Soil Microbial Activity in Coastal Douglas-fir Forests

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During forest development, carbon fixed by trees accumulates not only in the trees but also as organic matter in detrital pools such as coarse woody debris, the forest floor, and the soil. The amount of carbon in these detrital pools can often exceed that in the living tree biomass (Harmon *et al.* 1986). In the Canadian forest sector carbon budget model, assumptions about the size and dynamics of these pools greatly affects the overall carbon balance (Kurz *et al.* 1992). As well, this detritus contains a significant fraction of the forest's nitrogen, and as stands age a greater fraction can accumulate in the detritus. In some forests where rates of organic matter turnover and nutrient mineralization are especially low, the decrease in nutrient availability has been suggested as the prime cause for the reduction in tree growth as stands mature (Williams 1972).

Other than losses from stand disturbances such as harvesting or fire, carbon is lost from the soil and detrital pools as CO_2, through the respiration of roots and soil organisms (the latter respiring carbon derived from the decomposition of plant detritus). The activity and respiration of roots and soil organisms is controlled primarily by soil temperature and moisture. It has been demonstrated that up to 85% of the variability in soil respiration rates for a specific soil can be accounted for by variations in soil temperature and moisture (Coleman and Sasson 1980). Obviously any large changes in the numbers of roots or soil organisms will also affect rates of soil respiration as well as changes in the amount and kind of detritus available for decomposition by soil organisms (Hendrickson *et al.* 1982).

Soil temperature and moisture are affected by the forest cover—soil temperature through shading, and soil moisture through interception and transpiration. Therefore, in order to relate soil abiotic conditions to climate, functions must be used that account for the effect of the forest cover. Several models for soil moisture and temperature have been developed which use Leaf Area Index (LAI) as the primary variable.

This study has two objectives: 1) to monitor the effects of seasonal weather and stand cover type on soil moisture, temperature, respiration, microbial biomass, and litter decomposition; and 2) to obtain data on soil temperature and moisture under different forest covers for use in fitting an appropriate soil temperature and moisture model. Work will be conducted within plots established in the intensive CWHxm chronosequences (Pollard and Trofymow, in these proceedings).

Site Weather and Stand Conditions

Although it would be ideal to measure weather and soil conditions in all four seres at all three intensive chronosequences (Greater Victoria Watershed South [GVWS], Greater Victoria Watershed North [GVWN], Koksilah) for the entire 3-year study, logistical constraints require an alternative plan. Soil temperature, moisture, and weather measurements using data loggers and electronic sensors will be made for a 3-year period in the regeneration stand at all three locations. Weather data to be collected include daily and monthly air temperature, humidity, precipitation and solar radiation. In successive years, air and soil temperatures and moistures will be measured in the three other seres in a different chronosequence each year. In this way, site differences in weather can be measured over all 3 years while within-year measurements can be used to account for between-sere effects. Initial stand condition information collected as part of the carbon and nutrient survey (Trofymow and Blackwell, in these proceedings) will be supplemented with overstory LAI measurements to be made with a LICOR LAI2000 light ceptometer.

Soil Temperature and Moisture

Monthly monitoring of the four seres will begin with GVWN during 1993/94, GVWS in 1994/95, and Koksilah in 1995/96. Thermistors, soil moisture blocks, and a CR21X data logger will be used to measure air and soil temperatures (two replicate subplots at two soil depths: LFH/soil interface and 50 cm) on a daily maximum, minimum and average basis. Although soil moisture blocks can be monitored continuously, their

calibration requires data from other methods. Thus, in the chronosequence under study the daily soil moisture measurements will be supplemented with monthly measurements of volumetric soil moisture by neutron probe at 10, 20, 40, and 50 cm. Four access tubes, one in each subplot, will be installed in each plot adjacent to areas where soil respiration, microbial biomass, and litter decomposition are being measured.

