Fire-Decay: Interactive Roles Regulating Wood Accumulation and Soil Development in the Northern Rocky Mountains

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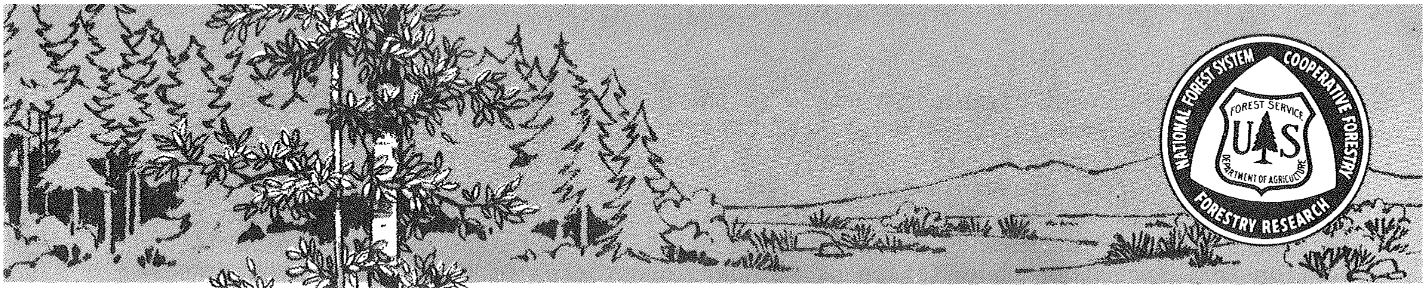

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FIRE - DECAY:

INTERACTIVE ROLES REGULATING WOOD ACCUMULATION AND SOIL DEVELOPMENT IN THE NORTHERN ROCKY MOUNTAINS

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ABSTRACT

Decay and fire play interactive roles in recycling wood and other organic materials in forest ecosystems, and contribute to the development of high quality soils in the Northern Rocky Mountains. Decayed wood, charcoal, and other decomposed organic matter are the principal media for ectomycorrhizal and nonsymbiotic nitrogen fixing microbes. The activities of these microbes are critical to the growth of forest trees. The balance between decay and fire, as it affects the amount, distribution, and type of organic matter, controls the ability of forest soils to support the growth of trees.

KEYWORDS: Prescribed fire, residues management, fuel management, soil organic reserves, nitrogen fixation, ectomycorrhizal, wildfire.

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The importance of organic materials to the quality of forest soils is frequently obscured by requirements for mineral seed beds to support seed germination and early survival of most conifers. The fire-evolved nature of most Northern Rocky Mountain forests implies that organic materials (fuels) may be expendable. However, in most cases, even after intense wildfires, substantial quantities of large woody fuels remain. This wood directly influences soils on these sites. The organic component of soil development, including accumulation of adequate quantities of both decayed and decaying wood plus other organic debris, provide the principal substrata for several important soil functions. Inadequate woody material may cause a regenerating stand to grow more slowly than otherwise possible.

QUANTITY OF WOOD IN FOREST SOILS

The persistance of wood in forest soils has been recognized only recently. Estimates on the quantity of decayed wood in soils vary but in all cases volumes are substantial. Day and Duffy (1963) estimated that decaying wood made up 16.5 percent of the surface area of one stand in the Rocky Mountains of Canada. McFee and Stone (1966) measured the volume of decayed wood on several forest plots in the Adirondack region of New York State. They reported from 14 to 30 percent of the surface area of these stands was made up of decayed wood. Measurements from western Montana show 15 percent of the top 15 inches (38 cm) of soil consisted of brown, cubical, decayed wood (Harvey and others 1976).

FUNCTION OF WOOD IN FOREST SOILS

The processes and organisms that decay wood are essential to soil development. They directly influence carbon and mineral cycling. Preliminary measurments indicate that decayed wood has a higher cation exchange capacity than any other component in several of the rocky soils of western Montana. Wood represents a potentially important site for retention of plant nutrients.

