United States
Department of
Agriculture

Forest Service

**Intermountain
Forest and Range
Experiment Station**

Research Paper
INT-275

May 1981

# Effects of Prescribed Fire on Soil Nitrogen Levels in a Cutover Douglas-fir/Western Larch Forest

**Martin F. Jurgensen, Alan E. Harvey, and Michael J. Larsen**

## THE AUTHORS

**MARTIN F. JURGENSEN,** professor of forest soils, teaches and conducts research in forest soils-soils microbiology. He earned a B.S. degree in forestry (1961), an M.S. degree in silviculture (1965), and a Ph.D. degree in soil science (1967). He has held the positions of research associate (1966-1967) and assistant professor (1966) at North Carolina State University. Dr. Jurgensen's position is with the Department of Forestry, Michigan Technological University, Houghton, Mich.

**ALAN E. HARVEY,** plant pathologist, is responsible for research into disease and other microbiological problems of reforestation in the central and northern Rockies. He is stationed at the Forestry Sciences Laboratory, Moscow, Idaho. Dr. Harvey received a B.S. degree in biology (1960), and M.S. degree in plant pathology (1962), a Ph.D. degree in plant pathology (1968), and an academic year of postgraduate work in plant pathology (1972). He joined the Intermountain Station in 1965.

**MICHAEL J. LARSEN,** mycologist, is presently investigating the taxonomy and ecology of forest fungi at the Center for Forest Mycology Research, Forest Products Laboratory, Madison, Wis. Dr. Larsen received a B.S. degree in botany (1960), an M.S. degree in plant products pathology (1963), and a Ph.D. degree in forest mycology (1967). He held a position with the Canadian Forestry Service (1966-1970) and joined the Center for Forest Mycology Research in 1971.

## RESEARCH SUMMARY

The effects of a prescribed broadcast fire on soil nitrogen (N) levels and related soil properties were determined following the clearcutting of a 250-year-old Douglas-fir/western larch stand in northwestern Montana. Soil N losses from burning amounted to slightly over 90 lb/acre (100 kg/ha), all from the surface organic layers. This was 6 percent of the total N originally present in the surface 12 inches (30 cm) of soil. In contrast, soil ammonium concentration increased within 2 days following the fire. Rapid nitrification also occurred after a 3-week lag period. The higher nitrate levels were associated with increased populations of nitrifying bacteria. Both soil ammonium and nitrate concentrations returned to preburn levels by the end of the following summer.

Soil acidity was decreased after the burn and had not yet returned to original levels in the organic horizons 4 years later. Organic matter content of the mineral soil was not affected by the fire.

No long-term depletion of soil N reserves would result from this prescribed fire. Plant reestablishment on the site benefited by increased soil N availability.

## ACKNOWLEDGMENTS

The able assistance of technicians Glenn Mroz, Andrew DePuydt, Margaret Gale, Scott Spano, Peter Cattelino, and the other "Hungry Horse Androids" in various phases of this study is gratefully acknowledged. Appreciation is also due Charles Brooks, District Ranger, Hungry Horse Ranger Station, Flathead National Forest, for his help and cooperation during this study.

## CONTENTS

## INTRODUCTION

The relationship of fire to soil nutrient cycling and availability has been the subject of intensive study for many years. Numerous reviews cover this and other facets of fire effects on soil (such as Viro 1974; Raison 1979; Wells and others 1979). Of the many essential plant nutrients, nitrogen (N) is the most affected by burning because nearly all N in forest soils is present in the organic form. Volatilization of soil and plant N occurs during a fire, with the actual amounts lost dependent on fire intensity (Knight 1966). In most soils, N-containing rocks and minerals are lacking to replace fire-related N losses. Nitrogen additions to the soil come from: (1) small amounts of N present in precipitation and dust; (2) conversion or "fixation" of atmospheric $N_2$ gas into usable forms by soil and root-inhabiting microorganisms; or (3) application of mineral or organic fertilizers.

