ROLE OF FOREST FUELS IN THE BIOLOGY AND MANAGEMENT OF SOIL

A. E. HARVEY, M. F. JURGENSEN, AND M. J. LARSEN

USDA Forest Service
General Technical Report INT-65
Intermountain Forest and
Range Experiment Station
Forest Service,
U.S. Department of Agriculture

USDA Forest Service
General Technical Report INT-65
September 1979

ROLE OF FOREST FUELS IN THE BIOLOGY AND MANAGEMENT OF SOIL

A. E. Harvey, M. F. Jurgensen, and M. J. Larsen

INTERMOUNTAIN FOREST AND RANGE EXPERIMENT STATION
Forest Service
U.S. Department of Agriculture
Ogden, Utah 84401

THE AUTHORS

A. E. HARVEY, Plant Pathologist, is responsible for research into microbiological impacts of intensive fiber utilization and prescribed fire. He is stationed at the Forestry Sciences Laboratory, Missoula, Montana. Dr. Harvey received the B.S. degree in Biology (1960), the M.S. degree in Plant Pathology (1962), the 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.

M. F. JURGENSEN, Associate Professor of Forest Soils teaches and conducts research in Forest Soils-Soils Microbiology. Dr. Jurgensen received the B.S. degree in Forestry (1961), the M.S. degree in Silviculture (1965), and the 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. His present position is with the Department of Forestry, Michigan Technological University, Houghton, Michigan.

M. J. LARSEN, Mycologist, is presently investigating the taxonomy and ecology of forest fungi at the Center for Forest Mycology Research, Forest Products Laboratory, Madison, Wisconsin. Dr. Larsen received the B.S. degree in Botany (1960), the M.S. degree in Plant Products Pathology (1963), and the 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

Microbial activities are the principal biological determinants of forest site quality. The energy source or substrate for most microbes is derived from soil organic matter (fuels). Microbial activities most critical to site quality are nitrification, dinitrogen fixation, decay, ectomycorrhizal symbiosis, and pathogensis. Research on these subjects supports the following conclusions.

The end product of nitrification, nitrate, is subject to leaching loss. Nitrification is increased by forest disturbances, particularly clearcutting and burning. In most cases, losses of nitrogen are small and short lived.

The quantities of nitrogen fixed in forest soil by symbiotic associations are dependent on the presence of host plants. Such hosts are sometimes scarce. Nonsymbiotic nitrogen fixers depend only on organic matter. Soil humus, decaying and decayed wood, are important sites for nonsymbiotic nitrogen fixation, particularly during dry periods or on dry sites.

Soil humus and decayed wood are also the principal substrates for ectomycorrhizal symbionts during dry seasons and on dry sites.

Decay of wood and other organic material contributes to soil development by cycling carbon and minerals. Products of decay provide sites for nitrogen fixation and ectomycorrhizal activity. Decay of newly formed residues, to a point where they function in these capacities, is a long-term process.

Removing or burning forest fuels can lead to increased feeder root disease. It can also create wound entry sites for decay in living trees. In some instances this provides active centers of nitrogen fixation. Infected wood in root disease centers is a potential source for inoculation and further spread of the diseases.

Adequate quantities of woody residue, and other soil organic matter sources, are critical to optimal forest growth. Except where wood constitutes potential for disease or intense wildfire or where it is replaced in relatively short time spans (warm, moist sites) it should be conserved. This is particularly true of marginal (dry or cold) sites. Excess accumulation or inadequate supplies of wood provides an opportunity for site protection and enhancement through fuel management.

CONTENTS

INTRODUCTION

The quality of a forest site is governed by its physical conditions (temperature, moisture, soil parent materials) as they affect plant and soil. Microbes greatly affect soil development. Their activities mediate nutrient status through release, acquisition, retention, and recycling. Microbes, in part, are responsible for soil physical state, tilth, and water retention, by controlling type and quantity of organic materials. These factors, in turn, affect microbial plant symbionts and pathogens. Thus, microbial action in many types of organic fuels is a major biological determinant of site quality.

Interactions between forest uses and their residues (fuels) or lack of them bring about changes in both population size and types of soil microorganisms (Bell 1974). Most microbes are dependent on organic materials (plant bodies) either for their energy source or as a growing medium (substrate). Therefore, disruption of the quantity, type, and distribution of humus, litter, and wood imposes controls on their populations. The chemical-physical nature of organic matter also affects microbes. Water content, temperature, and reaction (pH) are all influenced by forest use, especially harvesting and burning (DeByle 1976; Bollen 1974).

