STRIP CLEARCUTTING DID NOT DEGRADE THE SITE IN A SPRUCE-FIR FOREST IN CENTRAL MAINE

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ABSTRACT

Changes in the nutrient concentration in the forest floor and in the mineral soil were assessed on a mature spruce-fir stand in central Maine that had been harvested in 1965 by strip clearcutting. On part of the site, slash was left in place; on other parts it was removed, and on some it was burned. Eight years after the harvest, the clearcut areas tended to have increased pH and increased concentrations of bases and percentages of base saturation, but the amounts of N and P were comparable to those in the residual forest. Soil drainage class and differences in parent material were the major sources of variation. There were no significant differences between control and slash-disposal treatments or among treatments. There was no evidence of site degradation from strip clearcutting.

Keywords: spruce-fir, effects of strip clearcutting, nutrient concentration, forest floor

FOREST HARVESTING, particularly large-scale logging operations, may exert an impact on soil nutrients and fertility-related site characteristics. To culture a new stand that is physiologically healthy, it is important that the nutrient budget be assessed. If excessive amounts of nutrients have been removed by stand harvesting, corrective measures may be essential.

Recent studies on this subject have been conducted for mixed hardwoods *(Boyle and Ek 1972; Boyle et al. 1973)*, and the nutrient budget for a spruce-fir forest in Quebec was estimated by Weetman and Webber *(1972)*. However, our knowledge of nutrient budget for spruce-fir sites in Maine is not extensive. Young and Guinn *(1966)* and Young and Carpenter *(1967)* presented data on nutrient concentrations in wood, branches, bark, roots, and foilage of the major species. These data provide a basis for estimating nutrient budgets and for evaluating possible nutrient losses due to timber harvesting. The first attempt to estimate a nutrient budget for a softwood forest type in west-central Maine was made by Norton and Young *(1976)*.

There is no information about the effects of clearcutting spruce-fir forests on Maine soils. Because of rapid changes in silvicultural practices such as complete stand removal and the change from shortwood to full-tree logging, more and more biomass is being removed from the forest. Also, previously unusable species are now being used and different sizes and qualities of timber are now being marketed. Currently, large areas of spruce-fir forests are infested by the spruce budworm *(Choristoneura fumiferana* (Clem.)) and are being salvaged to reduce losses. Thus depletion of soil nutrients and possible site degradation is a cause for concern. A study on the Hubbard Brook Experimental Forest *(Likens et al. 1967)* and a report on the effects of whole-tree harvesting of eastern cottonwood *(Populus deltoides* Bartr.) in Alabama *(White)* support this concern.

However assessments of nutrients in soils, as related to clearcutting and slash-disposal method, are not extensive. In this paper we present data on nutrient concentrations (and related characteristics) of soils in central Maine on a residual and strip-harvested forest site that was primarily softwood.

STUDY AREA

A mature spruce-fir stand in the Penobscot Experimental Forest, Bradley, Maine, was harvested by strip clearcutting in 1965. The slash was either left in place, or removed, or burned. Eight years later we estimated the nutrient concentration both in the forest floor and in clearcut areas.

The Forest

Original stand.—The original stand was a spruce-fir type on a site that was primarily softwood; the major age class was 70 to 80 years. The height of dominant trees ranged from 11 to 17 m, and the average diameter of merchantable stock was about 18 cm. Initial volume totaled 130 m^3/ha in trees 11.4 cm in diameter at breast height (dbh) or larger. Fifty percent of this volume was white spruce (*Picea glauca* (Moench) Voss), red spruce (*P. rubens* Sarg.), and balsam fir (*Abies balsamea* (L.) Mill.); 25 percent was hardwoods; 10 percent each was eastern hemlock (*Tsuga canadensis* (L.) Carr.) and eastern white pine (*Pinus strobus* L.); and 5 percent was northern white-cedar, (*Thuja occidentalis* L.).

Strip-Harvest and Slash Disposal.—All trees 1.34 m in height or larger were felled. Only merchantable wood was removed from plots where slash was to be burned or left in place. On plots where slash was to be removed, full trees (bole and branches) that were 1.34 m in height or larger were removed by skidding. Strip harvesting began in the fall of 1964 and was completed by the spring of 1965. Slash burning was done in August 1965.