In contrast to total N changes, soil N availability may be improved following a fire, with increases in N mineralization rates frequently reported (Wells and others 1979). The growth of postfire regeneration may be favored by such higher levels of soil ammonium ($NH_4$) or nitrate ($NO_3$), but these greater amounts of available N would also be susceptible to leaching losses, especially as $NO_3$.

When evaluating the potential environmental impact of various harvesting treatments on site quality, some reduction of soil N levels from burning may be acceptable as compared to the N losses that may occur by use of mechanical site preparation equipment (Wells and others 1979). In order to determine the suitability of fire as a postharvest site treatment, information must be obtained on how fire affects the soil N status. This paper reports the results of a prescribed broadcast fire on soil N levels and other soil properties following the clearcutting of a mature Douglas-fir/western larch forest in western Montana.

## STUDY AREA AND TREATMENT

This study was conducted on the Coram Experimental Forest, approximately 10 miles (16 km) south of Glacier National Park in western Montana, as part of a comprehensive residue utilization research program. The experimental site was an undisturbed 250-year-old forest typical of the Douglas-fir/western larch timber type. Douglas-fir (*Pseudotsuga menziesii*), western larch (*Larix occidentalis*), subalpine fir (*Abies lasiocarpa*), and Engelmann spruce (*Picea engelmannii*) were the dominant tree species in the study area. The vegetation represents an *Abies lasiocarpa/Clintonia* habitat type (Pfister and others 1977).

Elevation of the study plots was nearly 4,538 ft (1 375 m). The plots were located on a steep (55 to 60 percent) east-facing slope. The soils were quite stony ($>$50 percent) and derived from weathered argillite and impure limestone material. Soil fine materials ($<$0.08 inch, or $<$2 mm) were silt loam in texture (Klages and others 1976).

The area used in this study was a 7.5-acre (3-ha) clearcut harvested in the fall of 1974 and broadcast burned in early September 1975. As part of the residue utilization study, all live and dead material (standing and down) of 8.0-ft (2.5-m) length, 3-inch (7.6-cm) diameter, and at least one-third sound was removed prior to burning. The fuels on the site were relatively moist at the time of burning, which resulted in a generally low-intensity fire. This was shown by a duff depth reduction of only 25 percent from the original 2.7-inch (6.8-cm) thick surface organic layer. A more detailed description of the burn conditions and fuel volumes have been given by Artley and others (1978) and Benson and Schlieter (1980). An adjacent uncut stand was used as a control.

## METHODS

### Sampling

We took 30 soil cores (4 x 12 inches, or 10 x 30 cm) randomly throughout the cut area 1 day prior to burning, 2 days following the burn, and 6 weeks after the burn for determination of: total and available N, organic matter content, acidity (pH), populations of nitrifying bacteria, and the occurrence of water repellent layers. In addition, we took 10 cores periodically from September 1975 to October 1976, both in the burned area and the adjacent control stand, to more closely monitor changes in available N levels and soil acidity. The bimonthly samplings in December, February, and April were limited to six cores at midplot due to deep snow on the site.

Each soil core was separated in the field into the following fractions: (1) surface litter ($0_1$ horizon); (2) humus ($0_2$ horizon); (3) decayed wood in the soil (referred to here as the $0_3$ layer); (4) surface 0-2 inches (0-5 cm) of mineral soil; and (5) remaining mineral soil to a total core depth of 12 inches (30 cm). Approximate soil volumes occupied by each fraction were determined by measuring its depth in the undisturbed core. The occurrence of water repellency in the mineral soil was determined using the water-drop-penetration test on the soil surface and at each 2-inch (5-cm) soil depth (Adams and others 1970).

