Effects of opening size on soil ecology and nutrient cycling in a high-elevation, southern Interior forest

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INTRODUCTION

The Sicamous Creek Silvicultural Systems Project was established to provide the forestry community with information on the ecology and responses to disturbance of high-elevation, Engelmann Spruce–Subalpine Fir (ESSF) forests in the southern Interior of British Columbia. Forty-five separate projects have been established at the site. These projects are in the broad areas of harvest logistics, forest dynamics, microclimate and hydrology, soils and nutrient cycling, tree regeneration and growth, flora, fauna, and habitat attributes. The intent is to create a comprehensive and integrated information base to help manage silvicultural systems in these forests.

Soil projects were established with two major aims:

1. to gain an understanding of the properties and processes affecting soil productivity in the forests; and
2. to understand the effects of canopy disturbance on those processes.

Soil organic matter appears to be the main soil component affected by harvesting in the ESSF zone because much of the harvesting takes place on a protective snowpack. In addition, soil biological activity and microclimate control many of the soil processes involving organic matter. These properties are consequently the focus of numerous soil-related studies at Sicamous Creek.

MATERIALS AND METHODS

The study area is located in the Hunter Range southeast of the town of Sicamous, in the Salmon Arm Forest District. The site is in the Engelmann Spruce–Subalpine Fir wet cold biogeoclimatic subzone (ESSFwc2), at an elevation of 1500–1800 m. Soils on the site are predominantly sandy loam-textured Orthic Humo Ferric Podzols. These soils occur on mesic and submesic site series. On wetter areas, soils are Gleyed Sombric Brunisols and Orthic Gleysols. Forest floors average 4 cm throughout the site (range: 1–14 cm) and contain approximately 10–30% decayed wood. Humus forms are predominantly Hemimors.

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Harvesting created five different opening types or sizes. Each treatment is replicated three times in a randomized block design separated by buffers of mature forest. Treatments included control, single-tree selection, and 0.1-, 1.0-, and 10-ha openings. The site was harvested in the winter of 1994/95 and site prepared the following summer. All openings were planted in the summer of 1996.

Table 1 provides a summary of soil-related projects established at Sicamous Creek.

TABLE 1 *Soil and nutrient studies at Sicamous Creek*

Study leaders	Focus	Parameters measured	Sampling locations	End products
Hope, Prescott, and Sachs	Organic matter and nitrogen dynamics	Soil C, N and S; N mineralization; litter decomposition; N uptake by seedlings	All treatments; plus transects in one 10-ha block	Soil nutrient budgets; N turnover rates; long-term C and N predictions
Johnson and Hope	Soil food webs and nitrogen dynamics	Total soil bacteria, fungi, and nematodes; N mineralization and denitrification	Control, 0.1 ha, and 10 ha	Food web biomass, N dynamics in the root zone
Jones, Durrall, and Hagerman	Ectomycorrhizal diversity and fungal sporocarps	Live ectomycorrhizal root tips; soil bioassays; sporocarp biomass and identification	Control, 0.1, 1.0, and 10 ha; plus transects in three 10-ha blocks	Number or biomass, and diversity of ectomyco-rrhizae and sporocarps
Hunt and Welke	Fine roots	Fine root biomass, nutrient content; and decomposition	Control, 0.1, 1.0, and 10 ha; plus transect in one 10-ha block	Nutrient capital and fluxes from fine roots
Nadel	Soil micro-arthropods	Mites and collembola; numbers and diversity	Control, 0.1, 1.0, and 10 ha; plus transect in one 10-ha block	Abundance and diversity of mites and collembola
Adams	Microclimate	Soil temperature	Transects in one each of the 0.1-, 1.0-, and 10-ha blocks	Models of edge effects on temperature
Prescott	Litter and coarse woody debris inputs	Annual litter and dead wood inputs	Control	Rates of input
Feller	Nutrient budgets, nitrogen fixation	Nutrients in precipitation and soil leachate; N fixation and denitrification	One control and one 10 ha block	Nutrient budget, gaseous N fluxes

RESULTS

Results presented here are for 2, 3, and 4 years after harvest.

Effects of Harvesting

The most dramatic decrease was in hypogeous sporocarp (truffle) biomass. Significant decreases were also observed in fungal biomass, numbers and diversity of active mycorrhizae, and fine-root biomass. Total and active fungal biomass, but not total bacterial biomass, decreased in the forest floor in the 1.0- and 10-ha openings ($p \leq 0.1$). Increases occurred in soil temperature, nitrogen mineralization, and denitrification (loss of nitrate as gaseous N) potential. Total bacterial biomass, nematodes, and mineral soil microbial biomass were insignificantly affected. Micro-arthropod abundance, but not diversity, was also reduced. Partial cutting did not significantly affect the low rate of nitrogen fixation (< 1 kg/ha per year) occurring in undisturbed forests.

Influence of Opening Size

Rates of inorganic N production (mineralization and nitrification) increased with increased opening size up to 1.0 ha in the second year. In the third year, any canopy disturbance increased both inorganic N and the proportion of nitrate. Increased mineralization was not accompanied by faster decomposition of litter or forest floor.

After two and three growing seasons, all opening sizes showed the same decrease in the richness of ectomycorrhizae away from forested edges into the openings. In the spring (but not in the fall) two and three years after harvest, some measures of fine-root biomass showed significant differences between openings. Two years after harvest, the collective abundance of soil micro-arthropods and the diversity of mites and collembola showed no significant change with opening size, although one group (the Collembola) do show a trend of being affected by cut size.

Changes Away from the Forested Edge

On hot, clear days, any change in temperature occurred very close to the forest edge on the opening side (< 12 m). On such days, variations across the edges are most pronounced. A general increase occurred in N mineralization from the south to the north edge of the 10-ha clearcut in both the first (statistically significant) and second (non-significant) years after harvest. Two and three growing seasons after logging, the richness of ectomycorrhizal types colonizing young, initially non-mycorrhizal seedlings, was significantly greater within 2 m from the forest edge compared to plots farther out into the openings. A significant difference in fine-root biomass along the 10-ha transects also occurred.

CONCLUSIONS

We arrived at the following conclusions.

- Increases in soil temperature and nitrogen availability, which improve early seeding establishment and growth after harvesting, are no greater in 10-ha cuts than 1-ha cuts.
- Site nitrogen should be conserved wherever possible because nitrogen inputs (fixation, precipitation) are low, and possible losses through nitrate leaching and denitrification may occur after harvesting (e.g., in tops, branches, and forest floor).
- Soil biological parameters are affected differentially by harvest and time after harvest, by opening size, and by the distance from the forest edge into the opening.

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