Alternate Strip Clearcutting in Upland Black Spruce

IV. Projected Nutrient Removals Associated with Harvesting

by

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Abstract

Nutrient removals associated with conventional, full-tree, and whole-tree harvesting on 100-year rotations in an upland boreal black spruce stand in northern Ontario were estimated. Conventional (stems only) logging would remove 219 kg ha⁻¹ of Ca, 62 of N, 36 of K, 18 of Mg and 9 of P from the site. Increased utilization of phytomass during full-tree harvesting, in comparison with conventional logging, could result in as much as a 400% increase in N removal and a 60% increase in Ca removal. Estimates of projected N and K removals by full-tree harvesting may be conservative, relative to those in other black spruce stands because of the low foliar mass of this forest. The forest floor contained 51% to 72% of the soil's reserves of nutrients, except for P, within the effective rooting zone. Post-harvesting site preparation methods should be restricted to those that ensure that forest floor nutrient reserves are retained on site.

Résumé

On a estimé l'exportation des éléments nutritifs liée à l'exploitation classique, à l'exploitation par arbres entiers et à l'exploitation de toute la phytomasse, sur une révolution de 100 ans, dans un peuplement d'épinettes noires de type boréal des hautes terres du nord de l'Ontario. L'exploitation classique (fûts seulement) s'accompagnerait d'une exportation de 219 kg de Ca, de 62 kg de N, de 36 kg de K, de 18 kg de Mg et de 9 kg de P à l'hectare. L'utilisation accrue de la phytomasse durant l'exploitation par arbres entiers provoquerait, par rapport à l'exploitation traditionnelle, une augmentation de jusqu'à 400% de l'exportation de N et de 60% de l'exportation de Ca. L'estimation de l'exportation prévue de N et de K, par l'exploitation par arbres entiers peut être prudente, si on la compare à celle d'autres peuplements d'épinettes noires, à cause de la faible masse foliaire de ce type de forêt. La couverture morte contient de 51 à 72% des réserves du sol en éléments nutritifs, sauf P, à l'intérieur de la zone utile d'enracinement. Les méthodes de préparation du sol après l'exploitation devraient se limiter à celles qui font en sorte que les réserves nutritives de la couverture morte restent sur place.

Introduction

In considering the effects of harvesting on forest ecosystems, a serious concern is the increased quantities of plant nutrients that are removed from the site because of the tendency toward more intensive management, with its fuller utilization of phytomass and shorter rotations. Knowledge of the quantities of nutrients contained in portions of the forest phytomass permits predicting nutrient removals associated with different degrees of utilization. This information, in turn, can be used in selecting forest management options for establishing and tending the next forest. For example, species with low nutrient demands might be chosen for sites on which nutrients are limited, or sites where fertilization may be needed to maintain or improve forest productivity. The objective of this

study was to quantify the phytomass and nutrient content of a mature upland black spruce (*Picea mariana* [Mill.] B.S.P.) stand on a shallow (0 to 85 cm deep) acid till. Potential nutrient removals associated with conventional, full-tree, and whole-tree harvesting on 100-year rotations are estimated and discussed.

Site Description

The study area was near Lake Nipigon in northern Ontario (lat. 49°30'N; long 87°50'W), within the Central Plateau Section (B.8) of the Boreal Forest Region (Rowe 1972). The experimental area was located on thin deposits of stony, silty, morainal till over compact, sandy, basal till and/or granitic bedrock. The soil has an Orthic Humo-Ferric Podzol profile (Canada Soil Survey Committee 1978).

Soil depth was highly variable, ranging from humus-over-bedrock to a maximum of 85 cm of till over bedrock, and generally increased in depth from the crest to the lower slope position. The average effective rooting depth in the mineral

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soil was 13 cm in the crest position and up to 21 and 23 cm in the upper and lower slope positions, respectively. Sinker roots with many branches and fine roots (< 1 mm) were present in abundance throughout the ablation till. The density of rooting was far less in the compacted, infertile, sandy basal till in the deeper soil deposits. Stoniness was about 40% throughout the soil profile.

