

Decaying Logs as Moisture Reservoirs After Drought and Wildfire

M. P. Amaranthus, D. S. Parrish and D. A. Perry

Siskiyou National Forest, Grants Pass, OR
Siskiyou National Forest, Grants Pass, OR
Department of Forest Science, Oregon State University, Corvallis, OR

Abstract. Decaying wood on the forest floor retains large reservoirs of moisture and thus provides long-lasting, high-moisture microsites that aid in forest recovery after prolonged drought or fire. Examination of logs after the Galice Complex fires in southwest Oregon revealed considerable root and mycorrhizal activity. Mean log moisture (157%) was 25 times greater than mean soil moisture (6%). After extended drought and wildfire, the moisture stored in logs may expedite forest recovery by providing important refuges for roots and associated mycorrhizal fungi of pioneering vegetation.

Fallen trees, in various stages of decay, form an important component of the forest habitat by providing a storehouse for moisture and nutrients and by furnishing a favorable environment for microorganisms that are critical in the growth of commercially important conifer species (Maser *et al.* 1979, Harvey *et al.* 1981). Woody material has a variety of physical and chemical properties important to biological processes (Larsen *et al.* 1980), and is the primary water and food base for a wide variety of essential organisms.

In addition to contributing to the biological diversity of the ecosystem, fallen logs function as a water reservoir in dry areas. Maser and Trappe (1984) found that water content of logs increases with length of time on the forest floor and with stage of decay. Plant moisture stress is probably the primary cause of mortality of conifer seedlings planted in reforestation sites in southern Oregon and northern California (Hermann 1965; Cleary 1971; Hermann 1977; Hobbs *et al.* 1980). During the late summer, soil moisture is at its lowest level (Amaranthus, unpublished data) due to infrequent summer precipitation, warm temperatures, and the low water-holding capacity of many soils (Meyer and Amaranthus 1979; Johnson and Beschta 1980; Kandiko *et al.* 1980). Potential for wildfire is greatest during this period and sources of plant-available moisture may be critical for recovery of vegetation.

Methods

Site description

Our study was conducted in an area that had been intensely burned during the Galice complex fires in 1987. The 8-ha site is located on the upper south fork of Galice Creek in the Klamath Mountains of southwest

Oregon. The aspect is northeast and the steep slopes average 50 percent. Soils are well drained loam with clay-loam subsoils underlain by amphibole gneiss parent material at a depth of 40 to 90 cm. Surface layers, down to 12.5 cm, are dark reddish-brown and average 45 percent rock fragments. Sand, silt, and clay percentages are 55, 27, and 18, respectively.

The area had been clearcut in 1965, broadcast burned in the fall, 1967, and planted with Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco) in the spring of 1969. At the time of the Galice Complex fire, Douglas-fir, white fir (*Abies concolor* (Gord. & Glend.) Lindl. ex Hildebr.), and incense-cedar (*Libocedrus decurrens* Torr.) were growing on the site at a density of about 1000 trees/ha. Sadler's oak (*Quercus sadleriana* R. Br. Campst), greenleaf manzanita (*Arctostaphylos patula* Greene), and chinkapin (*Castanopsis chrysophylla* (Dougl.) A. DC.) were also abundant.

The wildfire burned the site with high-burn intensity on 1 September 1987. Surface litter and duff and the crowns of existing vegetation were completely consumed. Some initial sprouting of the brush species was noted on 8 October, just 38 days after the fire. The site averaged 15 down logs per acre, most of which were class II or class III, based on the system devised by Maser *et al.* (1979). These logs were completely charred to a depth of 2.5 to 10.0 cm, reducing the diameter of the majority of them to between 20 and 45 cm.

The area experiences very low summer rainfall. Total precipitation, recorded at the weather station on Onion Mountain, 6.4 km from the study site, was 100 cm from 1 September 1986 to October 1987, with less than 7 percent falling between 1 June and 1 October (Table 1). No precipitation occurred in the 77-day period prior to sampling.

~~What was in down logs class III logs~~
(1987)

Table 1. Onion Mountain Precipitation-September 1, 1986 to October 1, 1987.

Month	Precipitation	Month	Precipitation
1986	cm	1987	cm
Sept	9.9	Jan	18.9
Oct	9.7	Feb	6.1
Nov	12.6	Mar	21.9
Dec	8.7	Apr	2.3
		May	3.0
		June	1.0
		July	5.8
		Aug	0.0
		Sept	0.0

Field Procedure and Analysis

On 9 October 1987 we sampled eight Douglas-fir logs, four from class II and four from class III (Maser *et al.* 1979), using a dot grid to ensure random selection from each class. Two 15 cm (6-inch) sections were cut at random locations along each log. The presence of roots and mycorrhizae was recorded for each sample. Two soil samples, each approximately 300 g, were taken at a 3 to 10-cm depth within 1.5 m of the sample logs.

