Nitrogen-fixation rates in brown-rotted wood (soil wood) were shown to be linearly related to moisture contents for a western conifer site. Rates of fixation for this substrate are reported as 273 g N/ha/yr. The potential importance of soil wood in this capacity is noted for dry sites and for dry periods on wet sites. Furthermore, this substrate does not appear to accumulate N beyond ca. 0.6 percent, which appears to be a “steady state” value. It is tentatively concluded that the importance of the contribution of N from \( \text{N}_2 \) fixation in soil wood is similar to that of humus on this site, but is probably outweighed by N inputs from other sources. Functionally, soil wood may be of greater importance if it provides a medium in which a N source is readily available for mycorrhizal feeder roots.
differences between the two substrates. Moisture contents in rotten wood were higher and more stable and only approached the wilting point after an extended dry period.

The purpose of this communication is to evaluate the importance of dinitrogen fixation in brown cubical decayed wood as an integral part of soil profiles in a highly productive ecosystem of the northern Rocky Mountains.

MATERIALS AND METHODS

Study-Site Characterization.—The study area is located at the westernmost extremity of the St. Joe National Forest in the state of Washington on upper Solo Creek, and approximately 26 km northeast of the Priest River Experimental Forest, Idaho.

Elevation of experimental plots is approximately 4,000 feet (1,200 m). They have a northerly aspect and gentle slopes (10 to 20 percent), except Treatment 1, in which the slope is approximately 40 percent. The habitat type (Daubenmire and Daubenmire 1968) is a mosaic of western redcedar/lady fern (*Thuja plicata/Athyrium filix-femina*) and hemlock/Pachistima (*Tsuga heterophylla/Pachistima myrsinites*), indicative of annual precipitation in the range of 60 to 75 cm/year. Stands in the area are judged to be 300 to 400 years old. Merchantable volumes removed during plot establishment were estimated to be 240 m$^3$/ha.

Experimental Procedure.—Four experimental plots approximately 1 to 2 ha each were established within the study area. They are defined by treatment: Treatment 1, conventional utilization, harvested and burned in 1976, with intense fire because of high fuel loadings, duff reduction was readily apparent with much exposed mineral soil, slope 30 to 40 percent; Treatment 2, undisturbed and designated as the control area; Treatment 3, cleared of essentially all woody material except crumbly, brown cubical decayed wood and other organic matter; Treatment 4, representative of conventional utilization, but heavy logging slash not burned.

Four samples each of humus and soil wood were collected with an impact soil sampler (Jurgensen and others 1977) and placed in airtight containers equipped with lids and septa for gas injection. Samples were taken from each plot four times between June 1 and September 30, 1977 (June 20; July 18; August 22; September 29).

Nitrogen fixation rates were estimated using an adaptation of the acetylene reduction technique discussed by Hardy and others (1968). Within 2 hours of sampling, the incubation containers were evacuated and flushed with argon five times and injected with the aid of a syringe with a known volume and concentration of acetylene gas. Samples were incubated in the dark for 24 hours at ambient field temperatures. Final oxygen concentrations in the containers approximated 0.05 percent. Acetylene was omitted from one of four replicates to serve as a control for monitoring endogenous ethylene production; the values obtained for the controls were subtracted from those obtained from samples injected with acetylene. Background ethylene in acetylene gas was also accounted for.

RESULTS AND DISCUSSION

Moisture regimes of soil wood for each treatment are presented in Figure 1 and rates of N$_2$ fixation for humus and soil wood are provided in Figure 2.

Treatment effects on rates of fixation were not demonstrated for either humus or soil wood. No significant differences were detected between the various treatments and this is attributed to data variability (and substrate heterogeneity). However, regression analysis (Fig. 3) of rates of fixation in soil wood in Treatment 1 for all sampling periods showed a positive relationship between fixation rates and moisture contents. Such a relationship could not be demonstrated for other treatments. Similarly, rates from sampling period June 20 for Treatments 1 through 4 for soil humus also showed a positive relationship (Fig. 3) between fixation rates and moisture content.