The stand examined occupied a south-facing slope extending 300 m, with the crest elevated 10 m above the drainageway. The main stand consisted of ca 110-year-old black spruce, contributing ca 87% of the total basal area (BA), with jack pine (*Pinus banksiana* Lamb.) accounting for 10%, and balsam fir (*Abies balsamea* [L.] Mill.), trembling aspen (*Populus tremuloides* Michx.), and white birch (*Betula papyrifera* Marsh.) combined accounting for the remaining 3%. Mean dominant height, measured on sample plots, was 19.6 m; mean diameter at breast height (DBH), averaged over all species and all trees with measurable diameter, was 14.8 cm (ranging up to 31.3 cm for black spruce, and up to 31.5 cm for jack pine). Mean BA was 23.0 m²/ha. There were ca 1200 stems/ha. Total standing volume was 178.3 m³/ha. Merchantable standing volume was 164.6 m³/ha. Additional details of vegetation and site are contained in Tables 1 and 2 and in Jeglum (1980).

Methods

Twelve contemporary 0.10-ha rectangular sample plots were established in adjacent first-cut leave strips, three each in the crest, upper slope, lower slope and drainageway. The DBH of all trees was tallied by species during the summer of 1977. Dry weights of 25 mature and 14 understory black

spruce trees, of 10 such jack pine and of 24 balsam fir trees, were determined. The jack pine data set was augmented by data from mature trees elsewhere in northern Ontario. A method adapted from Hegyi (1972), in combination with stand tables from the temporary sample plots, was used to calculate dry weights per hectare, by components.

Samples of foliage, cones, live branches, dead branches, stem bark, stem wood, and wood and bark material from stumps and roots were collected from a total of 88 trees. These trees were distributed in equal numbers covering the range of tree sizes found in the 12 sample plots during the late summer of 1978. Samples were oven dried at 70°C until they reached constant weight, were ground, and were analyzed chemically according to Morrison (1985). Contents of N, P, K, Ca, and Mg were calculated on a plot-by-plot basis by mean concentrations and plot dry weight. Data were expressed as the mean of 12 plots.

Dry weights of ground vegetation and forest floor horizons were estimated on the crest in late July from 100 0.09-m² and 80 0.02-m² randomly selected subplots, respectively. Litterfall was collected six times a year for three years from 20 0.25-m² traps within a 0.06-ha subplot on the crest. Soil samples were collected from 10 pits within each of three 0.25-ha plots, one on the crest, one on the upper slope and one on the lower slope. Soil pits were dug to bedrock. Each major horizon encountered was described and sampled. Soil was analyzed for the following: total N by semimicro-Kjeldahl digestion, total P after acid digestion, and exchangeable K, Ca and Mg by atomic absorption after extraction with 1N ammonium acetate buffered at pH 7.0. Potential mineralized N was estimated as the difference in N extracted by 2M KCl from soil at the

Table 1. Physical properties, pH and CEC of the soil. Average values $\pm$ SD.

Horizon	Depth (cm)	Bulk density (g cm ⁻³)	Percent of weight in materials > 2 mm	Texture	Organic matter (%)	CEC ^a c moles (+) kg	pH ^b	n
F	10-2	0.1	—	—	90.5 $\pm$ 1.3	104.1 $\pm$ 8.2	3.0	15
H	2-0	0.4	—	—	49.0 $\pm$ 9.1	99.1 $\pm$ 9.7	2.8	15
Ae	0-2	1.0	42 $\pm$ 25	silt loam	4.3 $\pm$ 1.8	16.2 $\pm$ 4.4	3.3	20
Bf ₁	2-7	0.9	43 $\pm$ 24	loam	5.1 $\pm$ 2.0	19.3 $\pm$ 6.5	3.7	22
Bf ₂	7-19	1.2	43 $\pm$ 25	loam	2.8 $\pm$ 1.6	11.9 $\pm$ 3.4	3.9	24
B _m	19-20	1.1	37 $\pm$ 26	loam	1.7 $\pm$ 0.8	7.4 $\pm$ 4.2	4.3	5
IIC	20-32	1.5	41 $\pm$ 27	sandy loam	1.1 $\pm$ 0.5	6.3 $\pm$ 1.9	4.3	18

^aNH₄OAc (pH 7.0)

^b0.01 M Ca Cl₂

Table 2. The dry matter and nutrient content of black spruce dominated forest.