EFFECTS OF FUEL DISTURBANCE ON SOIL BIOLOGICAL ACTIVITIES

Silvicultural activities and other forestry practices can influence type and quantity of forest fuels and hence have numerous effects on soil biology. Five biological effects are particularly significant:

(1) The conversion of other forms of nitrogen into nitrate (nitrification) and its potential loss by leaching.

(2) Fixation of atmospheric nitrogen.

(3) Decay of organic matter, with its effects on fuel reduction, mineral cycling, nitrogen acquistion, and organic structuring of the soil.

(4) Activities of mycorrhizal symbionts.

(5) Development of and damage caused by certain plant disease fungi (Harvey and others 1976a).

Knowledge accumulated on these subjects and results of current research in the northern Rocky Mountains suggests the following conclusions.

Nitrification

Nitrogen is usually the most limiting nutrient in forest ecosystems. Its quality and form in the soil is almost totally dependent on microbial action (Stone 1973). Consequently much interest is now developing with regard to the influence of forest uses on the ecology of the mocroorganisms that function in the cycling of nitrogen.

Decay or fire releases nitrogen from organic material in the form of ammonia. A select group of autotrophic soil bacteria, particularly *Nitrosomonas* and *Nitrobacter*, obtain their energy from a range of nitrogen compounds, especially ammonia. As a result of oxidation by these organisms, ammonia is converted to nitrate. Nitrate is not bound to soil exchange sites and creates a potential for leaching loss.

Clearcutting can dramatically increase this nitrification process (Rice and Pancholy 1972; Likens and others 1970). However, losses are usually small and short lived (Reinhart 1973).

Nitrogen Fixation

Another class of mircoorganisms of importance to the cycling of nitrogen are those that extract nitrogen from the atmosphere and convert it into forms useful to plants. There are two classes of nitrogen fixers:

(1) The symbiotic forms associated with plant nodules, usually the genus *Rhizobium*.

(2) A variety of nonsymbiotic nitrogen fixers that derive their energy from the breakdown of soil organic matter or from sunlight.

The relative contributions of symbiotic and nonsymbiotic forms to the nitrogen economy of forests is not well understood (Borman and others 1977; Wollum and Davey 1975; Jurgensen 1973; Jurgensen and Davey 1970). However, in many forest ecosystems, nodulated plants are infrequent. In contrast, nonsymbiotic nitrogen fixers are widely distributed, being found in nearly all forest soils.

The effects of fuel disturbance on symbiotic nitrogen fixers depends on the impact on distribution of the nodulated plants on which symbionts depend. Legumes and alder are examples of plants in the western United States that are favored by clearcutting (Youngberg and Wollum 1970). Opening forest stands also increase leguminous plants in the southeastern United States (Schultz 1976).

Nonsymbiotic nitrogen fixers are dependent on soil organic matter. Our data from western Montana show that humus and decayed wood are the principal sites for nonsymbiotic nitrogen-fixing activities. Smaller amounts are contributed by mineral soil and litter. Decaying woody materials, not yet incorporated into the soil, provide the highest-per-unit-weight nitrogen-fixing capacity of any material widely available on the forest floor (table 1).

Table 1.--*Mean daily nitrogen fixation rates from a Douglas-fir/larch stand* (ABLA/CLUN)[1] *in western Montana (June 24, 1976) based on five samples per stratum.*

Soil strata	Grams N_2/gram of dry substrate (10^{-9})[2]
Mineral soil	3.4
Humus (O_2)	18.8
Decayed wood in soil (O_3)[3]	29.0
Decaying log	142.0

[1]*Abies lasiocarpa/Clintonia uniflora* is a habitat type designation in western Montana (Pfister and others 1977).

[2]All fixations rates reported herin were determined by acetylene reduction (Hardy and others 1968).

[3]The O_3 horizon designation is used here to depict localized concentrations of brown cubicle decayed wood with mineral soil horizons that are clearly distinguishable from the litter layer (O_1 horizon) and humus layer (O_2 horizon).

Decay

The processes and organisms involved in decay of organic matter are essential to soil development through carbon and mineral cycling.

Past research has shown increased litter decomposition accompanies timber harvesting with attendant nutrient release and leaching from the soil (Packer and Williams 1976; Hart and DeByle 1975; Piene 1974; Cole and Gessel 1965). For most sites such losses are small. This was the result at our experimental site in western Montana.