### Soil Analysis

In the laboratory each soil fraction was shaken for 5 minutes in a standard 0.08 inch (2 mm) soil sieve. The decayed wood and humus aggregates were gently crumbled before sieving. Material less than 0.08 inch (2 mm) was retained for chemical analysis. Determinations of $NH_4$ and $NO_3$ content, acidity, and autotrophic nitrifying bacteria populations were performed on undried soil within 24 hours after collection.

Ammonium content of each soil fraction was measured in a 2$\underline{N}$ KCl extract by a specific-ion electrode (Banwart and others 1972). Nitrate content was determined on a distilled water leachate by specific-ion electrode, according to Bremner and others (1968). Acidity was measured electrometrically using a 1:2 mineral soil to water ratio, or a 1:5 organic matter to water ratio. Nitrifying bacteria numbers (*Nitrosomonas*) were estimated in the $0_2$ and 0-2 inches (0-5 cm) of mineral soil fractions using the Most-Probable-Number Technique (Alexander and Clark 1965).

Soil for total N and organic content analyses was dried in a forced-draft oven at 140° F (60° C). Total N values were determined by macro-Kjeldahl techniques with salicylic acid added to include $NO_3$ ( (Bremner 1965). Organic matter content was estimated by weight loss-on-ignition (Ball 1964).

### Statistical Analysis

Data on nitrogen concentrations and populations of autotrophic nitrifying bacteria were analyzed to detect significant differences among horizons before and after the prescribed broadcast fire. One-way and two-way analysis of variance was used to analyze these data.

## RESULTS

### Total Nitrogen

Since N is oxidized and/or volatilized as a result of fire, considerable changes would be expected in soil N content after the prescribed burn. Losses of N occurred only in the soil organic layers (table 1). The organic fractions are extremely important to the N economy of this site, containing over 53 percent of the total N in the surface 12 inches (30 cm) of soil prior to burning. Even after the fire, 49 percent of the N was still present in the organic layers. We did not find a significant decrease in the total N concentration of the surface litter layer ($0_1$) after the fire. We attributed this somewhat surprising result to the variable and spotty nature of the burn. However, the largest N losses occurred in the $0_1$ layer, which was caused by a 60 percent reduction in average horizon thickness. The depth of the humus horizon ($0_2$) decreased by nearly 30 percent, but the N concentration of the remaining material increased significantly. Consequently, only neligible amounts of N were lost from this layer. No significant differences were found in the decayed wood ($0_3$) or in the mineral soil. In total, slightly over 100 kg/ha or 6 percent of the N present in the surface 12 inches (30 cm) of soil was lost as a result of the prescribed fire. However, this value does not include any N losses from the burning of larger woody slash.

**Table 1.--Nitrogen content of soil organic layers as affected by prescribed fire**

| | Before burn | | | Two days after burn | | |
|---|---|---|---|---|---|---|
| **Soil layer** | **% N** | **Lb N/acre** | **kg N/ha** | **% N** | **Lb N/acre** | **kg N/ha** |
| Litter ($0_1$) | 1.19 | 114 | 128 | 0.87NS | 36 | 40 |
| Humus ($0_2$) | 0.71 | 302 | 339 | .91* | 297 | 333 |
| Decayed wood ($0_3$) | .46 | 421 | 472 | .69NS | 410 | 460 |
| Mineral | | | | | | |
| 0 - 5 cm | .12 | 205 | 230 | .12NS | 205 | 230 |
| 5 - 22 cm | .08 | 543 | 609 | .08NS | 543 | 609 |
| All layers | -- | 1,586 | 1 778 | -- | 1,492 | 1 672 |

NS = no significant difference $p > 0.05$.
* = significant difference $0.01 < p < 0.05$.