Wood and soil samples were placed in plastic bags and transferred to the laboratory, where they were weighed and oven dried at 70°C for 30 hours. Wood and soil moisture values were calculated for each sample by subtracting wet weight from oven dry weight and dividing by oven-dry weight. Means, variance, and standard errors were computed for paired values of wood and soil moistures and compared by a Student's t-test. Data on moisture for class II and class III logs were also compared.

Results and Discussion

We found tremendous quantities of water stored in the class II and class III logs. Even after 77 days without rain and an intense fire, we could wring water out of the wood. The logs we sampled contained 25 times more moisture on a weight basis than did soil samples (157% compared with 6%, Table 2). Class III logs held significantly more water than did class II logs (199% compared with 119% Table 3).

Comparing moisture contents on a weight basis between organic material and mineral soil can be misleading since the bulk densities, thus the unit weights are different. What is cited as a 25 x difference may be closer to 10 to 15 x difference if expressed on a volumet-

ric basis. Values expressed on a volumetric basis are difficult to attain because of problems in accurately determining the bulk density of rotten logs. The conclusions of the study would remain unchanged, however, using either method because of the magnitude of the differences between soil and log moistures.

Table 2. Log and soil moisture content following wild-fire.

	Moisture (% of Dry Weight)	Standard Error	t-value
Log	156.7	19.0	7.66
Soil	6.1	.8	

In winter, large amounts of water are stored in decaying wood. As the stage of decay advances, the wood becomes more porous and therefore retains more water. The presence of this moisture after drought and fire may help pioneering plants become established where available soil moisture is low.

Most of the woody plants of the Pacific Northwest forests depend upon ectomycorrhizae for water and nutrient uptake. Harvey *et al.* (1979) found large numbers of ectomycorrhizae in organic material with significantly more occurring in decaying wood than in soil. The importance of decaying wood in supporting feeder-root and ectomycorrhizal activity may be much greater on dry sites than on moist sites (Harvey *et al.* 1986). The wood component becomes critical when those dry sites are also low in nutrients.

Mycorrhizae were widely distributed in class III logs. Amaranthus *et al.* (1987b) found that the presence of native mycorrhizae is important for seedling growth after clearcutting and intense burning on droughty sites in southwest Oregon. In another study on a droughty southwest Oregon site, nitrogen fixation was associated with ectomycorrhizal activity (Amaranthus *et al.* 1987a). In periods of adequate moisture, humus supports the highest level of ectomycorrhizae, but during periods of drought soil wood becomes the most active site (Harvey *et al.* 1982; Larsen *et al.* 1982). Thus, during the dry season, the wood component provides not only essential moisture and nutrients, but also the means of utilizing them.

Class II + class III are decay levels

Protection or enhancement of the organic component of the soil is a primary requisite for maintaining long-term forest growth. In the Klamath Mountains, conifer seedling performance can depend on the ability of soil to retain moisture and support nitrogen-fixing and ectomycorrhizal organisms (Amaranthus and Perry 1987; Amaranthus and Perry 1988). The removal of large amounts of organic material may result in difficulty in the reforestation of these thin, droughty, or infertile soils.

In the managed forest, harvesting, yarding non-marketable material, broadcast burning, and tractor piling reduce the wood component in the ecosystem. The long and short-term consequences of this reduction are of growing concern to forest managers. A balance between fuel management guidelines and protection of the wood component of forest soil is critical. Large accumulations of woody residue can create a potential for wildfires of increased intensity, which would result in a lack of organic material and thus limit subsequent growth. When forest managers are analyzing for fire risk, they should take into account the high water content of fallen logs during the period in which wildfire potential is greatest. Class III logs in our study had a moisture content of 199%.

Table 3. Moisture Content for Class II and Class III Logs.

	Moisture (% of Dry Weight)	Standard Error	t-value
Class II Logs	114.0	5.5	3.98
Class III Logs	199.5	20.7	

Fallen trees, in a range of decay classes, therefore provide a long-term reservoir of moisture. A continuous supply of woody material left on the forest floor, not only protects the productive potential of the forest soil, but also provides a sanctuary for ectomycorrhizae and a significant source of moisture in the event of prolonged drought or wildfire.