Regeneration of Clearcut Strips.—Eight years after the cutting and slash treatments, all plots had well-established and well-distributed reproduction. There were more than 90,000 stems per hectare—two-thirds were 15.2 cm in height or larger and were considered established. The percentage of established seedlings was slightly greater on moderately well-drained and well-drained soils than it was on wetter soils. About 30 percent of the stems were spruce-fir; the remainder were primarily pioneer hardwoods. Plots where slash was left in place had the highest proportion of spruce-fir stems; plots where the slash was removed or burned had the lowest.

Soils

Elevations ranged from 37 to 43 m; there are complexes of well-drained to poorly drained soils on glacial till and moderately well-drained to poorly drained soils on marine sediments. The soils form an intricate pattern upon the landscape; on marine sediments they include Elmwood, Buxton, and Scantic. These soils are in low, nearly level positions, and abut the soils on glacial till; the latter include Marlow, Peru, and Monarda soils that are found on the slopes and small knolls. Soils are classified as Inceptisols or Spodosols

Forest Floor.—The forest floor was composed of dead residues of plant and animal kingdoms consisting of 01 and 02 soil layers, and living organisms, woody plants, herbs, grasses, and mosses. The forest floor in the residual forest was derived primarily from conifer needles and twigs. In clearcut areas, the forest floor also included hardwood and shrub foilage. This reflects the abundance of pioneer hardwood regeneration. Contributions to the forest floor by the different sources were not separated.

Mineral Soil.—Soil texture reflects the parent material. Nonstony silt loam surfaces above silty clay loam subsurfaces predominated in the marine sediments. There are also small areas that have a fine sandy loam surface above silty clay loam subsoil. In the stony glacial till, gravelly silt loams and loams extend to depths of 1.0 to 1.2 m or deeper unless restricted by bedrock. In some instances the subsoil is coarser as depth increases; it grades from a gravelly loam to a gravelly fine sandy loam.

Soil depth for rooting is 40 cm in the marine sediments and 40 to 60 cm in glacial till. Root penetration is restricted by a dense layer in the marine sediments and deep glacial till. This dense layer impedes water movement and contributes to the overall wet soil that is characteristic of the area. The resulting perched water table presents a barrier to root growth when it persists for extended periods.

METHODS

Strips about 40.0 and 60.0 m wide were harvested, leaving a 40.0-m wide alternate strip of residual forest; all strips were oriented east-west. We used a fixed grid of permanent regeneration sample plots at transects of 6 and 42 m from the northern forested edge. In the center of the residual strips, a similar line was used as a guide for sampling.

Field Procedure

We determined soil drainage from auger borings; there were three drainage classes: poorly drained, moderately well drained and well drained. We took core samples from the forest floor and from the mineral soil with a Uhland sampler.[1] We removed disturbed samples from the 01 and 02 horizons of the forest floor. We took samples from the upper 16 cm of the mineral soil, and included any genetic horizon that was present in this zone. The thickness of the forest floor was measured at several points and averaged to the nearest millimeter. A total of 88 points were sampled.

Laboratory Procedure

The core samples of the forest floor and mineral soils were dried to a constant weight and weighed to the nearest 0.1g. The quantities of the forest floor and of mineral soil per unit area, and their respective bulk densities, were calculated from ovendry core samples. The bulk density (Db) of the mineral soil was not corrected for stone content.

Air dried disturbed samples of the forest floor were ground in a Wiley mill to pass a 20-mesh screen, subsampled, and stored for analysis. Air-

[1]The use of trade, firm, or corporation names in this paper is for the information and convenience of the reader. It does not constitute an official endorsement or approval by the Forest Service or the U.S. Department of Agriculture.

dried disturbed samples of mineral soil were passed through a 2-mm sieve and stored.

Chemical Analysis.—In analyzing the air-dried materials, we used a Beckman pH meter to measure the pH, in a 1:1 (soil:water) aqueous solution for mineral soil, and in a 1:4 (organic:water) solution for forest floor materials. We determined exchange acidity by the method outlined by Adams and Evans *(1962)*; exchangeable cations were extracted with a neutral $1N$ NH_4OAc and determined with a Jarrel-Ash atomic absorption spectrophotometer. The extracts used for the analyses of Ca and Mg were prepared to contain 0.1 percent of La. Cation exchange capacity (CEC) was determined by adding the exchange acidity and exchangeable bases. Phosphorus was extracted with $0.05N$ HC1 + $0.025N$ H_2SO_4; it was determined colorimetrically by use of the molybdate-vanadate solution described by Nelson and others *(1953)*. The extracts were clarified with carbon black before being determined. We used the Kjeldahl method to determine total nitrogen.