Age	Basal area	Site	Phytomass			Standing crop (aboveground)					Reference
			Aboveground	Crown	Foliage	N	P	K	Ca	Mg	
years	m ² ha ⁻¹		t ha ⁻¹			kg ha ⁻¹					
65	42	SL till ^a	107	18.6	8.3	167	42	84	276	27	Weetman and Webber (1972)
75	28	—	113	—	—	240	30	112	314	33	Freedman and Duinker (1985)
95	25	SiL loess ^a	50	13.5	5.6	123	14	57	285	27	Van Cleve <i>et al.</i> 1983
48	33	sand	141	35.8	15.9	482	26	308	370	44	Gordon (1983)
108	40	peat	161	40.4	17.7	547	29	350	414	50	"
110	23	L till ^a	142	35.2	9.1	234	18	122	334	42	Present study
126	32	SL till ^a	138	22.7	7.6	536	65	141	1 024	66	Timmer <i>et al.</i> 1983 ^b
126	49	SL till	325	39.1	12.6	897	108	220	1 696	106	"

^aSL = sandy loam, L = loamy, SiL = silty loam.

^bValues represent nutrient exports associated with full-tree harvesting.

beginning and end of a 12-week incubation at constant 33 kPa moisture and 20°C. Soil nutrient contents were computed by horizons on the basis of nutrient concentrations, depth, and bulk density and stoniness.

Results

The largest nutrient pools within the forest vegetation component of the ecosystem were for N in the foliage, K in the live branches, P and Mg in the wood and Ca in the bark (Table 3). An additional 33% and 43% more phytomass could be harvested from this forest by using full-tree and whole-tree harvesting, respectively, rather than conventional methods (Table 4). This gain would result in a 400% increase in N removal from the site, a 300% increase in K, a 200% increase in P and Mg and a 60% increase in Ca. Whole-tree harvesting would more than double that component of soil acidification associated with cation uptake through removal of bases in vegetation (Table 5).

The forest vegetation contained 7% of the total N at the site and 3% of the total P (Table 6). There was more K and Ca in the vegetation than on the cation exchange sites in the soil. The nutrient content of the forest floor exceeded that of the ablation till for all nutrients except P (Table 6). The vegetation and forest floor together contained 62% of the N, but only 27% of the P, at the site.

Discussion

Vegetation Nutrient Contents

The results from this study apply only to a limited, but very representative, area of shallow podzolic soils supporting upland black spruce near Nipigon, Ontario, because nutrient accumulation is site and species specific. This site, with a medium textured till, supported a very productive but considerably understocked black spruce stand. Conventional shortwood or tree-length harvesting (where stems only are removed) would result in considerable Ca removal from this site because of the amount of Ca within the bark and wood (Table 3). The removal of nutrient-rich foliage and branches, however, would contribute to a much greater loss of N and K and, to a lesser extent, P and Mg, with full-tree harvesting (where the entire above ground portion is removed) than with conventional practice. For example, full-tree logging would remove approximately 172 kg more N per ha from this site than would conventional harvesting. The additional removal of nutrients associated with extracting and removing the stump and roots along with the above ground components (often referred to as whole-tree as opposed to "full-tree" harvesting)

would be small. The results of the vegetation assessment indicate that full-tree harvesting of this spruce stand would exert a considerably larger nutrient drain on soil reserves than would conventional (stems only) logging.

Nutrient contents in this stand in general, and N and P accumulations specifically, were quite modest in comparison with those reported previously for black spruce (Table 2). The black spruce stands were quite variable in their nutrient content and hence in their potential for nutrient removal by harvesting. The variability is related to differences in stand productivity which are determined by stand age, environmental factors, site fertility and genetic variation within black spruce populations. In part, the low nutrient content of this stand reflects the low stand density and, particularly, the very low foliar mass which was well below that of some stands of equal crown weight (Table 2). Consequently, one might expect an even greater N and K drain with full- or whole-tree harvesting from a site with a greater foliar mass, and this was observed (Table 2).

Soil Nutrient Reserves

From a nutritional point of view it is the nutrient content of the humus and surface mineral horizons that is critical for black spruce because fine roots are commonly most abundant there, and in some cases are restricted largely to these horizons. Forest floor horizons, in these shallow soils, contained a large proportion (K 72%, Ca 68%, N 59%, Mg 51%, P 23%) of the nutrient capital of the soil (Table 6). Moreover, organic horizons protect the mineral soil from the impact of rainfall, so that surface runoff and soil erosion are reduced. Slash removal exposes the ground surface to excessive heating and drying.

It is generally considered necessary to expose mineral soil to favor natural regeneration of black spruce on upland sites. Exposure may be accomplished by fire or scarification. Of the two, fire will have particularly serious consequences, in that much of the N reserve in the slash and humus could be volatilized into the atmosphere and other plant nutrients could be subject to erosion by wind and water. Post-harvesting treatments to encourage regeneration that result in removal of the nutrient capital of the humus should be avoided on shallow till soils. A light scarification, i.e., one in which organic materials are mixed with the surface mineral soil, is preferable to treatments that remove slash and humus. Incorporation of organic matter into the soil also increases the cation exchange capacity of the soil and hence the capacity of the soil for nutrient retention.

