Assessing the Effects of Forestry Practices on Carbon and Nutrient Dynamics in Coastal Forests: An Introduction to Project PC-71-20

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The diverse and highly productive forests of the Pacific and Yukon Region are increasingly being perceived as significant elements of the global biosphere. The forests of British Columbia alone contain 40% of Canada's wood volume (Bonnor 1985). The living carbon reservoir in British Columbia forests is 5 billion tonnes, and could be a major element of Canada's carbon budget (Kurz *et al.* 1992). The use and management of these forests are viewed by some as indicators of national responsibility in the context of the global atmospheric environment.

An understanding of the biological roles of forests and of how they are affected by forestry practices has become a necessity for rational land use decision-making. This is especially evident for coastal forests, where productivity and biomass accumulations are high. Unfortunately, the principles underlying the biological roles of coastal forests are poorly understood. Harvesting, silviculture, and post-harvesting practices strongly influence succession, growth, formation of detritus, and decomposition. These processes determine the organic structure of the forest and are strongly associated with nutrient conservation, the hydrologic cycle, and provision of habitat for a multitude of organisms. It is generally assumed that the productive capacity and biological diversity of a forest diminish with harvest. Less readily acknowledged is the restoration of these values as trees become reestablished, as productivity becomes diffused among more elements of the ecosystem, and as habitat for organisms becomes more diversified. We do know, however, that some sites—especially those with low nutrient capital—are sensitive to disturbance. This has made their capacity to sustain repeated harvest the subject of some concern (Kimmins 1985).

Objective

The overall objective of the project is to establish how attributes of sustainable forestry, specifically nutrient dynamics and carbon retention, are affected by harvesting and other practices; and to identify opportunities for enhancing these attributes through forest management.

Effects of Conversion on Carbon and Nutrient Cycling

Research will proceed through comparative analyses of developmental phases of important coastal forest types, from regeneration to old growth. Much of the initial work is focused on determining the changes in quantity and characteristics of the carbon and nutrient pools. This is being done by measuring and sampling these different pools in sets of chronosequence in the CWHxm and CWHvm biogeoclimatic zones (Pollard and Trofymow, in these proceedings). In each phase investigated, the principal pathways and agents of carbon flux and the magnitude and form of important carbon pools will be determined; initial emphasis will be placed on biological, chemical, and physical factors affecting carbon and nutrient transfers at soil and forest floor levels, and on the changes in stand structure during post-harvest succession. Qualitative and quantitative analyses of variables will define the organic structure of the forest, including habitats and substrates for organisms active in essential ecological processes.

From this information, practical guides will be derived on the changing quantity and form of detrital carbon (including coarse woody debris), carbon retention, changing nutrient availability with forest succession, and other subjects critical to sustainable use of forest resources. Results of the survey of C and N distributions in successional stands will also be used to initialize a dynamic stand carbon and nitrogen cycling model which is being developed to prepare more refined estimates of carbon emissions resulting from the harvest of old-growth forests. Funding for this work is from several sources including ENFOR under its sustainable forests initiative, the FRDA integrated resource management program, and the B.C. Ministry of Forests sustainable environment fund.

Nutrient Cycling in Low-productivity Sites

Much of the project is focused on the effects of conversion of old-growth to second-growth forests. However, the needs of our clients and the expertise we have developed in nutrient cycling, especially of nitrogen, have led us to develop links with other studies concerned with the effects of harvest on the long-term productivity of sensitive, nutrient-poor sites. In coastal forests these sensitive sites are found especially in dry rocky areas in the very dry Coastal Western Hemlock zone (CWHxm) and in the wet, nutrient-poor sites in the very wet hypermaritime Coastal Western Hemlock (CWHvh) zone. Young and immature forests in both these areas have been the subject of several fertilizer research experiments, the results of which have been used to justify and plan operational treatments. Most of the experiments have been empirical growth and yield trials or single tree fertilization trials. Much less is known about the long-term fate of the nitrogen in these systems.

