hog mulch were wetter and cooler than the other soils.
- For untreated soils, and those that were simply decompacted, values of soil resistance exceeded the growth-limiting threshold for much of the growing season.

Results – Coastal Trial:
- Decompaction improved Douglas-fir survival after 3 years.
- Tree survival, height, and condition were highest in treatments receiving shrimp–wood waste compost.
- Bulk density was lowered by decompaction alone, and in combination with organic amendments.
- Available nutrients (mineralizable nitrogen and cation exchange capacity) were increased in plots treated with shrimp–wood waste compost.

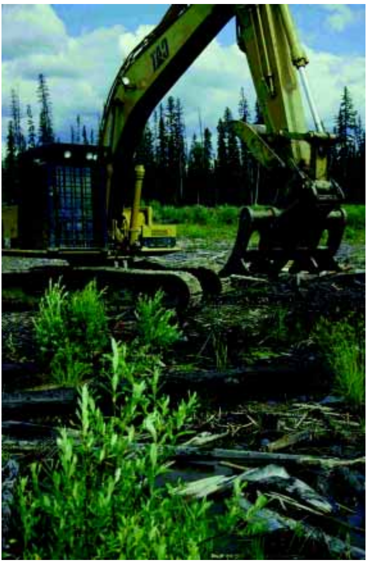
Management Implications:
- Decompaction and addition of wood waste has the potential to improve soil physical conditions and nutrient status on roads and landings.
- Some wood wastes and composts can improve survival, condition, and growth of seedlings in nutrient-poor and compact soils.

13 Wood Waste for Soil Rehabilitation

Objectives: To evaluate operationally feasible techniques for restoring productivity on fine-textured soils.
Investigators: P. Sanborn; C. Bulmer
Location: Aleza Lake; 55 km Northeast of Prince George
Biogeoclimatic Unit (Soil Texture): SBS (silty clay loam)
Species (Planting Date): Spruce (1997); lodgepole pine (1999)

Methods:

1. Five replicate landings were treated with each of the following treatments:
   - deep (60 cm) tillage with the winged subsoiler
   - shallow (20 cm) excavator tillage and topsoil recovery
   - shallow excavator tillage and incorporation of 150 t/ha of wood chips, along with 600 kg/ha of N to offset nutrient immobilization.
2. Landings were split to receive spruce, birch, or a mixture. After severe rodent damage, birch was replaced with lodgepole pine.



Results:

- Winged subsoiler tillage was cheaper than excavator tillage.
- Incorporation of wood chips lowered soil bulk density.
- The topsoil recovery treatment had lower bulk density than the subsoiled treatment.
- Wood chip decomposition occurred rapidly.
- Spruce seedlings grew best where wood chips and fertilizer were mixed with the surface soils.
- Survival of birch was very low, due to rodent damage.

Soil structure development

Management Implications:

- The results suggest that rehabilitation of fine-textured soils is possible with the relatively expensive techniques.
- A challenge is to see if cheaper rehabilitation alternatives also work, or if prevention is still a better approach.

14 Techniques for Fine-textured Soils

Objectives: To evaluate operational techniques for landing rehabilitation across a wide variety of sites in the central interior.

Investigators: B. Chapman (MoF); R. Meister (Inland Timber Management Ltd.); K. Peel (Lignum)

Location: Williams Lake, Horsefly, and 100 Mile House Districts

Biogeoclimatic Units: IDF; ICH; SBPS; SBS; ESSF

Species (Planting Date): Lodgepole pine (1997, 1998, 1999)

Methods: More than 600 landings were treated with a wide variety of tillage, amendment, revegetation, and reforestation techniques.

Results:

- Costs ranged from about $250/landing to $4500/landing.
- Power disc trenching, Tilth winged subsoiler, and patch treatment with a Bobcat-mounted rototiller were the least expensive treatments, and resulted in the some of the best seedling growth.
- The most expensive treatment was an excavator-mounted Silva Tiller, which could operate under poor site conditions. However, tree seedlings did not perform well on those sites.
- Almost all implements were capable of producing satisfactory results over a range of conditions.
- Survival rates ranged from 66 to 100% in 2001, and growth rates ranged from 87 to 125% of the expected normals for the various biogeoclimatic subzones.
- Landings within range units with a high degree of cattle use had higher seedling mortality rates and more cattle damage to seedlings. Trampling damage was particularly serious for old landings with established patterns of cattle use.
- Seedling mortality rates were higher for landings with a high coverage of ground-covering vegetation, especially grasses.
- Constructing berms to guide cattle away from planted trees appeared to be effective. Treatments that disrupted grass cover and those that left a very rough surface also tended to have less cattle damage, as did the winged subsoiler.