The effect of harvesting on the decay of large fuels (logs) is presently uncertain; however, the end result of this process is known. Decaying logs are a significant site for nitrogen-fixing activity (Larsen and others 1978; Borman and others 1977; Cornaby and Waid 1973). The decayed residue, in the form of brown, crumbly wood on or in the soil provides a site for continued nitrogen fixation (table 1). Decayed wood becomes the primary site for this activity during dry periods or on dry sites (table 2). This is probably due to a unique ability of decayed wood to retain large quantities of moisture (table 3). It also has a much higher cation exchange capacity than other soil components, thus increasing soil cation exchange capacity. Decayed wood has been reported to make up 15-30 percent of the top 12-15 inches of various forest soils (Harvey and others 1976b; McFee and Stone 1966).

Table 2.--*Mean daily nitrogen fixation rates from various forest sites on July 24, 1976, (beginning of the summer dry period) based on three samples per stratum*

Site		Soil Strata		
		0_2 [1]	0_3	M_1
		Grams N_2/gram of dry substrate (10^{-8})		
1 (PSME/PHMA)	warm-dry	5.9	22.8	2.3
2 (ABLA/CLUN)	cool-moist	15.8	32.3	3.2
3 (TSHE/CLUN)	warm-moist	39.5	30.6	2.1

[1] Soil strata are: 0_2, humus; 0_3, decayed wood in soil; M_1, first 5 cm mineral soil.

Table 3.--*Mean moisture content of soil strata from various forest sites, based on 150 random samples per site, June through September, 1976*

Site	Soil Strata	Moisture content (Pct. dry wt.)
1 (PSME/PHMA)	Litter (0_1)	58.6
warm-dry	Humus (0_2)	65.4
	Decayed wood in soil (0_3)	91.0
	Mineral (M_1)	17.1
2 (ABLA/CLUN)	0_1	110.3
cool-moist	0_2	116.8
	0_3	164.4
	M_1	34.0
3 (TSHE/CLUN)	0_1	122.6
warm-moist	0_2	117.3
	0_3	166.0
	M_1	27.0

Our preliminary estimates indicate that the input of functional decayed woody material into summer dry, winter cold forest soils characteristic of the northern Rocky Mountains may require hundreds of years.

Ectomycorrhizal Activity

The failure of afforestation efforts in areas lacking ectomycorrhizal associates for conifers attests to the obligate nature of the association between tree roots and fungi (Mikola 1973). Presence of the ectomycorrhizal association is particularly important to the ability to extract water, nitrogen, and phosphate from infertile soils (Bowen 1973; Melvin and Nilsson 1952).

Intense post-harvest burning is known to reduce mycorrhizal activity in subsequent regeneration (Wright and Tarrant 1958). This is probably a result of an alkaline shift in soil reaction, a high nutrient flux, and a reduction in soil organic matter. All these are detrimental to mycorrhizal development if they are extreme. The first two effects are transitory, the latter (decayed wood, etc.) is not.

In a mature ecosystem, upwards of 90 percent of the mycorrhizal activity in a stand is supported by organic matter (Harvey and others 1976b). During dry periods (Harvey and others 1978) or on dry sites most ectomycorrhizal activity is directly supported in decayed wood (table 4 and 5).

Table 4.--*Mean numbers of active mycorrhizal root tips per liter and moisture content of soil from a Douglas-fir larch (ABLA/CLUN) site in western Montana, by 60-day periods during the 1975 growing season*

Sampling period	Soil strata	Active tips/liter	Pct. H_2O
May-June	Litter (O_1)	5.9	112.0
	Humus (O_2)	369.0	130.1
	Decayed wood in soil (O_2)	75.4	204.7
	Mineral (M_1)	13.5	32.4
July-August	O_1	0	79.6
	O_2	75.4	74.2
	O_3	108.9	118.1
	M_1	4.6	27.9
September-October	O_1	4.0	156.6
	O_2	58.9	141.8
	O_3	27.9	244.4
	M_1	11.9	34.5

Table 5.--*Mean numbers of active mycorrhizal root tips per liter of soil from various forest sites, based on 150 random samples per site, June through October 1976*

Site	Soil strata	Active tips/liter
1 (PSME/PHMA) warm-dry	Litter (O_1)	0
	Humus (O_2)	12.8
	Decayed Wood (O_3)	17.2
	Mineral (M_1)	10.2
2 (ABLA/CLUN) cool-moist	O_1	1.6
	O_2	109.8
	O_3	25.2
	M_1	16.8
3 (TSHE/CLUN) warm-moist	O_1	82.7
	O_2	203.7
	O_3	108.4
	M_1	41.7

Thus, excessive residue removal could adversely impact some sites throughout one or more rotations, depending on the total amounts of woody material added to that site and to its rate of decay and incorporation into the soil.

