THE CHALLENGES OF STEWARDSHIP: SUSTAINING FOREST LAND PRODUCTIVITY IN BRITISH COLUMBIA

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The forest industry is the most important component of B.C.'s economy. Sustaining the productivity of forest soils is the key to the economic future of our province. Harvesting and site preparation can adversely affect soil chemical, physical and biological factors, with consequent reductions in productivity. Increased research activities, and improved implementation of existing knowledge, will minimize soil degradation in the future. As well, we must improve our capability to rehabilitate degraded soils, restoring them as nearly as possible to their former productivity.

THE IMPORTANCE OF THE FOREST INDUSTRY IN B.C.

The theme of this conference - "Sustained Productivity of Forest Land" - is of considerable interest to British Columbians. For residents of our province, this could be paraphrased as "Sustained Productivity of British Columbia". Economically, B.C.'s forests are its most important resource. The forest industry employs more people than any other single industry in the province.

British Columbia's commercial forests cover more than half of the province's land area. More than 52 million hectares of provincial forest land support close to 8 billion m$^3$ of mature timber, about 97% of which are conifers. The province's stock of standing softwood timber represents 40% of the Canadian inventory and about 20% of the North American inventory.

In 1987, the timber harvest in British Columbia was over 90 million m$^3$. As measured by the value of shipments, the forest products manufacturing sector has been the major contributor to the province's manufacturing activity. The value of shipments from British Columbia's wood industries (which includes sawmills, planing mills and veneer and plywood mills) was $5.5 billion in 1986; from paper and allied industries, $3.9 billion. Together they accounted for about 46% of the total value of shipments from British Columbia manufacturing industries.

Forest-based industries directly employ about seven percent of B.C.'s workers. Many of these workers are employed in the silviculture program, under which 200 million seedlings will be planted in 1988. This will replenish about 60% of the areas harvested. The remaining 40% will be treated to promote natural regeneration.

Trees are a natural resource unlike most others. Forests are renewable (or replaceable), if the resource is properly managed. In many ways, this is proving to be a big "if". If we get seedlings back on all of our sites, and if they don't get eaten by wildlife or insects, and if they don't burn up, or dry up, or fry up, they may form another forest. But all of our efforts to make forests a renewable resource will be wasted if we fail to protect the medium the forest grows in - the soil. The soil is the primary resource, and unlike the trees, it is essentially non-renewable. This seems an obvious point, particularly so to a group such as this. But it is only since the 1940's in the United States, and the 1970's in B.C., that we have begun to seriously address the problem of maintaining the integrity of the soil resource. Forest soils have been scraped and furrowed, plowed and mounded, crushed and burned. As available technology advanced, so did our ability to degrade soils. A seedling placed in some of these inhospitable

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soil environments might be forgiven for not contributing to our "future forests". And soil degradation which reduces the productivity of forest soils for producing trees usually reduces the productivity of those soils for other uses such as agriculture, fisheries, wildlife, and recreation.

EFFECTS OF HARVESTING ON FOREST SOILS

Most of British Columbia's forested soils are relatively recent in origin and nutrient-poor. The majority of nutrients are contained in the humus layer and in organically-enriched upper mineral horizons. Because of this, it is important that forestry activities not only avoid soil compaction, but also maintain these important humus forms and organically-enriched mineral horizons.

During the construction and use of haulroads, skid roads and landings:

- fertile organic and upper mineral soil layers are scalped or buried;
- surface soil is compacted by heavy equipment; and
- calcareous or compact subsoils are exposed (Still and Macdonald 1987).

This disturbance results in a significant portion of the harvested area developing higher soil bulk density, lower penetrability of the soil to plant roots and water, and lower nutrient and organic matter levels compared to undisturbed soils. As well, soil microclimate is affected, including changes in soil temperatures (maxima and minima) and moisture. Landings will typically make up 4-5% of a setting, while skid trails may comprise 14-30% (or more) of the area. Soil bulk density increases which range from 15-60% on landings and 25-88% on skid roads, often extend to 30 cm in depth and last for 30 years or more (Lousier 1988). Soil bulk density is often increased to more than 1400 kg/m³, with consequent reduction in root penetration and growth. Effects on seedling survival and growth may be drastic.