Management Implications:

- Early results indicate that successful rehabilitation of backlog landings is possible with a wide range of techniques, some of which are inexpensive.
- Consult with ranchers to resolve issues surrounding cattle grazing and grass seeding before rehabilitating backlog landings.
- Cattle control techniques may involve additional costs.
- Intensive techniques such as fertilization, mixed planting, and mulches do not appear necessary for seedling establishment, but may have advantages in the longer term.

Objectives: To evaluate the potential for commercially available biological inoculants to increase colonization of seedling root systems, and to improve field performance of planting stock on rehabilitated and standard reforestation sites.

Investigators: G. Xiao; S. Berch; C. Bulmer

Location: Miriam Creek (30 km east of Vernon); Weedon Lake (60 km west of Bear Lake)

Biogeoclimatic Unit (Soil Texture): ICH (sandy loam); SBS (sandy loam)

Species (Planting Date): Douglas-fir, lodgepole pine (1999)

Methods:

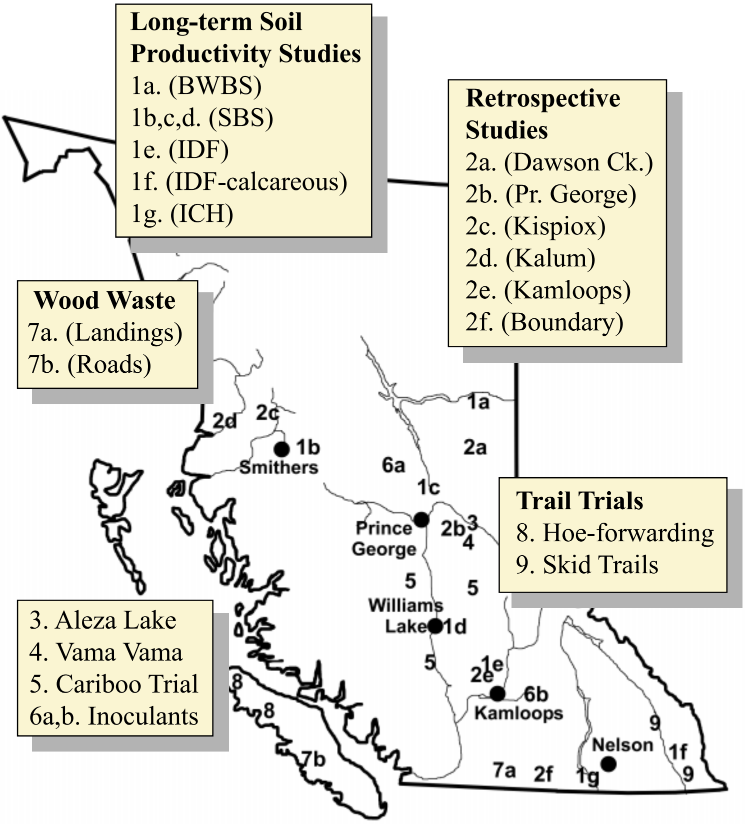
1. Seedlings were grown in the nursery with or without addition of commercially available mycorrhizal and bacterial inoculants.
2. Landings and road segments were rehabilitated as part of ongoing operations.
3. Treatments used on landings at Miriam Creek included:
   - shallow (10 cm) tillage only sufficient to facilitate planting
   - deep (15 cm) tillage to reduce strength and facilitate rooting
   - burn piles
   - plantation sites with undisturbed soils
4. Treatments used on roads at Weedon Lake included:
   - shallow tillage
   - deep tillage alone
   - deep tillage with surface mulch of tops and branches
   - slope recontouring on road segments with 1 m cutslopes
   - burn piles
   - plantation sites with undisturbed soils

Results:

- Although results varied, mycorrhizal colonization of lodgepole pine and hybird spruce was generally good, while Douglas-fir from most nurseries was poorly colonized.
- Even after inoculation, colonization of Douglas-fir was variable, which suggests that techniques for inoculation need improvement.
- Field performance of inoculated and standard seedlings was similar after 1 year in the field, but monitoring is continuing.

Management Implications:

- Despite the importance of mycorrhizae in natural ecosystems, more work is needed before inoculation of seedlings becomes standard operational practice.



Forest Soil Conservation and Rehabilitation in British Columbia

The following individuals have contributed to this project:

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