### Available Nitrogen

In contrast to total N contents, $NH_4$ and $NO_3$ concentrations increased as a result of the fire. The levels of available N present in the humus layer for 13 months after burning are shown in figure 1. Similar changes in $NH_4$ and $NO_3$ concentrations were recorded for the soil mineral layers, but the actual values were much lower than those found in the organic fractions. A large increase in $NH_4$ levels was evident immediately after burning. No postfire change was detected in $NO_3$ values until nearly 3 weeks later when rapid nitrification began. This rise in $NO_3$ concentration was followed by an equally rapid decline over the next week. Leaching of $NO_3$ due to 2.5 inches (6.3 cm) of rain during that period probably caused this loss. In fact, the 6 weeks following the fire were especially wet, with the area receiving 5.4 inches (13.5 cm) of rain. After this decline, $NO_3$ concentrations again increased substantially. We found that the higher soil $NO_3$ level after burning was associated with a significant population increase of autotrophic nitrifying bacteria, both in the organic layers and mineral soil (table 2).

By the middle of October, the $NH_4$ concentrations began to decline and showed a steady decrease during the winter and spring months until preburn levels were reached by the end of the next summer (fig. 1). Nitrate concentrations generally followed a similar pattern, but a spring nitrification peak was evident on the burned site. Such an increase in the nitrification rate may also have occurred in the control soil but could have been obscured by plant N uptake.

When the $NH_4$ and $NO_3$ results were converted to total amounts of available N present in the surface 12 inches (30 cm) of soil (table 3), the pronounced effect of fire on surface organic horizons was again evident. Available N levels in these layers increased by fourfold within 2 days after the fire, followed by a gradual decrease during the next 13 months. The mineral soil showed a similar trend but attained the highest available N values later in the fall, presumably due to leaching of $NH_4$ and $NO_3$ from the organic horizons.