Soil Respiration and Microbial Biomass

To monitor soil biological activity, soil CO_2 evolution will be measured and related to changes in the seasonal soil moisture and temperature regimes and to stand development. Once a month, at four subplots in each of the four seres under study, CO_2 evolution over a 1-day period will be measured with NaOH base traps. As well, four times a year samples of the forest floor will be taken adjacent to the traps, and the amounts and activity of the heterotrophic populations monitored by substrate-induced respiration and basal respiration using a multichannel IRGA. This technique has recently been applied to forest soils and proved extremely useful in understanding how soils function (Parkinson 1991).

Litter Decomposition

To integrate the effects of stand and site conditions over the 3-year period, a litterbag experiment has been installed in all seres at all three intensive chronosequences. Such a study was also suggested as an important ancillary study during a proposal development workshop for the CIDET experiment (Trofymow, in these proceedings). Two major questions to be addressed by this litterbag study include:

1. What are the effects of stand development on rates of decay? Are the changes in soil temperature and moisture conditions with stand development sufficient to explain variation in rates of decay between stands of different age?
2. What are the effects of stand development on the types of organisms affecting litter decay? Does the abundance and types of decomposing microflora change with stand development? Does the activity and influence of the soil macrofauna change with stand development?

In October 1992, four strings of litterbags were installed in three subplots within each of 12 plots, 4 seres x 3 locations. Two types of litter (Douglas-fir needles and western hemlock wood) and mesh bags (fine mesh - 0.2 x 0.4 mm, coarse mesh - 3.0 x 3.0 mm) were used. Six treatments were included:

- 10-g needles in a fine mesh bag placed on the surface
- 50-g wood block in a fine mesh bag placed on the surface
- 50-g wood block in a coarse mesh bag placed on the surface
- 50-g wood block in a fine mesh bag buried at 10 cm
- 50-g wood block in a coarse mesh bag buried at 10 cm
- coarsely chipped 50g wood block in a fine mesh bag on the surface
- coarsely chipped 50-g wood block in a coarse mesh bag on the surface

Bags will be sampled at 12, 24, 36 and 48 months after placement and mass loss and nutrient content measured. As well estimates of microbial biomass and, if possible, species of colonizing bacteria, fungi, and microarthropods will also be made. In addition to testing for the effects of stand age and microclimate on rates of decay, several other comparisons can be made. The comparison of coarse and fine mesh bags tests for the effects of macrofauna on decomposition; comparison of chipped and unchipped wood tests for the effects of surface area exposure on rates of decay; and comparison of surface and buried wood tests for the effects of microenvironment on decay rates.

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References

Coleman, D.C. and A. Sasson. 1980. Decomposer subsystem. Chapter 7. *In* Grassland, systems analysis and man. IBP 19. A.J. Breymeyer and G.M. Van Dyne (editors). Cambridge Univ. Press. Cambridge, Mass., pp. 609–655.

Harmon, M.E., J.F. Franklin, F.J. Swanson, P. Sollins, S.V. Gregory, J.D. Lattin, N.H. Anderson, S.P. Cline, N.G. Aumen, J.R. Sedell, G.W. Lienkaemper, K. Cromack, Jr., and K.W. Cummins. 1986. Ecology of coarse woody debris in temperate ecosystems. Adv. Ecol. Res. 15:133–302.

Kurz, W.A., M.J. Apps, T.M. Webb, and P.J. McNamee. 1992. The carbon budget of the Canadian forest sector: Phase I. For. Can., Northwest. Reg., Nor. For. Cent., Edmonton, Alta. Inf. Rep. NOR-X-326. 93 p.

Hendrickson, O., J.B. Robinson, and L. Chatarpaul. 1982. The microbiology of forests soils: a literature review. Can. For. Ser., Petawawa National For. Inst. Inf. Rep. PI-X-19. 75 p.

Parkinson, D. 1991. Microbial communities, activity and biomass. *In* Modern techniques in soil ecology. D.A. Crossley, D.C. Coleman, P.F. Hendrix, W. Cheng, D.H. Wright, M.H. Beare and C.A. Edwards (editors). Elsevier, New York, N.Y., pp. 3–34.

Williams, B.L. 1972. Nitrogen mineralization and organic matter decomposition in Scots pine humus. Forestry 45:177–188.