Post-harvest regeneration can benefit from the nutrients in slash and in the forest floor that would not have been

Table 3. Distribution ($\bar{x} \pm SD$) of phytomass and nutrients in a 110-year-old black spruce forest.

Component	Phytomass (kg ha ⁻¹)	Stand content (kg ha ⁻¹)				
		N	P	K	Ca	Mg
Foliage	9 100 $\pm$ 2 200	80 $\pm$ 19	5.7 $\pm$ 1.4	33 $\pm$ 8	54 $\pm$ 13	8.8 $\pm$ 2.1
Cones	3 600 $\pm$ 1 000	11 $\pm$ 3	1.5 $\pm$ 0.4	3 $\pm$ 0.8	3 $\pm$ 0.8	1.7 $\pm$ 0.5
Live branches	16 200 $\pm$ 3 900	67 $\pm$ 16	1.0 $\pm$ 0.2	48 $\pm$ 11	53 $\pm$ 13	13.5 $\pm$ 3.2
Dead branches	6 300 $\pm$ 1 700	12 $\pm$ 3	0.6 $\pm$ 0.2	1 $\pm$ 0.4	5 $\pm$ 1	0.6 $\pm$ 0.2
Stem wood	93 000 $\pm$ 24 000	34 $\pm$ 9	6.5 $\pm$ 1.7	24 $\pm$ 8	93 $\pm$ 24	13.9 $\pm$ 3.6
Stem bark	14 200 $\pm$ 3 600	28 $\pm$ 7	2.6 $\pm$ 0.6	12 $\pm$ 3	126 $\pm$ 32	4.1 $\pm$ 1.0
Stump and roots	43 000 $\pm$ 11 000	22 $\pm$ 6	3.4 $\pm$ 0.9	14 $\pm$ 3	76 $\pm$ 20	6.8 $\pm$ 1.8
Tree total	185 000 $\pm$ 47 000	256 $\pm$ 63	21.3 $\pm$ 5.5	136 $\pm$ 33	410 $\pm$ 103	49.5 $\pm$ 12.3

Table 4. Quantity of phytomass and nutrients removed from a 110-year-old black spruce forest by conventional (stems only), full-tree, and whole-tree harvesting.

Harvesting method	Phytomass (kg ha ⁻¹)	Stand content (kg ha ⁻¹)				
		N	P	K	Ca	Mg
Conventional	107 000	62	9	36	219	18
Full-tree	142 000	234	18	122	334	43
Whole-tree	153 000	239	19	125	353	45

Table 5. Acidification (keq ha⁻¹) associated with harvesting 110-year-old black spruce.

	Conventional harvest	Full-tree harvest	Whole-tree harvest
Cations	18.5	40.8	47.8
Anions	1.1	2.8	3.2
Difference	17.4	38.0	44.6

available when the present stand originated after fire. Jeglum (1983) reported that after strip-cutting the proportion of trembling aspen and white birch in natural regeneration on similar sites increased relative to their abundance in the uncut forest. Hendrickson *et al.* (1987) have speculated that aspen, which accumulates large amounts of nutrients in foliage and bark, may take advantage of the increased availability of nutrients after harvesting. In a mature forest dominated by spruce and fir, white birch responded to added N, but black spruce did not (Morrison and Foster 1979). During early stand development, competition for nutrients between species is intense since the site must provide nutrients that in mature individuals could be translocated from older tissue into young tissues.

Forest removal, moreover, has an undesirable acidifying effect on the soil, because K, Ca and Mg contained in the phytomass are not returned to the soil. The neutralizing effect of full incorporation of forest phytomass into the soil would be equivalent to 13% of the exchangeable acidity (335 keq ha⁻¹) within the soil (effective rooting zone). This particular forest is remote from point sources of air pollution, with a 1979-1981 average annual pH of bulk precipitation of 5.4². The annual acidifying effect of the vegetation removal by full-tree harvesting averaged over the rotation period was eight times greater than the estimated annual acid deposition from

precipitation. Conventional harvesting would acidify the soil less than full-tree logging because less phytomass and hence less nutrients are removed.