Disease Activity

Harvesting and burning can provide a major source of infection for many root and stem pathogens primarily due to wound damage in residual trees or changes in soil chemistry (Harvey and others 1976a).

Burning may increase the activities of the potentially damaging *Rhizina* root rot (Morgan and Driver 1972) or other feeder root diseases of young conifers (Wright and Bollen 1961). Thus far, in our lightly burned experimental plots, disease has made only minor contributions to regeneration mortality.

In active root disease centers large, buried residues, stumps, and roots infected or subject to infection are known to perpetuate diseases (Nelson and Harvey 1974; Kaarik and Rennerfelt 1957; Gill and Andrews 1956).

The presence of root and stem disease should not, in all cases, be considered bad. We have discovered at least some types of pathological decay, as with residue (saprophytic) decay, provide a site for nitrogen fixation (table 6).

In overmature stands pathological decay contributes to preparation of the site for future stands. This fiber loss can, therefore, be an energy investment in, as well as a threat to future site productivity.

Table 6.--*Daily nitrogen fixation rates from wood in live, standing western Hemlock and down, dead Douglas-fir. Decayed by* Echinodontium tinctorium *(Ell. & Ev.) and* Fomitopsis pinicola *(Swortz ex Ft.) Korst., respectively, based on 5 samples per decay type*

Decay stage	*E. tinctorium* (TSHE/CLUN)	*F. pinicola* (ABLA/CLUN)
	Grams N_2/gram of substrate (10^{-9})	
Undecayed (no visual discoloration)	20.7	17.1
Incipient decay (light dicoloration, wood firm)	22.2	15.8
Advanced decay (highly discolored, wood soft)	19.88	98.5

MANAGEMENT IMPLICATIONS AND RECOMMENDATIONS

Forest Fuels — An Asset

Forest managers and forest users should recognize the benefits, equivalent to long-term fertilization and moisture conservation, of retaining wood and other organic materials in forest ecosystems. Three separate lines of evidence (nitrogen fixation, decay rate, ectomycorrhizal activity) indicate these materials should be considered an important, functional part of forest soils, particularly on droughty sites.

Extreme scarification, intensive pile and burn, or hot wildfire that drastically reduces organic matter are potentially dangerous to dry sites. Such treatments may provide good early regeneration but poor ultimate survival and slow growth. This is primarily because both nitrogen and moisture reserves are lost from the root zone.

In extreme cases, because of slow decay rates on dry or cold sites, one or more rotations may be required to rebuild soil too low in organic matter to support the growth potential of that site.

Forest Fuels — A Liability

In specific areas, for example where fuel loading represents potential for highly destructive wildfire, or where woody residues are sources of pathogens from destructive disease centers, the benefits of removal will likely exceed those of preservation. Similarly, accumulations of organic matter in excess of site requirements may be undesirable. The potential for such circumstances is highest on cool, moist sites. This aspect of forest soil ecology is not, as yet, well documented.

High productivity and rapid decay render warm, moist forests less sensitive to long-term damage by depletion of soil organic matter either by fire or by other of man's activities.

Forest Fuels — An Opportunity

The vital role of wood in the functions of forest soil biology provides an opportunity for control of the soil system through harvest management. Where soils are low in organic matter, wood can be left on the site. Here it will gradually decay to provide nitrogen and moist microsites for ectomcorrhizal activity. Conversely, where wood has accumulated in quantity it can be removed and utilized or burned in place. Where the soil system is adequately supplied with organic matter it can be maintained in that condition. Thus, knowledgeable fuels management can improve, at least protect, any forest site where comtemplated use has the potential to disturb the distribution, quantity, or type of organic matter on that site.

PUBLICATIONS CITED

Bell, M. A. M., J. M. Beckett, and W. F. Hubbard.
1974. Impact of harvesting on forest environments and resources. Can. For. Serv., Pac. For. Res. Cen., Victoria, B.C.

Bollen, W. B.
1974. Interaction between soil microbes, forest residues, and residue treatments. *In* Environmental effects of forest residues management in the Pacific Northwest. O. P. Crammer (ed.) USDA For. Serv. Gen. Tech. Rep. PNW-24. Pacific Northwest For. and Range Exp. Stn., Portland, Oreg.