Organic matter in both the forest floor and the mineral soil was determined by loss on ignition at >500°C. Carbon was calculated from the percentage of loss on ignition; we used a conversion factor of 0.58.

Statistical Analysis.—The data were tabulated by soil drainage class and by slash disposal method. The data in this study were multivariate, and multivariate procedures were used to analyze the results. We used a simultaneous test procedure (STP) to test the hypothesis that there were no differences among treatments. (Simultaneous test procedures in multivariate analysis of variance are discussed by Gabriel *(1968)*). The STP is based on the maximum characteristic root statistic (θ) The critical value of θ depends on the fact that there are four treatments; and that 19 forest floor variables and 16 mineral soil variables were measured. (The Db was not included.) The significance level in an STP is said to be experimentwise rather than testwise.

The first step of the analysis was to determine the variables that best characterized the differences among the treatments. We used a stepwise discriminate analysis *(Dixon, 1975)*. The best discriminating variables were those with the largest mean squared differences among treatments.

Separate analyses were performed on forest floor and mineral soil variables for each soil drainage class. Variables were included in the stepwise analyses if the variance ratio (F) exceeded the critial value of the (F) Distribution with appropriate degrees of freedom.

RESULTS AND DISCUSSION

Mean values for the 19 forest floor variables are presented in table 1 and those for the 17 mineral soil variables in table 3. The data show considerable variability in all characteristics. Some variables followed certain patterns according to soil drainage class or slash disposal method; others followed no particular pattern.

Variance ratios for comparisons of pairs of treatments and the best variable for discriminating among the treatments are given for forest floor variables in table 2, and for mineral soil variables in table 4.

Forest Floor

On poorly drained and moderately well-drained soils, the percentage of base saturation was the best variable for discriminating between control plots (undisturbed forest) and the three slash-disposal treatments. The percentage of base saturation was consistently higher on strip-clearcut areas than it was on the undisturbed forest. The percentage of base saturation also was higher on plots where slash was left in place and on those where it was burned. Comparisons between the three slash treatments showed that the percentage of base saturation was significantly higher on plots where slash was left in place and on plots where it was burned than it was on plots where slash was removed.

On poorly drained soils, two other variables with high variance ratios, pH ($F = 3.78$) and exchangeable Mg ($F = 3.76$), could also be used to discriminate among the treatments. Both pH and Mg were correlated with the percentage of base saturation ($r = 0.91$ and 0.77, respectively).

On moderately well drained soils, there were significant increases in the percentage of base saturation on plots where slash was left or removed compared to the control plots.

On well-drained soils, pH was the best dis-

Table 1.—Means of forest floor properties, by soil drainage class and slash disposal method

Forest floor properties	Poorly drained				Moderately well drained				Well drained			
		Slash disposal				Slash disposal				Slash disposal		
	Control	Left	Removed	Burned	Control	Left	Removed	Burned	Control	Left	Removed	Burned
Thickness (cm)	9.6	9.7	14.5	10.2	6.6	6.4	5.3	7.1	5.3	7.2	7.4	5.8
Bulk density (g/cc)	0.10	0.10	0.09	0.12	0.19	0.16	0.17	0.14	0.22	0.13	0.14	0.19
Ovendry weight (kg/m^2)	9.6	9.0	8.7	10.7	12.4	10.0	8.1	9.4	11.4	9.3	10.5	10.6
Volatile matter (kg/m^2)	8.1	6.6	6.6	7.9	9.6	6.7	5.3	6.8	9.4	7.6	7.9	8.1
Nitrogen (%)	1.34	1.61	1.38	1.43	1.38	1.27	1.00	1.25	1.23	1.46	1.33	1.27
Phosphorus (ppm)	37.3	39.1	27.5	41.9	50.0	62.7	42.4	57.3	66.2	68.4	67.8	64.1
Calcium (meq/100g)	26.0	46.0	31.6	42.7	22.5	28.2	31.8	24.9	21.1	23.8	26.5	25.8
Magnesium (meq/100g)	4.4	7.1	5.1	5.4	2.6	4.6	4.1	4.1	3.0	3.3	4.2	5.1
Potassium (meq/100g)	1.7	2.8	1.8	2.0	1.8	2.8	2.1	1.9	2.2	3.1	2.9	2.7
Sodium (meq/100g)	0.2	0.4	0.3	0.3	0.1	0.2	0.2	0.1	0.1	0.1	0.1	0.1
Exchange acidity (meq/100g)	68.6	47.1	53.3	49.7	64.4	47.6	41.5	50.0	66.4	61.2	55.9	53.9
CEC (meq/100g)	100.9	103.5	92.1	100.0	91.4	83.4	79.7	81.1	92.8	91.7	89.7	87.7
Total bases (meq/100g)	32.3	56.4	38.8	50.3	27.0	35.8	38.1	31.1	26.4	30.4	33.8	33.7
Base saturation (%)	31.9	53.6	40.8	49.9	30.3	43.0	48.0	38.0	28.5	32.8	37.2	38.7
Zinc (ppm)	11.8	11.8	10.3	11.1	7.2	16.1	11.6	11.1	10.5	14.0	14.0	12.6
Iron (ppm)	14.7	9.2	12.1	9.9	13.5	17.4	16.8	14.2	10.5	17.7	14.0	13.3
Manganese (ppm)	101.4	135.0	101.4	245.3	353.0	400.0	350.7	409.2	149.2	240.6	251.1	498.9
C/N ratio	35.9	27.9	33.9	30.2	32.3	32.0	35.6	32.7	38.5	33.2	33.2	35.7
pH	4.1	5.0	4.6	4.7	3.9	4.4	4.6	4.3	3.8	4.0	4.1	4.3
Number of samples	7	14	13	17	3	6	5	6	4	5	5	3