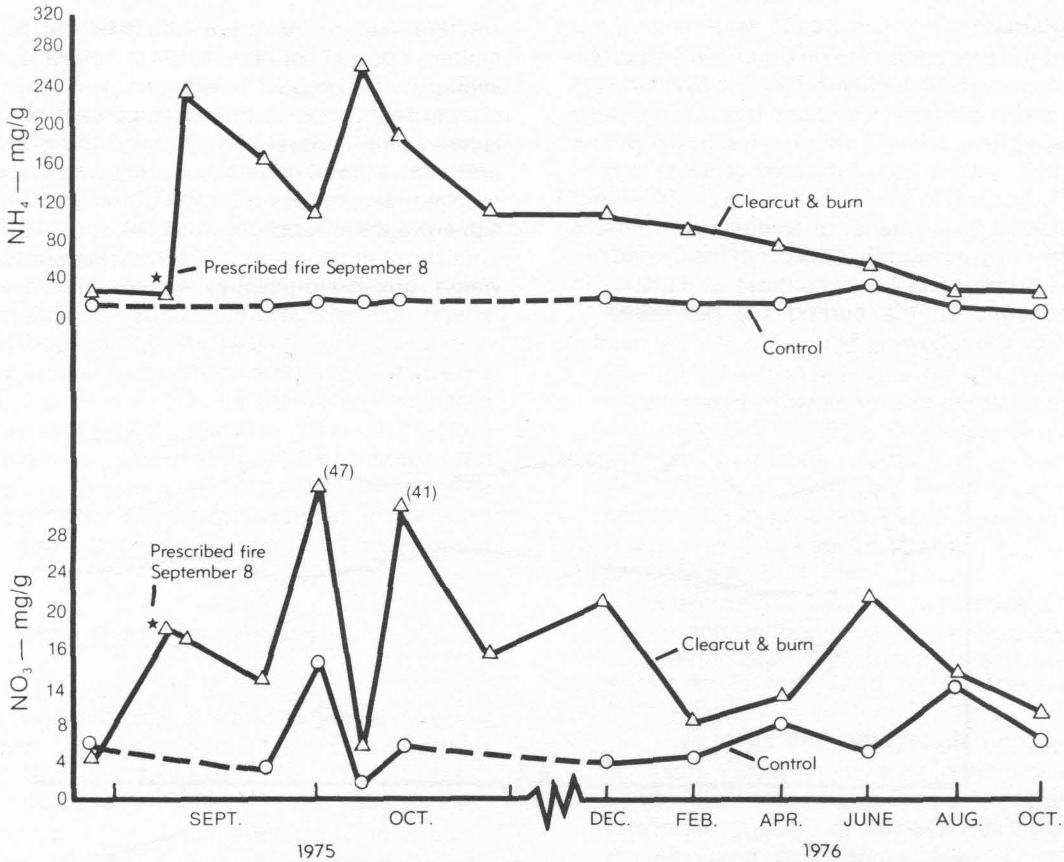


Figure 1.--Available nitrogen levels in the humus layer ($0_2$) after a prescribed fire in a clearcut Douglas-fir/western larch stand.

**Table 2.--Soil populations of autotrophic nitrifying bacteria (*Nitrosomonas*) before and after a prescribed fire**

| | Bacteria/g of dry soil | |
|---|---|---|
| **Soil layer** | **Before burn** | **Six weeks after burn** |
| Humus ($0_2$) | 800 | 3 280* |
| Mineral (0 - 5 cm) | 240 | 960* |

* = significant difference $0.01 < p < 0.05$.

**Table 3.--Available soil nitrogen ($NH_4$ and $NO_3$) content as affected by prescribed fire**

| | | After fire | | | |
|---|---|---|---|---|---|
| **Soil layer** | **Before fire** | **2 days** | **6 weeks** | **9 months** | **13 months** |
| | *Lb/acre (kg/ha)* | | | | |
| $0_1 + 0_2$ | 1.9 (2.1) | 9.0 (10.1) | 4.4 (4.9) | 1.6 (1.8) | 0.7 (0.8) |
| Decayed wood ($0_3$) | 1.8 (2.0) | 6.5 (7.3) | 6.2 (6.9) | 5.2 (5.8) | 2.1 (2.3) |
| Mineral | | | | | |
| 0 - 5 cm | 1.2 (1.3) | 2.9 (3.3) | 5.1 (5.7) | 2.1 (2.4) | .7 ( .8) |
| 5 - 22 cm | 3.7 (4.2) | 4.8 (5.4) | 7.0 (7.9) | 5.2 (5.8) | 2.4 (2.7) |
| All layers | 8.6 (9.6) | 23.3 (26.1) | 22.7 (25.4) | 14.1 (15.8) | 5.9 (6.6) |

### Other Soil Properties

The effects of the prescribed fire on other soil properties were also monitored. Soil acidity decreased over one pH unit in the $0_2$ layer following the burn (fig. 2). We also found decreased soil acidity in the mineral horizons but to a lesser degree. At the end of the next growing season the pH of the $0_2$ horizon in the burned soil was still higher than in the adjacent uncut stand. A sampling of the area 4 years after the burn showed that the pH of the $0_2$ had not yet returned to preburn status. In contrast, soil acidity in the mineral horizons on the burned site decreased to original values by the following fall.

There was no apparent effect of the fire on organic matter content of the surface mineral layer, which averaged 4.2 percent before and after the fire. Fire did not cause any appreciable development of water repellent layers in the mineral soil. Prior to the fire the surface of only one of the 30 mineral cores showed evidence of water-repellent properties. After the burn nine of the cores gave a positive water repellency test but only on the soil surface. This development was temporary, since at the end of 6 weeks no water repellency was found.