Borman, F. H., C. E. Sikas, and J. M. Milillo.
1977. Nitrogen budget for an aggrading northern hardwood forest ecosystem. Science 196:981-983.

Bowen, G. D.
1973. Mineral nutrition of ectomycorrhizae. *In* Ectomycorrhizae--their ecology and phyciology, p. 151-206. G. C. Marks and T. T. Kozlowski, (eds.) Academic Press, New York.

Cole, D. W., and S. P. Gessel.
1965. Movement of elements through a forest soil as influenced by tree removal and fertilizer additions. *In* Forest soil relationships in North America, p. 95-104. C. T. Youngberg, (ed.), Oreg. State Univ. Press, Corvallis.

Cornaby, B. W., and J. W. Waide.
1973. Nitrogen fixation in decaying chestnut logs. Plant and Soil 39:445-448.

DeByle, N. V.
1976. Fire, logging and debris disposal effects on soil and water in northern coniferous forests. *In* Proc. IVI, IUFRO World Congr., Oslo, Div. 1, p. 201-212.

Gill, L. S., and S. R. Andrews.
1956. Decay of ponderosa pine slash in the Southwest. USDA For. Serv., Res. Note 19, 2 p. Rocky Mt. For. and Range Exp. Stn., Ft. Collins, Colo.

Hardy, R. W. F., R. D. Holsten, E. K. Jackson, and R. C. Burns.
1968. The acetylene-ethylene assay for N_2-fixation: Laboratory and field evaluation. Plant Physiol. 43:1185-1207.

Hart, G. E., and M. V. DeByle.
1975. Effects of lodgepole pine logging and residue disposal on subsurface water chemistry. Watershed Manag. Symp., ASCE, p. 98-109.

Harvey, A. E., M. F. Jurgensen, and M. J. Larsen.
1978. Seasonal distribution of ectomycorrhizae in mature Douglas-fir/larch forest soil in western Montana. For. Sci. 24:203-208.

Harvey, A. E., M. F. Jurgensen, and M. J. Larsen.
1976a. Intensive fiber utilization and prescribed fire: Effects on the microbial ecology of forests. USDA For. Serv. Gen. Tech. Rep. INT-28, 46 p. Intermt. For. and Range Exp. Stn., Ogden, Utah.

Harvey, A. E., M. J. Larsen, and M. F. Jurgensen.
1976b. Distribution of ectomycorrhizal in a mature Douglas-fir/larch forest soil in western Montana. For. Sci. 22:393-398.

Jurgensen, M. F.
1973. Relationship between nonsymbiotic nitrogen fixation and soil nutrient status--a review. J. Soil Sci. 24:512-522.

Jurgensen, M. F., and C. B. Davey.
1970. Nonsymbiotic nitrogen fixing micro-organisms in acid soils and the rhizosphere. Soils Fert. 33:435-446.

Kaarik, A., and E. Rennerfelt.
1957. Investigation on the fungal flora of spruce and pine stumps. Status Skogsforskningsinst. (Sweden), Medd. 47:1-88.

Larsen, M. J., M. F. Jurgensen, and A. E. Harvey.
1978. Nitrogen fixation associated with wood and wood decay fungi in western Montana. Can., J. For. Res. (In press).

Likens, G. E., F. H. Bormann, N. M. Johnson, D. W. Fischer, and R. S. Pierce.
1970. Effects of forest cutting and herbicide treatment on nutrient budgets in the Hubbards Brook watershed ecosystem. Ecol. Monogr. 40:23-47.

McFee, W. W., and E. L. Stone.
1966. The persistence of decaying wood in humus layers of northern forests. Proc. Soil Sci. Soc. Am. 30:513-516.

Melvin, E., and H. Nilsson.
1952. Transfer of labelled nitrogen from an ammonium source to pine seedlings through the mycelium of *Boletus variegatus* Fr. Svensk Bot. Tidskr. 46:281-285.

Mikola, P.
1973. Mycorrhizal symbiosis in forestry practice. *In* Ectomycorrhizae--their ecology and physiology, p. 388-412. G. C. Marks, and T. T. Kozlowski (eds.) Academic Press, New York.

Morgan, R., and C. H. Driver.
1972. *Rhizina* root rot of Douglas fir seedlings planted on burned sites in Washington. Plant Dis. Rep. 56:402-409.