Nonsymbiotic nitrogen fixers are dependent on soil organic matter. Data from western Montana show that humus and decayed wood are the principal sites of nitrogen fixing activity, particularly on dry sites (Larsen and others 1978; Harvey and others 1978b; Jurgensen and others 1977). Nitrogen fixing activities have also been reported in decaying wood in the southeast (Cornby and Waide 1973), the northeast (Bormann and others 1977) and the northwestern United States (Aho and others 1974).

Nonsymbiotic nitrogen fixation is critical to forest ecosystems in the Northern Rocky Mountains. In the Rocky Mountain region symbiotic nitrogen fixing plants are frequently less common than in many other regions. Their presence is restricted to early stand development or limited by habitat requirements.

In mature forest ecosystems of the Northern Rocky Mountains, upwards of 90 percent of the active ectomycorrhizal roots of a forest stand are supported by soil organic matter (Harvey and others 1976). During dry periods or on dry sites most of this activity was supported by decayed wood (Harvey and others 1978a, 1978b). Ectomycorrhizal activity in decayed soil wood has also been observed in western Canada (McMinn 1963), the northwestern (Zak 1971; Trappe 1965) and northeastern United States (McFee and Stone 1966).

Wood in forest soils, therefore, contributes to soil quality and stand growth in a broad geographical area.

DECAY-FIRE INTERACTION

The incorporation of wood into forest soils involves a choice or a combination of biological (decay) and physical (fire) forces. Decay is rapid in warm-wet ecosystems where fire occurs infrequently. Conversely, decay proceeds slowly in cold or dry ecosystems where fire occurs more frequently.

Decayed wood consists primarily of complex lignin molecules highly resistant to further biological breakdown. Therefore, highly decayed soil wood should accumulate even on warm-moist sites despite rapidity of decay. On dry or cold sites decay is impaired. These sites should accumulate relatively undecayed woody debris until the occurrence of a wildfire. Fuel accumulation leads to hot wildfires that remove even large fuels. This will likely deplete the soil wood leading only to accumulations of soil charcoal. Sites with intermediate conditions of temperature and moisture should provide a balanced relationship between these forces.

Preliminary field data indicate that these types of relationships do hold, at least for selected areas, in the Northern Rocky Mountains.

MANAGEMENT OF WOOD IN FOREST SOILS

Evidence that soil organic reserves, particularly wood, play important roles in maintaining forest site quality emphasizes the need to properly manage woody materials. Thus, the viewpoint that woody residue represents only waste or a fire hazard must be reassessed. Forest users and managers must recognize the benefits, equivalent to long-term fertilization, that woody and other organic reserves contribute to forest ecosystems.

Although the precise quantities and types of organic materials required to maintain optimum site conditions are still under study, some general guidelines for wood management can be set forth.

Within the Northern Rocky Mountains, the high productivity and rapid decay rates of warm-moist forests make them less sensitive to depletion than sites with low-to-moderate productivity. However, managing old-growth forests more characteristic of the coastal Douglas-fir region may require conservation of decayed wood, even on productive sites (Franklin and others 1979). Conversely, management of dry or cold sites should emphasize conservation of large woody materials where this does not create unacceptable wildfire risk. Such woody materials should, where possible, be left in contact with the soil to create optimum conditions for decay.

Where early creation of mineral soil seedbeds is critical to reforestation, post-harvest slash treatments should be directed toward a mosaic of fuel dispersal. It will be advantageous to have both large woody residues and bare mineral surface scattered across the site so seeds can germinate rapidly and the seedlings can have access, within a short distance, to the nutrients, moisture, and ectomycorrhizal activity provided in decaying wood and humus. Size of both slash piles and windrows for prescribed burning should be dictated by minimum standards that will achieve adequate reduction of small fuel. Soil disturbance should be minimal and not create continuous expanses of mineral surface.

Management of wood on intermediate sites is less clear. Until more data are available, such sites should be treated as if at least moderately sensitive to reduction of soil wood.

An awareness of the importance of wood and other organic reserves to forest ecosystems and the risk of site degradation through wood depletion will help to improve forest practices over wide geographic areas.

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