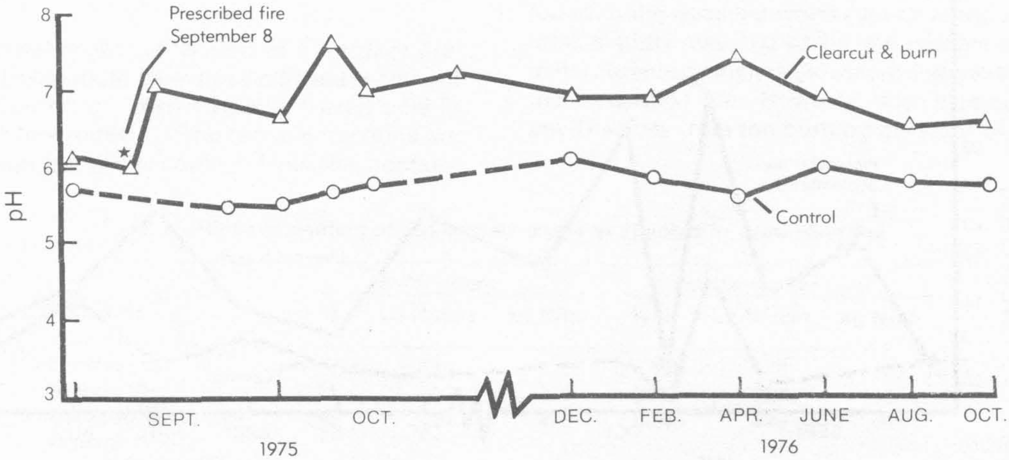


Figure 2.--Effects of a prescribed fire on pH in the humus layer ($0_2$) of a clearcut Douglas-fir/western larch stand.

## DISCUSSION

Investigations concerned with the effects of fire on soil N status have often been contradictory. Some have reported losses of soil N, while others have indicated either no change, or in a few cases, N gains after a fire (Wells and others 1979). Many of these contradictions undoubtedly come from differences inherent in study design, sampling technique, and analytical methods. Others come from actual site differences as reflected in the type, amount, and condition of forest fuel present.

The intensity and duration of a fire are important variables that affect N losses (Knight 1966). The moist fuel conditions on the Coram site prior to the fire resulted in a generally "cool burn" (Artley and others 1978). Such a fire would account for the rather small N losses from the forest floor and the lack of organic matter change in the mineral soil. These results contrast with those of DeByle (1976), who found a significant reduction of organic matter in the surface mineral layer and N losses exceeding 180 lb/acre (200 kg/ha) following a prescribed fire on a similar clearcut Douglas-fir/western larch site. In this instance, the fire was more intense and fuel consumption more complete than occurred at the Coram site. The relatively high proportion of N present in the surface organic matter as compared to the mineral soil makes this timber type highly susceptible to N losses during a fire. Similar soil conditions exist in ponderosa pine stands in the Southwest (Campbell and others 1977; Welch and Klemmedson 1975).

As noted earlier, N would be added to burned sites by inputs from precipitation and biological N-fixation by soil microorganisms. The N gains from both these sources over a stand rotation of 100 to 150 years on the Coram site would more than replenish the N losses due to this fire, as well as the N removed in the timber harvest (Jurgensen and others 1979; Stark 1979). Consequently, no long-term site depletion of soil N is expected to result from the effects of the prescribed burn.

Increases in the concentration and total amounts of available soil N were found after burning. Similar fire-related gains in $NH_4$ and/or $NO_3$ content have also been reported for other conifer sites in the Northern Rocky Mountain Region (Hooker and Tisdale 1974; Orme and Leege 1976; Skujins[1]). Higher $NH_4$ levels result from an immediate release of N when the organic matter is burned followed by a partial mineralization of remaining organic N by the soil microflora (Mroz and others 1980). Microbial activity is stimulated by the release of available carbon sources and mineral salts from the burned organic matter, and by the decrease in soil acidity (Ahlgren 1974).

In contrast to the $NH_4$ release pattern, nitrification showed a definite 3-week lag following the fire. The initial low nitrification rates may be related to the inability of the nitrifying microflora to compete with the other soil microorganisms for available $NH_4$ (Jones and Richards

[1]Skujins, J. 1977. Effect of modified slash disposal practices on the biochemistry of soils. Final rep., Study FS-INT-1203, 145 p. Intermt. For. and Range Exp. Stn., Ogden, Utah.