Restructuring of the data by combining and averaging rate figures for all treatments by sampling periods for both soil wood and humus did yield a significant difference ($P = 0.05$) between these substrates on the August 22 sampling date. This difference appears to be a function of moisture content and indicates that soil wood is potentially more effective than humus as a substrate for N$_2$ fixation. Only when the relative amounts of each substrate and associated moisture contents (Fig. 2) are taken into account is this
FIGURE 1. Mean percent moisture contents of brown-rotted soil wood in experimental plots, Solo Creek, St. Joe National Forest, 1977.


Key
- N Fixation - Humus
- Moisture Content - Humus
- Moisture Content - Soil Wood
- N Fixation - Soil Wood

Date of Sampling
- 6/20
- 7/18
- 8/22
- 9/29

Moles x10^-9 of Dinitrogen Fixed 24 hr. g^-1 Substrate
- 0
- 20
- 40
- 60
- 80
- 100

Percent Moisture Content
- 0
- 50
- 100
- 150
- 200
- 250

(M 148 806)

(M 148 807)
FIGURE 3. Linear relationship between moisture content and nitrogen-fixation rates in humus (upper) and soil wood (lower). Solo Creek, St. Joe National Forest, 1977.

potential realized. On the experimental sites, volumes of soil wood and humus are approximately equal (ca. 50 metric tons ha\(^{-1}\) each). The moisture holding capacities of each are different (soil wood 200 percent, humus 80 percent; significance \(P = 0.001\)). Thus, it appears that soil wood as a substrate for \(N_2\) fixation becomes more important on wet sites only during dry periods during the summer, and on dry sites where humus layers dry out rapidly early in the growing season (also see Harvey and others 1980).

We estimate that 273 g N ha\(^{-1}\) are fixed annually. If existing soil wood persists for an additional 300 years, then potentially 82.5 kg N ha\(^{-1}\) would accrue. These figures assume an average rate of net ethylene measured at \(3 \times 10^{-9}\) moles (or \(28 \times 10^{-9}\) g N fixed) 24 h\(^{-1}\) g\(^{-1}\) odw substrate, 48.75 metric tons of soil wood ha\(^{-1}\) and 200 days of fixation. By comparison, the estimated annual rates of N fixation for humus in the same area is 118 g N ha\(^{-1}\) (assuming net ethylene production of \(1.3 \times 10^{-8}\) moles 24 h\(^{-1}\) g\(^{-1}\) odw substrates).

The rate reported here for soil wood is considerably lower than that reported earlier (Larsen and others 1978) for a site in northwest Montana of \(7 \times 10^{-9}\) moles (65 \(\times 10^{-9}\) g N). However, the Montana value was derived from aboveground decayed woody residues, the principal component being Douglas-fir (\(Pseudotsuga menziesii\) (Mirb.) Franco) which proved to be the most favorable woody substrate for N fixation of those tested. We have observed (unpublished data) that different substrate species, with similar moisture contents, may provide differing fixation rates.

An important aspect of soil wood biology (Harvey and others 1976. 1979) is the notable occurrence of conifer root biomass and ectomycorrhizae in this substrate. This observation lends credence to the view that much of the dinitrogen fixed in soil wood is used for current stand development. Total nitrogen analysis of soil wood indicates that N is not continuously accrued, and that an end point of about 0.6 percent N (Larsen and others 1980) content appears to be a "steady state" value. Sound conifer wood contains approx-
imately 0.045 percent N. Thus, we visualize an eleven- to twelve-fold increase in N content during the decay process leading to brown-rotted wood that functions as a soil medium in a manner similar to humus. We estimate that "decay time" for residues on this site is 150 to 250 years. Thus, larger diameter residues have a potential "residence" time of 300 years or longer.

Though we have not ascertained the relative importance of N from soil wood N\textsubscript{2} fixation directly, we suspect that in this habitat type, particularly during regimes of high moisture availability, it is outweighed by imports from other sources such as precipitation, canopy throughfall, and other sources of N\textsubscript{2} fixation, e.g., phyllosphere (Jones 1969). Therefore, efforts to manage this substrate for N at present do not appear to be warranted in this habitat type. However, soil wood may be of greater importance than indicated by these data if it provides a major source of N to mycorrhizal feeder roots as suggested above.

**LITERATURE CITED**


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