Table 2.—Forest floor variance ratios for comparisons of slash-disposal treatments, by soil drainage class, and the best discriminating variable among treatments.

Treatment	Poorly drained	Moderately well drained	Well drained
		F ratio	
Control vs. slash left	14.84**	4.53*	3.44
Control vs. slash removed	2.48	8.27*	6.83*
Control vs. slash burned	10.86**	1.66	12.20**
Slash left vs. slash removed	7.36**	0.96	0.65
Slash left vs. slash burned	0.70	1.06	3.80
Slash removed vs. slash burned	4.06*	3.85	1.57
Among treatments	6.30**	3.12	4.45*
Best discriminating variable	Base saturation	Base saturation	pH

*Significant at the 0.05 level; **significant at the 0.01 level. (Based on F distribution.)

criminating variable. The pH values were significantly higher on plots where slash was removed or burned than they were on the undisturbed forest.

Base saturation was the best discriminator among treatments for forest floor variables on poorly drained soils (F = 6.30), and on moderately well-drained soils (F = 3.12). On well-drained soils, pH (F = 4.45) was the best discriminator.

Because the forest floor is an important source of nutrients for tree growth—and influences physical characteristics of soil—it has received considerable attention in recent years. Studies on this subject have been made by Mader *(1953)*; McFee and Stone *(1965)*; Stutzbach and others *(1972)*; and Wollum *(1973)*. So certain comparative values are available.

We found that thickness decreased slightly as soil drainage improved (poorly drained to well drained); the values for clearcut areas were somewhat higher than they were in the undisturbed forest. The range of thickness in the undisturbed forest approximates earlier estimates by Lull *(1959)*. The Db was lowest on poorly drained soils and remained the same in residual and clearcut areas, but it decreased on clearcut areas of moderately well-drained and well-drained soils compared to the undisturbed forest. A mean Db of 0.15 g/cm^3 approximates the values reported by McFee and Stone *(1965)* for a yellow birch - red spruce forest in the Adirondacks. The range of ovendry weight was 9.6 to 12.4 kg/m^2 in the undisturbed forest, and 8.1 to 10.7 kg/m^2 in clearcut areas. The differences were not consistent for soil drainage class or slash disposal method.

The weight of volatile matter tended to increase as soil drainage improved, and was consistently lower on clearcut areas. This weight correlated positively (r = 0.87) with ovendry weight.

By contrast, Wollum *(1973)* reported ranges of 0.9 to 8.1 kg/m^2 for ovendry weight, and 0.5 to

Table 3.—Means of mineral soil properties, by soil drainage class and slash disposal method