The area disturbed by various harvesting systems varies greatly, from 6-87% of the harvested area depending on site, equipment, and season of activity. More disturbance is caused by ground skidding, though values as high as 56% exposed mineral soil have been recorded from cable-yarded sites (Lousier 1988). Harvesting may also cause soil erosion, mass wasting and diversion of subsurface water flow. These reduce productivity and may degrade off-site values such as water quality and aesthetics.

EFFECTS OF SITE PREPARATION ON FOREST SOILS

Mechanical site preparation treatments such as windrowing can result in extensive scalping and compaction. Other treatments may be either less severe in effect (e.g. drag scarification) or may affect a smaller percentage of the cutblock (e.g. patch scarification). There is little information available on the efficacy of mechanical site preparation in B.C., or on its effects on soil physical, chemical and biological properties. It is safe to assume that practices such as V-blading and windrowing significantly reduce site nutrient capital in all cases.

Slashburning can result in substantial nutrient losses through volatilization, wind and water erosion. Results of slashburning, as measured in seedling growth, may be misleading. Work in interior B.C. (Ballard 1984) indicates improved seedling growth on sites slashburned five years previously. This has probably occurred as a result of improvements in soil microclimate (warming as a result of organic layer removal) and reduction of competition from other vegetation. Concentrations of foliar N, Cu and active Fe, however, were significantly lower in the seedlings on slashburned sites, and the rotation-length nutritional implications of this method of site preparation are not clear.

PRODUCTIVITY LOSSES

The estimated total areas of degraded soils resulting from harvesting and silviculture activities from 1976 - 1986 in the six Forest Regions in B.C. are presented in Utzig and Walmsley (1988). The total area of degraded soils is in excess of 20% of the area harvested during this time. This varies from 12%-15% in the Vancouver Region and coastal area of the Prince Rupert Region, where cable harvesting systems are extensively used, to 21-26% in the
Interior Regions, where most harvesting is done using ground-based systems (wheeled skidders or crawler tractors). Though these figures are based on a number of "best-guess" assumptions, they suggest that soil degradation may affect one million hectares in B.C. by the year 2000.

What will this degradation do to conifer productivity on these soils? Current annual growth losses were calculated by Utzig and Walmsley (1988) for each Forest Region by considering the previous estimate of the area affected by soil degradation in our province from 1976-1986, literature reports of growth reductions, and known mean annual increments. The calculation shows that growth losses by the year 2000 may exceed one million m$^3$/year. A conservative estimate of the cost of these losses, based on a value of $200/m$^3$ (the estimated total economic benefit of harvesting wood in B.C. [Association of B.C. Professional Foresters 1985]), is in excess of $80 million annually at present, and will more than double by 1995.

**SOLUTIONS**

The problems associated with soil degradation, and consequent reduction of soil productivity, in B.C. are of two sorts:

- First - a lack of information, which should be addressed by research activities and an aggressive extension and demonstration program; and
- Second - a lack of implementation of knowledge, which can be addressed through clearly stated degradation and rehabilitation guidelines, a careful monitoring program, and a series of appropriate incentives to ensure compliance.

Research activities at present are directed towards:

- looking at the effects of different harvesting and site preparation activities on different soils and slopes;
- examining the relationship between degree of soil disturbance and short- and long-term forest productivity;
- deriving appropriate ecosystem-specific guidelines for harvesting and site preparation; and
- investigating the efficacy of various soil rehabilitation techniques.

Much of the information presented earlier about degree and extent of soil degradation is from research conducted in B.C. Ongoing projects are directed towards evaluating the areal extent and the severity of soil disturbance by different machines and by prescribed fire on different ecosystems. Areas of particular interest include:

- alternative harvesting and site preparation techniques for reducing the percentage of a setting disturbed;
- soil bulk density changes occurring as a result of these practices;
- nutrient changes (soil and seedling foliage) which take place in response to these activities; and
- microclimatic changes accompanying soil disturbance.