There were sufficient nutrient reserves in the soil to replace the projected nutrient drain associated with another 100-year rotation of spruce if conventional harvesting were conducted. Calcium and K removals by full-tree harvesting would exceed the reserves of extractable Ca and K in the soil, P and Mg removals would not (Tables 4, 6). As Weetman and Webber (1972) have pointed out, however, exchangeable nutrient reserves are not necessarily those nutrients that are available to the vegetation. Exchangeable reserves are dynamic, changing in response to the release of nutrients from the much larger content associated with primary minerals in the soil. The size of the exchangeable pools is dependent on the rate of biological and geochemical reactions in the soil and on nutrients received from atmospheric sources.

Nutrient Replenishment

Precipitation and Weathering

Replenishment consists of nutrient inputs to the ecosystem (mineral weathering, precipitation) and the mineralization of organically combined nutrients to inorganic forms available to plants. Established forests can depend on nutrient cycling through decomposition of tree litter that helps satisfy their nutrient demands. Only a small portion of the nutrients absorbed annually by the forest is retained in the standing phytomass. Most are returned to the soil each year by litterfall. In this black spruce forest, a three-year average estimate of annual litterfall was 2600 kg ha⁻¹ of organic matter containing 15.0 N, 1.4 P, 2.7 K, 15.5 Ca, and 1.8 kg ha⁻¹ of Mg.

Nutrients removed in harvesting can be replaced if atmospheric and weathering inputs exceed the nutrient loss associated with harvesting and leaching from the soil. Average (1980-1984) annual nutrient inputs in precipitation were approximately 7 kg ha⁻¹ N and Ca, 2 K, 1 Mg and 0.5 P³. Primary mineral weathering inputs averaged over a rotation were approximately 28 kg ha⁻¹ yr⁻¹ of Ca, 9 of Mg and 2.5 of K. Weathering inputs were computed by difference with a mass balance equation in which the nutrient released is equal to leaching loss minus precipitation input plus change in storage in vegetation. Weathering and precipitation inputs together are greater than an annual prorated, projected nutrient loss that is due to full-tree harvesting, and this suggests that nutrient losses are replaceable.

Table 6. Distribution of organic matter and nutrients in a 110-year-old black spruce ecosystem.

Ecosystem component	Organic matter (kg ha ⁻¹)	Nutrient distribution (kg ha ⁻¹)				
		N	P	K	Ca	Mg
Trees	185 000	256	21	136	410	50
Ground vegetation	300	2.7	0.2	1.5	1.9	0.8
Moss	1 600	15.9	1.6	5.8	6.6	1.3
Forest floor	120 000	1 790	100	75 ^a	206 ^a	36 ^a
Ablation till	144 000	1 240	335	29 ^a	97 ^a	34 ^a
Basal till	11 500	349	319	10 ^a	70 ^a	20 ^a
Total	463 000	3 660	777	257	792	142

^abased on exchangeable (NH₄OAc-pH 7) in forest floor and till

²Nicolson, J.A. 1987. Canadian Forestry Service, Great Lakes Forestry Centre, Personal Communication.

³Nicolson, J.A. 1987. Personal communication.

Nitrogen is the nutrient most limiting to the growth of conifers in the Canadian boreal forest (e.g., Weetman and Webber 1972, Foster and Morrison 1983). In mature boreal coniferous forests, the cycle of N from litterfall through the soil to the vegetation is commonly interrupted by N accumulation in humus (F and H horizons) (Weetman and Webber 1972), brought on in part by N immobilization in microbial biomass during the decomposition process. It is difficult to generalize about the impact of N removals without examining the transformations of N in this soil in greater detail.

The total potential N mineralization, largely as $\text{NH}_4^+\text{-N}$, in the forest floor we examined was 40 kg ha^{-1} over 12 weeks or approximately 2% of the total N in the forest floor. Our results contrast with those of Roberge and Knowles (1966) who reported no net mineralization of N in the humus layers of an upland black spruce forest. This suggests that there are large differences in N turnover rates in undisturbed black spruce forests. Actual mineralization rates are unlikely to approach potential rates, however, because optimum conditions for microbial activity are seldom maintained in the field. We suggest, therefore, that it is the slow rates of decomposition, rather than withdrawal of available N in microbial biomass, that are likely to limit N release in this humus (F and H horizons). Forest growth was not stimulated appreciably when additional N was applied to a nearby mature black spruce forest on a lower topographic position (Foster *et al.* 1986). Lack of response suggests that, on similar sites, the annual N turnover in the soil is sufficient to meet the N requirements of mature black spruce forest.