Mineral soil properties	Poorly drained				Moderately well drained				Well drained			
		Slash disposal				Slash disposal				Slash disposal		
	Control	Left	Removed	Burned	Control	Left	Removed	Burned	Control	Left	Removed	Burned
Bulk density (g/cc)	1.6	1.5	1.3	1.4	1.0	1.1	1.1	1.2	1.0	1.1	1.0	1.0
Organic matter (%)	5.7	7.0	8.9	7.7	7.3	6.5	8.4	6.8	8.2	9.0	9.2	7.7
Nitrogen (%)	0.19	0.21	0.26	0.22	0.23	0.16	0.20	0.16	0.16	0.21	0.21	0.14
Phosphorus (ppm)	3.2	6.2	4.8	4.0	5.1	7.9	5.0	12.0	5.5	0.8	6.8	3.8
Calcium (meq/100g)	3.0	8.3	5.2	5.7	0.9	1.2	2.9	0.8	1.1	1.2	1.6	0.9
Magnesium (meq/100g)	0.6	1.3	1.0	0.8	0.1	0.2	0.3	0.2	0.2	0.2	0.2	0.2
Potassium (meq/100g)	0.1	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Sodium (meq/100g)	<0.1	0.1	0.1	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Exchange acidity (meq/100g)	9.3	8.4	12.4	10.2	12.7	10.5	11.9	11.5	11.7	12.5	15.0	13.1
CEC (meq/100g)	13.0	18.2	18.8	16.9	13.8	12.1	15.3	12.6	13.1	14.0	16.9	14.3
Total bases (meq/100g)	3.7	9.9	6.4	6.7	1.1	1.5	3.4	1.1	1.4	1.5	1.9	1.2
Base saturation (%)	22.9	50.9	32.1	35.3	7.7	12.8	22.6	8.7	10.2	11.8	12.2	8.0
Zinc (ppm)	3.0	2.3	2.4	1.9	5.6	2.3	1.8	1.3	2.0	1.9	3.2	1.0
Iron (ppm)	4.1	1.1	3.2	3.1	12.5	5.8	10.3	5.5	14.3	12.6	21.6	14.7
Manganese (ppm)	3.3	3.8	10.8	10.8	1.5	4.7	11.4	5.2	3.3	2.3	6.8	6.8
C/N ratio	18.4	18.6	20.9	20.8	19.0	24.2	26.2	23.8	29.8	26.2	25.0	30.7
pH	4.9	5.6	5.1	5.0	4.5	5.0	5.0	4.8	4.8	5.0	4.7	4.7
Number of samples	7	14	13	17	3	6	5	6	4	5	5	3

Table 4.—Mineral soil variance ratios for comparisons of slash-disposal treatments, by soil drainage class, and the best discriminating variable among treatments.

Treatment	Poorly drained	Moderately well drained	Well drained
		F ratio	
Control vs. slash left	11.30**	0.13	—
Control vs. slash removed	0.90	9.05**	—
Control vs. slash burned	0.85	0.08	—
Slash left vs. slash removed	8.32**	10.28**	—
Slash left vs. slash burned	10.32**	0.62	—
Slash removed vs. slash burned	0.01	15.68**	—
Among treatments	5.30**	6.12*	—
Best discriminating variable	pH	Ca++	None

*Significant at the 0.05 level; **significant at the 0.01 level. (Based on F distribution.)

4.7 kg/m^2 for volatile matter, in an arid region in southern New Mexico. Youngberg *(1966)* reported ranges of 2.3 to 8.6 kg/m^2 for ovendry weight, and 1.6 to 6.9 kg/m^2 for volatile matter, on a Douglas-fir forest in the humid region of the Pacific Northwest.

Concentrations of Ca, Mg and K were consistently higher on clearcut areas than they were on the undistrubed forest; the increase in Ca ranged from 3 percent of total CEC on well-drained soils to 19 percent on poorly drained soils. The range of increase in Mg was 0 to 3 percent, for K it was 0 to 1 percent.

The Ca concentration tended to decrease as the soil drainage improved; concentration for Mg and K were inconsistent for soil drainage class or slash disposal method.

The exchange acidity was composed of exchangeable H and A1. Contributions by either source were not separated, but a study by Hoyle *(1973)* showed that the concentration of A1 exceeded that of H. Acidity was high and stable for all soil drainage classes and slash treatments: It was consistently higher in the residual forest floor and was primarily from coniferous needles. The forest floor of well-drained soils had the highest average values for all treatments. The variations were not related to any slash treatment.

The mean values for CEC were slightly lower on clearcut areas, but increased as the sites became wetter.

The N data show that there were no drastic changes due to clearcutting. Only slight increases were observed on clearcut areas of poorly drained and well-drained soils. On moderately well-drained soils this pattern was reversed. N values were consistently higher on plots where slash was left in place. The data correlated weakly with ovendry weight and volatile matter.