A number of studies are attempting to correlate seedling performance with changes in soil chemical and physical properties, but results are available, in most cases, for only the first few years' growth.

The degradation to be expected from a given disturbance, and the consequent reduction in site productivity, is ecosystem-specific. In order to benefit from our knowledge of the effects of soil disturbance, resource managers must understand the structure and function of the ecosystems they are managing. A major research thrust in B.C. has been the ecological classification of our provincial landbase. An investment of approximately 250-300 man years, and approximately 14 million dollars, has resulted in a series of maps, technical reports and field guides describing the ecosystems over approximately 90% of our province's 30 million hectares. Part of this classification involved the description of the soils and humus forms for ecosystems in the various climatic regions of B.C., including a taxonomic classification of humus forms developed for the classification program. Within the framework of the biogeo climatic ecosystem classification, ecosystem structure, function, and response to manipulation have been documented, and these findings have been incorporated into management interpretations available to foresters.
In addition to gathering this information and providing it to foresters, it is important that the information be used by the resource managers to alter their practices in order to protect the soil resource. To this end, a number of the Forest Regions in British Columbia have implemented or are considering implementing, policies limiting the areal extent of landings and skid trails, and dictating their rehabilitation following harvesting. In general, foresters have been quick to respond, and careful planning of harvesting and site preparation has been shown to be cost effective when reduced rehabilitation costs are factored in. As an example, prelocation of skidroads to take advantage of terrain features can reduce skidroad density, and so reduce the percentage of the harvested area occupied by skidroads.

**REHABILITATION**

Most degraded soils can be at least partially restored to their former productivity. This is an expensive process, however, and preventing soil degradation is a much more cost-effective and responsible practice. Forestry activities will involve some degree of degradation, however, and so it is important that we investigate soil rehabilitation options.

Soil rehabilitation research activities commenced in B.C. in the 1970's in the Cariboo Forest Region, in conjunction with landing and skidroad reclamation guidelines. Studies since then, primarily in B.C.'s interior, have shown that:

- soil decompaction without restoration of nutrients will not sustain commercial tree growth;
- soils with low amounts of organic matter will usually reconsolidate soon after decompaction, in as little as one year; and
- rock rippers produce unacceptable decompaction; the winged subsoiler seems to be more successful.

Current practices in British Columbia include tilling of various sorts (particularly with the winged subsoiler), mulching, fertilizing, seeding to grass and/or legumes, and planting with Sitka alder. These activities are expensive; costs range from $750/hectare for ripping landings, respreading top soil, fertilization and seeding with a grass/legume mixture to $2500-4000/hectare (estimated) for severely disturbed sites with active erosion (Lousier 1988). It is not expected that such rehabilitation techniques will restore full site productivity. As well, some sites, particularly those with compacted fine-textured soils low in organic matter, may not be amenable to rehabilitation at all. Clearly prevention of soil degradation is the best policy.

**SUMMARY**

Maintaining the productivity of B.C.'s forest land is the key to the economic future of our province. Forestry activities, particularly harvesting and poor silvicultural practices, have the potential to seriously reduce the productivity of forest land.

The economic losses associated with this reduction in productivity, though not obvious, are substantial. Though rehabilitation of degraded soils is possible, and much promising research in this field is underway, prevention of degradation is a preferable and ultimately less expensive option.

The key to maintaining the productivity of B.C.'s forest landbase is:

- a greater awareness of the soil as the primary resource;
- a better understanding of the effects of our forestry activities on that resource; and
- better planning and execution of forest management activities in consideration of the soil resource.

Resource managers must realize that public and industry concerns about sustained productivity are now at a level where we can take steps to ensure that productivity is sustained. We have been challenged to practice responsible stewardship on our province's forest lands. As soil specialists, we must be committed to helping B.C.'s foresters meet that challenge.
LITERATURE CITED


