CHANGES IN FINE ROOT DYNAMICS AND DISTRIBUTION ALONG A CHRONOSEQUENCE OF UPLAND OAK-HICKORY FORESTS

Travis W. Idol[1], Phillip E. Pope[1], and Felix Ponder, Jr.[2]

Abstract: Central Hardwood forests regenerate rapidly following a major disturbance like a clear-cut. The subsequent aboveground growth and development of the resulting stands have been well-documented for these forests. However, the belowground components, specifically the dynamics of fine roots, are not well understood. Fine roots are the main vectors through which plants uptake water and nutrients and represent a significant proportion of a plant's net primary productivity. Studying the dynamics of fine roots during stand/forest development is essential to understand forest ecosystems and for responsible forest management.

This study was installed at the Southern Indiana Purdue Agricultural Center (SIPAC) in Dubois County, Indiana to assess the fine root dynamics in stands of different age. The stands are historically upland oak-hickory forests and each was clear-cut at a different time in the past. The first stand was cut in 1991 (Site 1), the second in 1985 (Site 2), the third in 1966 (Site 3), and the fourth is a mature stand (80-120 years old) which serves as a control (Site 4). Stand density, species composition, and litterfall assessments of the aboveground vegetation have been conducted in companion studies. In this study, fine root dynamics: biomass, growth, mortality, and decomposition, and the soil environment: temperature, moisture, and N and P availability were evaluated in both the A and E or B horizons from July 1995 to June 1996. Time Period in Table 1 refers to the month, starting with July 1995, which the measurements represent.

Results indicate that fine root biomass is not significantly different among the stands, but that the live component of fine roots changes dramatically during the growing season. Fine root growth, mortality, and decomposition generally decrease from the younger to the older stands (Table 1). Patterns of fine root dynamics are also seasonally distinct among the stands. Peak fine root growth rates occur later during the fall in the younger stands than in the older ones. The distribution of fine roots becomes more concentrated in the A horizon with increasing stand age. Soil nitrate and phosphate availability are the soil variables most strongly related to fine root growth and mortality; whereas, fine root decomposition is also responsive to changes in soil temperature (Table 2). The quadratic nature of the relationships indicates that nutrient deficiencies may stimulate fine root growth in the regenerating stands. In general, following a clear-cut harvest, reestablishment of fine root biomass occurs more quickly than leaf area. Therefore, before canopy closure, availability of and competition for belowground resources may in large part determine the productivity and composition of regenerating stands in the Central Hardwoods Region.

[1] Graduate Research Assistant and Professor, respectively, Department of Forestry & Natural Resources, Purdue University, West Lafayette, IN.
[2] Supervisory Research Soil Scientist, USDA Forest Service, North Central Forest Experiment Station, 208 Foster Hall, Lincoln University, Jefferson City, MO.

Table 1. Fine root dynamics integrated over 30-cm depth

Site	Fine root parameter	Time Period 1	3	5	8	11	Annual average
							(Mg/ha)
	Growth	1.42b	3.09a	3.48a	1.80b	1.62b	7.96
1	Mortality	1.59c	2.99b	4.33a	1.86c	1.26c	8.87
	Decomposition	1.15b	-0.18b	7.07a	1.11b	1.64b	7.15
	Growth	1.44c	3.12b	3.87a	2.18c	1.93c	8.87
2	Mortality	2.82ab	2.95ab	4.40a	2.53bc	0.78c	9.60
	Decomposition	2.44bc	0.74bc	5.09a	4.20ab	0.15c	10.11
	Growth	1.84ab	4.83a	1.87b	0.73b	1.21b	6.72
3	Mortality	4.10ab	5.84a	1.96b	0.50b	1.00b	8.32
	Decomposition	3.24ab	4.94a	2.31ab	1.19b	0.38b	7.92
	Growth	1.52b	3.01a	1.54b	0.94c	0.97c	5.36
4	Mortality	2.72b	4.79a	1.63bc	0.62cd	0.17d	6.28
	Decomposition	1.99a	2.69a	1.81a	2.09ab	0.12b	6.46

Time Period values expressed in g/m^2-day. Values followed by the same letter within a row do not differ significantly.

Table 2. Regression analysis of fine root parameters-single depth

Site	Parameter	Regression equation	R^2	P-value
	Growth	No significant relationships		
1	Mortality	No significant relationships		
	Decomposition	$Y = 36.541341 - 3.494705*Temp + 0.084657*(Temp)^2$	0 .973	<0.05
	Growth	$Y = 3.938654 - 0.649512*NO_3 + 0.049107*(NO_3)^2$	.998	<.01
2	Growth	$Y = 4.017974 - 1.329603*Phos + 0.170152*(Phos)^2$	.674	<.01
	Mortality	$Y = 3.069869 + 0.127808*NO_3 - 0.044552*(NO3)^2$	.741	<.05
	Decomposition	$Y = 31.536046 - 3.428857*Temp + 0.094458*(Temp)^2$	.981	<.05
	Growth	$Y = 4.968778 - 4.229065*Phos + 1.101870*(Phos)^2$	.882	<.01
3	Mortality	$Y = 6.054396 - 5.790557*Phos + 1.638396*(Phos)^2$	.926	<.05
	Decomposition	$Y = 5.627110 - 5.475538*Phos + 1.514369*(Phos)^2$	.990	<.01
	Growth	No significant relationships		
4	Mortality	No significant relationships		
	Decomposition	No significant relationships		