References

- Amaranthus, M.P., and D.A. Perry. 1987. Effect of soil transfer on ectomycorrhizal formation and the survival and growth of conifer seedlings on old non-forested clearcuts. *Can. J. For. Res.* 17:944-950.
- Amaranthus, M.P., and D.A. Perry. 1988. Mycorrhiza formation and growth of Douglas-fir seedlings in three vegetation types: are there successional guilds? *In* D.A. Perry, B. Thomas, R. Meurisses, R. Miller, J. Means, P. Sollins and K. Cromack, Jr. (eds.) *Maintaining Long Term Productivity of Pacific Northwest Forest Ecosystems*. Timber Press, Portland, Oregon (in press).
- Amaranthus, M.P., C.Y. Li, and D.A. Perry. 1987a. Nitrogen fixation within mycorrhizae of Douglas-fir. *In* D.M. Sylvia and J.H. Graham (eds.), *Proc. North American Conference on Mycorrhizae*, University of Florida, Gainesville. Pp. 79.
- Amaranthus, M.P., D.A. Perry, and S.L. Borchers. 1987b. Reduction of native mycorrhizae reduces growth of Douglas-fir seedlings. *In* D.M. Sylvia and J.H. Graham (eds.), *Proc. North American Conference on Mycorrhizae*, University of Florida, Gainesville. p. 80.
- Cleary, B.D. 1971. The effect of plant moisture stress on the physiology and establishment of planted Douglas-fir and ponderosa pine seedlings. Oregon State University, Corvallis. Ph.D. Thesis.
- Harvey, A.E. 1982. The importance of residual organic debris in site preparation and amelioration for reforestation. *In* *Site Preparation and Fuels Management on Steep Terrain: Symp. Proc. Washington State University, Cooperative Extension, Pullman*. Pp. 75-85
- Harvey, A.E.; M.F. Jurgensen; and M.J. Larsen. 1981. Organic reserves: importance to ectomycorrhizae in forest soils in western Montana. *For. Sci.* 27: 442-445.
- Harvey, A.E., M.F. Jurgensen, M.J. Larsen, R.T. Graham. 1986. Decaying organic materials and soil quality in the inland Northwest: A management opportunity. *USDA For. Serv. Gen. Tech. Rep. INT-225*. Intermt. For. Range Exp. Sta., Ogden, Utah. Pp. 15.
- Harvey, A.E., M.J. Larsen, and M.F. Jurgensen. 1979. Comparative distribution of ectomycorrhizae in soils of three western Montana forest habitat types. *For. Sci.* 25: 350-360.
- Hermans, R.K. 1965. Survival of planted ponderosa pine seedlings in southern Oregon. *For. Res. Lab., Oregon State University, Corvallis. Res. Pap.* 2. 30 p.

- Hermann, R.K. 1977. Growth and production of tree roots. In J.K. Marshall (ed.) The Belowground Ecosystem: A Synthesis of Plant Associated Processes. Colorado State University, Fort Collins. Pp. 7-28.
- Hobbs, S.D., R. H. Byars, D.C. Henneman, and C.R. Frost. 1980. First-year performance of 1-0 containerized Douglas-fir seedlings on droughty sites in southwest Oregon. For. Res. Lab., Oregon State University, Corvallis. Res. Pap. 42. 14 p.
- Johnson, M.G. and R.L. Beschta. 1980. Logging infiltration capacity and surface erodibility in western Oregon. J. For. 78:334-337.
- Kandiko, R.A., R. Timmis, and J. Worrall. 1980. Pressure-volume curves of shoots and roots of normal and droughty conditioned western hemlock seedlings. Can. J. For Res. 10:10-16.
- Larsen, M.J.; A.E. Harvey, and M.F. Jurgensen. 1980. Residue decay processes and associated environmental functions in northern Rocky Mountain forests. In Environmental Consequences of Timber Harvesting in Rocky Mountain Coniferous Forests. USDA For. Serv. Gen. Tech. Rep. INT-90. Intermt. For. Range Exp. Sta., Ogden, Utah. Pp. 157-194.
- Larsen, M.J.; M.F. Jurgensen, and A.E. Harvey. 1982. N₂ fixation in brown-rotted soil wood in an intermountain cedar-hemlock ecosystem. For. Sci. 28:292-296.
- Maser, C., and J.M. Trappe. Tech. Eds. 1984. The seen and unseen world of the fallen tree. USDA For. Serv. Gen. Tech. Rep. PNW-164. Pac Northwest For. Range Exp. Sta., Portland, Oregon. Pp. 56.
- Maser, C.; R.G. Anderson, K. Cromack, Jr., J.T. Williams, and R.E. Martin. 1979. 6. Dead and down woody material. In J.W. Thomas (tech. ed.) Wildlife Habitats in Managed Forests: The Blue Mountains of Oregon and Washington. USDA Agric. Handb. 553. In cooperation with: Wildlife Management Institute and the U.S. Department of the Interior, Bureau of Land Management. Pp. 78-95.
- Meyer, R., and M.P. Amaranthus. 1979. Soil Resource Inventory of the Siskiyou National Forest. USDA For. Serv. Siskiyou National Forest, Grants Pass, Oregon.

From: Proceedings
of Watershed '89: a
Conference on the stewardship
of soil, air and water
resources. USDA For. Serv.,
Alaska Region: pp 191-194 (1989).

Stresses are low
get listing for additional study
via e-mail