1977), or to an inhibition of the nitrifiers by mineral salts released during the fire (Heilman 1975).

The steady decrease in available N levels during the winter and spring months may be attributed to immobilization and denitrification reactions by the soil microflora, as well as $NO_3$ leaching by snowmelt. Increased $NO_3$ concentrations were found in subsurface soil water and in an adjacent stream, but the amounts lost were too low to affect site productivity (Stark 1979).

Higher levels of available soil N found after prescribed fire may be beneficial for subsequent regeneration (Wells and others 1979), although the potential effects of this added N would appear to be of short duration. Available soil N levels on the clearcut-burned site were comparable to the untreated stand by the next fall following the fire. However, increased organic matter mineralization in the spring, coupled with reduced N uptake due to tree removal, could enhance available N supplies in the early part of the growing season on this site for at least several years.

## PUBLICATIONS CITED

Adams, S., B. R. Strain, and M. S. Adams.
1970. Water repellent soils, fire and annual plant cover in a desert scrub community of southeastern California. Ecology 51:696-700.

Ahlgren, I. F.
1974. The effect of fire on soil organisms. *In* Fire and ecosystems. p. 47-72. T. T. Kozlowski and C. E. Ahlgren, eds. Academic Press, New York.

Alexander, M., and F. E. Clark.
1965. Nitrifying bacteria. *In* Methods of soil analysis, part II. p. 1477-1483. C. A. Black and others, eds. Agron. Monogr. 9, Am. Soc. Agron, Madison, Wis.

Artley, D. K., R. C. Shearer, and R. W. Steele.
1978. Effects of burning moist fuels on seedbed preparation in cutover western larch forests. USDA For. Serv. Res. Pap. INT-211, 14 p. Intermt. For. and Range Exp. Stn., Ogden, Utah.

Ball, D. F.
1964. Loss-on-ignition as an estimate of organic matter and organic carbon in noncalcareous soils. J. Soil Sci. 15:84-92.

Banwart, W. L., M. A. Tabatabai, and J. M. Bremner.
1972. Determination of ammonium in soil extracts and water samples by an ammonium electrode. Comm. Soil Sci. Plant Anal. 3:449-458.

Bensen, R. E., and J. A. Schlieter.
1980. Woody material in northern Rocky Mountain forests: volume, characteristics, and changes with harvesting. *In* Environmental consequences of timber harvesting in Rocky Mountain coniferous forests. p. 27-36. USDA For. Serv. Gen. Tech. Rep. INT-90, 527 p. Intermt. For. and Range Exp. Stn., Ogden, Utah.

Bremner, J. M.
1965. Total nitrogen. *In* Methods of soil analysis, part II. p. 1149-1176. C. A. Black and others, eds. Agron. Monogr. 9, Am. Soc. Agron., Madison, Wis.

Bremner, J. M., L. G. Bundy, and A. S. Agarwal.
1968. Use of selective ion electrode for determination of nitrate in soil. Anal. Let. 1:837-843.

Campbell, R. E., M. B. Baker, Jr., P. F. Ffolliott, R. F. Larson, and C. C. Avery.
1977. Wildfire effects on a ponderosa pine ecosystem: an Arizona case study. USDA For. Serv. Res. Pap. RM-191, 12 p. Rocky Mt. For. and Range Exp. Stn., Fort Collins, Colo.

DeByle, N. V.
1976. Soil fertility as affected by broadcast burning following clearcutting in Northern Rocky Mountain larch/fir forests. Proc. Tall Timber Fire Ecol. Conf. 14:447-464.

Heilman, P.
1975. Effect of added salts on nitrogen release and nitrate levels in forest soils of the Washington coastal area. Soil Sci. Soc. Am. Proc. 39:778-782.