Mineralization of forest floor N reserves is likely to increase temporarily in the post-harvest period because of more favorable temperature conditions in the humus (Foster, unpubl.). On some sites the presence of nutrient-rich slash and litter after conventional harvest stimulates N transformations (nitrification, denitrification) that can reduce the N availability on the site. Potential nitrification (NO_2^- included) in the black spruce humus we examined was low in relation to $\text{NH}_4^+\text{-N}$ mineralization, in agreement with the findings of Roberge and Knowles (1966) and Mahendrapa and Salonijs (1982). Nitrate-N, likewise, was a minor component ($0.2 \text{ kg ha}^{-1}\text{yr}^{-1}$) of N exports ($2.4 \text{ kg ha}^{-1}\text{yr}^{-1}$) from this forest in streamwater.⁴ Assessment of post-harvest nutrient losses from the land to streamwater will be presented in a companion paper (Nicholson, in preparation). Additional N losses by leaching and gaseous transfer in the post-harvest period are likely to be small. Phytomass removal from the site, therefore, is a good indication of the expected total N loss associated with harvesting. The consequences of N removal, even with full-tree harvesting, may not be severe since removals are modest in relation to total soil N reserves and their potential turnover on this site.

Weetman and Webber's (1972) contention that nutrient losses associated with full-tree harvesting of black spruce forest are unlikely to result in any additional nutrient limitations developing in acid tills of the Canadian Shield during a second rotation is supported by our results, despite the restricted rooting depth and volume on the site we examined. Weetman and Webber (1972), Gordon (1983) and Timmer *et al.* (1983) have cautioned that some infertile or shallow soils may contain insufficient P, K or Ca to sustain a fully productive second rotation forest after full-tree logging. These studies

document the large site-to-site variability in nutrient reserves, as was observed in stand nutrient contents. For example, soil Ca reserves within the effective rooting zone on acid tills varied from 44 kg ha^{-1} (Weetman and Webber 1972) to 2324 (Timmer *et al.* 1983). This, together with the high degree of uncertainty in quantifying site nutrient reserves, demonstrates the difficulties of trying to generalize about potential impacts of harvesting on the nutrition of future rotations of spruce forest. A modelling approach, perhaps one that develops and incorporates easy-to-quantify surrogates that might represent the nutrient status of a site, is needed to assess, on a site-by-site basis, the significance of nutrient losses owing to harvesting.

In summary, potential nutrient removals associated with full-tree harvesting were much greater than those associated with conventional (stems only) logging. There appear to be sufficient nutrient reserves and replenishment at this site after full-tree logging, despite the restricted rooting depth and volume, to sustain the next generation of spruce through the early growth period. Thereafter, nutrient drain on the soil reserves will be reduced by the extent that nutrient needs are met by nutrient cycling within the tree and the stand. These conclusions are based on the assumption that soil nutrient reserves will be protected from leaching and erosion by rapid revegetation. They should be substantiated by examining black spruce productivity and nutrient contents, at this site, during the next rotation. Nutrients contained in slash and forest floor horizons should be conserved because a substantial proportion of the nutrient reserves of a site are contained in these materials.

Acknowledgments

The assistance of Messrs. D. Kurylo and D. Ropke with sample collection, of Mr. J. Ramakers with chemical analysis of samples, and of Messrs. P. Hazlett and D. Ropke with analysis of the data is gratefully acknowledged. The cooperation of Domtar Inc. and the Ontario Ministry of Natural Resources, Nipigon District is appreciated.

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⁴Nicholson, J.A. 1987. Personal communication.

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Married or equivalent, second member only	\$ 67.00	CR \$8.00	RM \$10.00
All other Affiliate Members	\$ 88.00	KO \$10.00	SK \$10.00
Members with Retired Status receiving The Forestry Chronicle	\$ 29.00	LW \$13.00	SN \$8.00
Members with Retired Status not receiving The Forestry Chronicle	\$ 00.00	MB \$7.00	SO \$10.00
Student Members	\$ 27.00	MR \$18.00	VA \$10.00
Sustaining Members (CIF)	\$ 30.00	ND \$10.00	VI \$5.00
Sustaining Members (Other)	\$200.00	NO \$5.00	
		NW \$10.00	

The Institute year runs from July 1 to June 30. Applications dated after January 1 will be charged half dues for that Institute year. Applications dated after April 1 will be charged no dues for that Institute year.

Section dues are in addition and range from \$5.00 to \$18.00.