RESEARCH NOTES

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USING ACCOUNTING TO MANAGE THE BOREAL FOREST: A New Indicator of Soil Fertility Maintenance

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Introduction

Healthy trees require healthy soil. One of the challenges faced by forest managers is maintaining soil quality after harvesting. Managers have few tools, however, to assist in decision-making in this area. Furthermore, what is beneficial and what is detrimental to the maintenance of soil fertility is not always clear. Standards for soil and water conservation in forests (Canadian Council of Forest Ministers' Criterion 3) generally address only physical damage to the soil, such as rutting, erosion and compaction, and rarely deal with the following issues:

Slash left on-site following harvesting.

- Does removing forest biomass contribute to soil impoverishment over the long term?
- To maintain soil fertility, should unused tree parts, such as foliage and branches, be left in the cutting area?
- Can logging residue (bark, branches, foliage) be recovered and utilized for other purposes without harming soil fertility?

Nutrient budget

A tool for determining the situations most likely to result in the loss of soil fertility was designed for the boreal forest. The approach used, the nutrient budget, was borrowed from accounting. This method involves estimating the nutrient gains and losses that may occur in a forest

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ecosystem and determining the risk of losses exceeding gains in a series of situations. Forests are open ecosystems that experience annual nutrient gains and losses even in the absence of logging. For example, in the boreal forest, fire may bring about significant losses of nutrients such as nitrogen, but these losses are generally offset by inputs from atmospheric deposition or soil minerals. A number of studies suggest that losses due to logging may be equal to or greater than those from natural disturbances in the case of some nutrients such as calcium, potassium and magnesium, but less important in the case of other nutrients such as nitrogen. The soil fertility maintenance indicator (SFMI) developed in the study is based on estimated nutrient losses and gains for different types of forests and for two types of logging (whole-tree and stem-only harvesting). Estimation methods are summarized below.

Slash piles composed of residues from forest harvesting extracted from the site but not used following whole tree harvesting.

Estimating gains

Soil richness and atmospheric nutrient deposition were taken into account in estimating gains. Due to the inadequate coverage of soil properties in Quebec's boreal forest, soil analyses could not be used to estimate the capacity of soils to provide nutrients. Instead, information on surface deposits and ecological data on forest composition and the productivity of stands found on different surface deposits were used to estimate soil richness. This information was used to determine nutrient fluxes; for example, in sandy soils, which often support jack pine stands with low to moderate growth rates, nutrient fluxes (such as the accumulation of nutrients in vegetation) are much lower than in balsam fir stands on till or aspen stands on clay. This allowed us to estimate the soil's capacity to generate nutrients for four main types of surface deposits: S: thin soil; F: sand; T: till (thick and thin); and C: clay.

Estimating losses

Nutrient losses were estimated at harvesting on the basis of stand characteristics and the harvesting method used. Stand composition, age, density and productivity, as indicated by the site index (SI) or height in metres at 50 years, are all stand characteristics that affect the quantity of nutrients found in forest biomass. Stand age at harvesting also has an impact on losses. Roughly, losses appear to peak (over the long term) at a point corresponding to the age of financial maturity, i.e. the point at which mean annual growth and current annual growth coincide. Harvesting a stand before or after maturity generally has a positive effect on the nutrient budget of the site, but is detrimental to yield in biomass or stand volume.

Table 1.

Assessment of risk of depletion of soil nutrients in stands harvested at financial maturity based on stand composition, stand density, site quality index, harvesting type and surface deposits (S: thin soil; F: sand; T: till; C: clay).

SQI	Density	Whole Tree S	Whole Tree F	Whole Tree T	Whole Tree C	Stem Only S	Stem Only F	Stem Only T	Stem Only C
Black spruce									
9	low								
12	low								
15	low								
18	low								
9	mod.								
12	mod.								
15	mod.								
18	mod.								
9	high								
12	high								
15	high								
18	high								
Balsam fir									
9	low								
12	low								
15	low								
18	low								
9	mod.								
12	mod.								
15	mod.								
18	mod.								
9	high								
12	high								
15	high								
18	high								
Jack pine									
9	low								
12	low								
15	low								
18	low								
9	mod.								
12	mod.								
15	mod.								
18	mod.								
9	high								
12	high								
15	high								
18	high								

SQI	Density	Whole Tree S	Whole Tree F	Whole Tree T	Whole Tree C	Stem Only S	Stem Only F	Stem Only T	Stem Only C
White birch									
12	low								
15	low								
18	low								
21	low								
12	mod.								
15	mod.								
18	mod.								
21	mod.								
12	high								
15	high								
18	high								
21	high								
Trembling aspen									
15	low								
18	low								
21	low								
24	low								
15	mod.								
18	mod.								
21	mod.								
24	mod.								
15	high								
18	high								
21	high								
24	high								

LEGEND

- Losses < gains
- Losses > gains by less than 33%
- Losses > gains by 33-66%
- Losses > gains by over 66%

Source: Paré et al. (2002).

The type of harvesting carried out (whole tree or stem only) also affects nutrient losses, but the impact varies greatly depending on the stand type. For example, heavy nutrient losses occur under whole-tree logging in balsam fir stands, but the same method produces much lower losses in jack pine stands.

An indicator for comparing gains and losses

When nutrient gains and losses are compared for various combinations of stand types (composition, density, SQI) and harvesting types (whole tree, stem only), the risk of removing more nutrients than the site can supply may range from zero to high (Table 1). For conifers, the highest-risk situations (i.e. losses estimated to be over 66% greater than gains) involve mainly balsam fir stands and, for hardwoods, trembling aspen stands; both species are relatively fast growing and have high concentrations of nutrients in their tissues. The highest-risk situations consist of high-density stands with high growth rates. It should be noted, however, that a number of these situations, involving fast-growing stands on poor soils, do not actually occur in nature.

The soil fertility maintenance indicator does not provide results that are 100% reliable, but rather serves as an indicator of risk. Studies are currently being undertaken to validate these conclusions and to determine whether these criteria need to be relaxed or tightened. The ranking of situations according to the degree of risk should however remain the same.

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Conclusion

The research led to an increased understanding of the factors affecting the nutrient balance in forests. For example, we found that harvesting non-mature stands did not create a greater drain on nutrients than did harvesting mature stands. The harvest of non-mature stands could be envisaged in the event of an insect infestation such as a spruce budworm epidemic.

Reference

Paré, D.; Rochon, P.; Brais, S. 2002. Assessing the geochemical balance of managed boreal forests. Ecological Indicators 1:293-311.

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