We use N-15 tracer techniques to develop an understanding of the factors that limit N availability in low-productivity sites, including natural nitrogen cycling, the contribution of nitrogen-fixing plants, and the long-term fate and efficacy of nitrogen fertilization. Sampling now in progress of a 10-year study on a young coastal Douglas-fir site at Northwest Bay (Aarnio *et al.*, in these proceedings) will complement studies being completed on the distribution and transformations of N-15 at Shawnigan Lake, the location of the immature plot in the Greater Victoria Watershed North chronosequence. Results of these studies will be applicable to immature Douglas-fir stands in the CWHxm zone. Another study in the CWHvh zone on northern Vancouver Island (Chang, in these proceedings) will examine the effects of nitrogen fertilization and salal competition in old-growth cedar–hemlock cutovers. Funding for these studies has come from FRDA I, FRDA II, WFP and NSERC. Other collaborators include Lincoln University (New Zealand), UBC, and Agriculture Canada.

Methodology Development in Forest Soil Ecosystem Research

While chronosequence studies permit the study of long-term temporal trends of natural successional processes in a relatively short time period, they do have limitations (Cole and van Miegroet 1989). These limitations include differences in site conditions between plots and in initial harvest or disturbance history. A way to compensate for these limitations is to conduct studies of the short-term dynamics of a particular process. Thus, while traditional soil survey techniques are adequate to describe the conditions in the chronosequence plots and the information used to infer how soils change during secondary succession, they are of limited value in describing how soil dynamics change with succession.

Techniques for measuring changes in the dynamics and types of soil carbon and nitrogen pools require continued development. At the Pacific Forestry Centre, our focus has been on developing methods to characterize organic carbon, quantify nitrogen dynamics, and quantify soil microbial activity. Over the past 20 years, development in Nuclear Magnetic Resonance (NMR) spectroscopy has made possible its routine application to a wide array of problems. In particular, C-13 NMR of samples in the solid state offers a simple and powerful approach to characterizing the complex materials encountered in forest ecosystems (Preston and Rusk 1990). Similar advances in the use of N-15 tracer have improved our understanding of soil nitrogen pools and their dynamics. At the Pacific Forestry Centre, N-15 tracers have been carried out for many years and we now have two independent techniques for N-15 analysis: mass spectrometry and optical emission spectrometry. As methods for measuring the microbial biomass of forest soils have improved, so has our understanding of how forests soils function (Parkinson 1991). Two methods that have been successfully adapted to forest soils, and that we now use, are substrate-induced respiration measured with a multichannel IRGA and C14 labelling to differentiate substrate from bulk soil respiration.

References

Bonnor, G.M. 1985. Inventory of forest biomass in Canada. Can. For. Serv., Petawawa National For. Inst., Chalk River, Ont. 63 p.

Cole, D.W. and H. van Miegroet. 1989. Chronosequences: a technique to assess ecosystem dynamics. In: W.J. Dyck and C.A. Mees (editors) Research strategies for long-term site productivity. Proc. IEA/BE A3 workshop, Seattle, Wash., Aug. 1988. IEA/BE A3 Rep. No. 8. For. Res. Inst., New Zealand, Bull. 152., pp. 5–23

Kimmins, J.P. 1985. Future shock in forest yield forecasting: the need for a new approach. For. Chron. 61(6):503–513.

Kurz, W.A., M.J. Apps, T.M. Webb, P.J. McNamee, and T. Lekstrum. 1992. The carbon budget of the Canadian Forest Sector: Phase I. ENFOR Contract Rep., Northern For. Cent., For. Can., Edmonton, Alta. 77 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.

Preston, C. M. and A.C.M. Rusk. 1990. A bibliography of NMR applications for forestry research. Pac. For. Cent. Inf. Rep. BC-X-322, pp. 42.