Nelson, E. E., and G. M. Harvey.
1974. Residues and forest disease. *In* Environmental effects of forest residues management in the Pacific Northwest--a state-of-knowledge compendium, p. 51-511. USDA For. Serv. Gen. Tech. Rep. PNW-24. Pacific Northwest For. and Range Exp. Stn., Portland, Oreg.

Packer, P. E., and B. D. Williams.
1976. Logging and prescribed burning effects on the hydrologic and soil stability behavior of larch/Douglas fir forests in the Northern Rocky Mountains. Proc. Tall Timbers Fire Conf. 14:465-479.

Piene, H.
1974. Factors influencing organic matter decomposition and nutrient turnover in cleared and spaced, young conifer stands on the Cape Breton Highlands, Nova Scotia, Can. For. Serv. Infor. Rep. M-X-41, 33 p.

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

Reinhart, K. G.
1973. Timber-harvest clearcutting and nutrients in the northeastern United States. USDA For. Serv. Res. Pap. NE-170, 5 p. Northeast. For. Exp. Stn., Upper Darby, Pa.

Rice, E. L., and S. K. Pancholy.
1972. Inhibition of nitrification by climax ecosystems. Am. J. Bot. 59:1033-1040.

Schultz, R. P.
1976. Environmental change after site preparation and slash pine planting on a flatwoods site. USDA For. Serv. Res. Pap. SE-156 p. Southeast. For. Exp. Stn., Asheville, N.C.

Stone, E. L.
1973. Regional objectives in forest fertilization, current and potential. *In* Forest fertilization, p. 10-18. USDA For. Serv., Northeast. For. Exp. Stn., Broomall, Pa.

Wollum, A. G. II, and C. B. Davey.
1975. Nitrogen accumulation, transformation, and transport in forest soils. *In* Proc. 4th N. Am. For. Soils Conf., Quebec, 1973.

Wright, E., and W. B. Bollen.
1961. Microflora of Douglas fir soil. Ecology 42:825-828.

Wright, E., and R. F. Tarrant.
1958. Occurrence of mycorrhizae after logging and slash burning in the Douglas fir type. USDA For. Serv., Pac. Northwest For. and Range Exp. Stn. Res. Pap. 160, 7 p. Portland, Oreg.

Youngberg, C. T., and A. G. Wollum II.
1970. Non-leguminous symbiotic nitrogen fixation. *In* Tree growth and forest soils, p. 383-395. C. T. Youngberg and C. B. Davey, (eds.) Oreg. State Univ. Press, Corvallis.

☆U.S. GOVERNMENT PRINTING OFFICE: 1979-0-677-019/62

Harvey, A. E., M. F. Jurgensen, and M. J. Larsen
1979. Role of Forest Fuels in the Biology and Management of soil. USDA For. Serv. Gen. Tech. Rep. INT-65, 8 p. Intermountain Forest and Range Experiment Station, Ogden, Utah 84401.

Reviews current understanding of and provides research data on the relationship between forest fuels (organic matter accumulations) and forest soil productivity. Concludes that soil organic matter and woody residues are important to ectomycorrhizal and nitrogen-fixing activities. Protecting site quality will likely become an important factor in residue management.

KEYWORDS: prescribed fire, wildfire, residues-fuel management, soil organic reserves, nitrogen fixation, ectomycorrhizal, disease, decay, nitrification.

Harvey, A. E., M. F. Jurgensen, and M. J. Larsen
1979. Role of Forest Fuels in the Biology and Management of soil. USDA For. Serv. Gen. Tech. Rep. INT-65, 8 p. Intermountain Forest and Range Experiment Station, Ogden, Utah 84401.

Reviews current understanding of and provides research data on the relationship between forest fuels (organic matter accumulations) and forest soil productivity. Concludes that soil organic matter and woody residues are important to ectomycorrhizal and nitrogen-fixing activities. Protecting site quality will likely become an important factor in residue management.

KEYWORDS: prescribed fire, wildfire, residues-fuel management, soil organic reserves, nitrogen fixation, ectomycorrhizal, disease, decay, nitrification.

Headquarters for the Intermountain Forest and Range Experiment Station are in Ogden, Utah. Field programs and research work units are maintained in:

- Billings, Montana
- Boise, Idaho
- Bozeman, Montana (in cooperation with Montana State University)
- Logan, Utah (in cooperation with Utah State University)
- Missoula, Montana (in cooperation with University of Montana)
- Moscow, Idaho (in cooperation with the University of Idaho)
- Provo, Utah (in cooperation with Brigham Young University)
- Reno, Nevada (in cooperation with the University of Nevada)