Hooker, L. L., and E. W. Tisdale.
1974. Effects of prescribed burning on a seral brush community in northern Idaho. Idaho For. Wildl. and Range Exp. Stn. Pap. 14, 11 p.

Jones, J. M., and B. N. Richards.
1977. Effect of reforestation on turnover of $^{15}N$-labeled nitrate and ammonium in relation to changes in soil microflora. Soil. Biol. Biochem. 9:383-392.

Jurgensen, M. F., S. F. Arno, A. E. Harvey, M. J. Larsen, and R. D. Pfister.
1979. Symbiotic and nonsybiotic nitrogen fixation in Northern Rocky Mountain forest ecosystems. *In* Symbiotic nitrogen fixation in the management of temperate forests. p. 294-308. J. C. Gordon, C. T. Wheeler, and D. A. Perry, eds. Oreg. State Univ. Press, Corvallis.

Klages, M. G., R. C. McConnell, and G. A. Nielson.
1976. Soils of the Coram Experimental Forest. Mont. Agric. Exp. Stn. Res. Pap. 91, 43 p. Missoula.

Knight, H.
1966. Loss of nitrogen from the forest floor by burning. For. Chron. 42:149-152.

Mroz, G. D., M. F. Jurgensen, A. E. Harvey, and M. J. Larsen.
1980. Effects of fire on nitrogen in forest floor horizons. Soil Sci. Soc. Am. J. 44:395-400.

Orme, M. L., and T. A. Leege.
1976. Emergence and survival of redstem (*Ceanothus sanguineus*) following prescribed burning. Proc. Tall Timbers Fire Ecol. Conf. 14:391-420.

Pfister, R. D., B. L. Kovalchik, S. F. Arno, and R. C. Presby.
1977. Forest habitat types of Montana. USDA For. Serv. Gen. Tech. Rep. INT-34, 174 p. Intermt. For. and Range Exp. Stn., Ogden, Utah.

Raison, R. G.
1979. Modification of the soil environment by vegetation fires, with particular reference to nitrogen transformations: a review. Plant and Soil 41:73-108.

Stark, N. M.
1979. Nutrient losses from timber harvesting in a larch/Douglas-fir forest. USDA For. Serv. Res. Pap INT-231, 41 p. Intermt. For. and Range Exp. Stn., Ogden, Utah.

Viro, P. G.
1974. Effects of forest fire on soil. *In* Fire and ecosystems. p. 7-45. T. T. Kozlowski and C. E. Ahlgren, eds. Academic Press, New York.

Wells, C. G., R. E. Campbell, L. F. DeBano, and others.
1979. Effects of fire on soil. A state-of-knowledge review. USDA For. Serv. Gen. Tech. Rep. WO-7, 34 p. Washington, D. C.

Welch, T. G., and J. O. Klemmedson.
1975. Influence of the biotic factor and parent material on distribution of nitrogen and carbon in ponderosa pine ecosystems. *In* Forest soils and forest land management. p. 159-178. B. Bernier and C. H. Winget, eds. Laval Univ. Press, Quebec.

Jurgensen, Martin F., Alan E. Harvey, and Michael J. Larsen.
1981. Effects of prescribed fire on soil nitrogen levels in a cutover Douglas-fir/ western larch forest. USDA For. Serv. Res. Pap. INT-275, 6p. Intermt. For. and Range Exp. Stn., Ogden, Utah 84401.

Reports 6 percent of total nitrogen lost and changes in other related soil properties after a clearcut and broadcast burn. The most persistent change (4 years) was a reduction in soil acidity. Forest management implications are discussed.

KEYWORDS: available nitrogen, ammonium, nitrate, nitrifying bacteria, site preparation

**USDA Forest Service**
**Intermountain Forest and**
**Range Experiment Station**
**Ogden, Utah 84401**



☆ U.S. GOVERNMENT PRINTING OFFICE 1981 — 777-028/2 Region No. 8