Extractable P was little affected by stand harvesting. Differences among slash disposal methods were inconsistent, but the lowest values were observed on plots of poorly drained and moderately well-drained soil where slash was removed. The average Fe concentration was highest on moderately well-drained sites but the concentration was inconsistent between treatments. The Zn concentration increased as soil drainage improved from poorly drained to well drained. The Mn concentration in the forest floor was high because of the high contents of Mn in spruce-fir-hemlock needles. Since a high Mn level may be toxic to plant growth, it would be desirable to establish what levels of Mn are critical.

None of the F ratios was significant at the 0.05 experimentwise level.

Mineral Soil

There were differences in the physical and chemical characteristics of surface mineral soil (table 3). Some differences reflected patterns similar to those shown by forest floor variables; others did not.

The pH values on poorly drained soils and the Ca++ concentrations on moderately well-drained soils were the best variables for discriminating between control plots and slash treatments (table 4). On well-drained soils, none of the variables was distinctive.

On poorly drained soils, pH values were significantly higher on plots where slash was left in place than they were on control plots or on plots where slash was burned or removed (table 3). The differences in pH on poorly drained soils and in Ca++ concentrations on moderately well-drained soils were also significant among the treatments. Again, variance ratios were not significant at the 0.05 experimentwise level.

The levels of Ca and Mg tended to parallel each other closely; both were strongly related to soil drainage. On clearcut areas, Ca and Mg levels were considerably higher on poorly drained soils than they were on moderately well-drained and well-drained soils. The parent material of the soil may be the main source of these variations. Marine deposits predominated on poorly drained sites. The lower level of these cations is attributable to differences in parent material and to more intensive leaching on moderately well-drained and well-drained glacial till. Similar trends have been reported by Hoyle *(1973)* and Wollum *(1973)*. The differences in K levels were less conspicuous.

Clearcut areas contained more exchangeable Ca and Mg. The effects of slash disposal methods were inconsistent.

The exchange acidity of the soil in clearcut areas for all drainage classes was highest where slash was removed and lowest where slash was left in place. This implies that, within clearcut areas, slash removal contributed to increased exchange acidity that did not result in a decrease in pH. Sites where slash was removed also showed a higher CEC than those that received other treatments.

Data on N indicated that there were no drastic changes due to clearcutting. We observed marked increases in N, primarily in the mineral fraction on poorly drained sites, and decreases on moderately well-drained sites. Losses of N due to slash burning were minor.

Extractable P was little affected by stand removal and the differences were inconsistent.

The average Zn and Fe levels increased as drainage class became drier. The Mn concentration was inconsistent between drainage classes.

Differences in Db between poorly drained and moderately well-drained and well-drained soils are partially explained by differences in the parent material of the soil. Quantities of organic matter (the percentage of loss on ignition) differed only slightly from one soil to another. The carbon-nitrogen ratios, relatively high and stable, show that the organic matter fraction of the soil was resistant to decomposition. The C/N ratio was in the order of poorly drained < moderately well-drained < well-drained soils. This possibly reflects greater microbial activity on the better drained soils, perhaps because of increased temperature, and better aeration.

SUMMARY AND CONCLUSIONS

From our assessment of some of the physical and chemical characteristics of spruce-fir sites eight years after strip clearcutting, we concluded that:

1. Strip clearcutting of the stand resulted in the alteration of certain characteristics in the forest floor and in the surface mineral soil
2. Natural soil drainage conditions were the major source of variation
3. The influence of clearcutting on the forest floor was distinct in the increase in the percentage of base saturation on poorly drained and moderately well-drained soils, and the increase in pH on well-drained soils
4. The effect of the clearcutting on the mineral soil was distinct in the increase in pH on poorly drained soil, and in Ca^{++} on moderately well-drained soil
5. The differences in chemical and physical properties of the forest floor and mineral soils among treatments could have been due to chance. None of the F ratios were significant at the 0.05 experimentwise level.

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Headquarters of the Northeastern Forest Experiment Station are in Upper Darby, Pa. Field laboratories and research units are maintained at:

- Amherst, Massachusetts, in cooperation with the University of Massachusetts.
- Beltsville, Maryland.
- Berea, Kentucky, in cooperation with Berea College.
- Burlington, Vermont, in cooperation with the University of Vermont.
- Delaware, Ohio.
- Durham, New Hampshire, in cooperation with the University of New Hampshire.
- Hamden, Connecticut, in cooperation with Yale University.
- Kingston, Pennsylvania.
- Morgantown, West Virginia, in cooperation with West Virginia University, Morgantown.
- Orono, Maine, in cooperation with the University of Maine, Orono.
- Parsons, West Virginia.
- Pennington, New Jersey.
- Princeton, West Virginia.
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