The Canadian Intersite Decomposition Experiment (CIDET): Long-term Rates of Leaf Litter and Wood Decay

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Introduction

Climate change has the potential to have large impacts upon the continued productivity and health of Canadian forests. Forestry practices can also affect site carbon balances, influencing the amounts of C exchanged with the atmosphere. Currently, several projects are under way to model quantitatively the current and potential changes in the C budgets of Canadian forests (e.g., Kurz *et al.* 1992). To develop the models, published results and expert advice were used to develop algorithms and provide input data. For many of the processes modelled, information was limited. In particular, data on soil processes such as decomposition rates were found lacking in extent and in length. Some forest types have been extensively studied while others have not. More significantly, long-term studies are rare, with most having been for 2–3 years. To overcome this deficiency, a group of researchers was assembled to conduct a long-term intersite decomposition experiment.

Objectives

The objectives of the experiment are five-fold: 1) to provide data on the long-term rates of litter decomposition and nutrient mineralization for a range of forested ecoclimatic regions in Canada; 2) to examine the role substrate quality and climate have on long-term decomposition rates; 3) to examine the relative importance of site factors and microclimate on decay rates; 4) to test the influence that site moisture regimes have on decay rates; and 5) to test specific hypotheses on the patterns of litter decay.

Experimental Design

Ecoclimatic region specific decay rates

To obtain data on long-term decay rates over the broad range of forested ecoclimatic regions, 18 upland and 3 wetland sites were chosen (Figure 1). Sites were selected to be representative of upland forest types for the ecoclimatic region they were within, as well as for proximity to a nearby climatic station and the availability of a site cooperator. At each site, four replicate plots are established with enough bags of 11 standard litter types (Table 1) placed to allow for annual collections for 10 years. The 20 x 20 cm bags are constructed from polypropylene mesh shade cloth with 0.2 x 0.4 mm openings and contain 10 g of litter or a 50 g wood block.

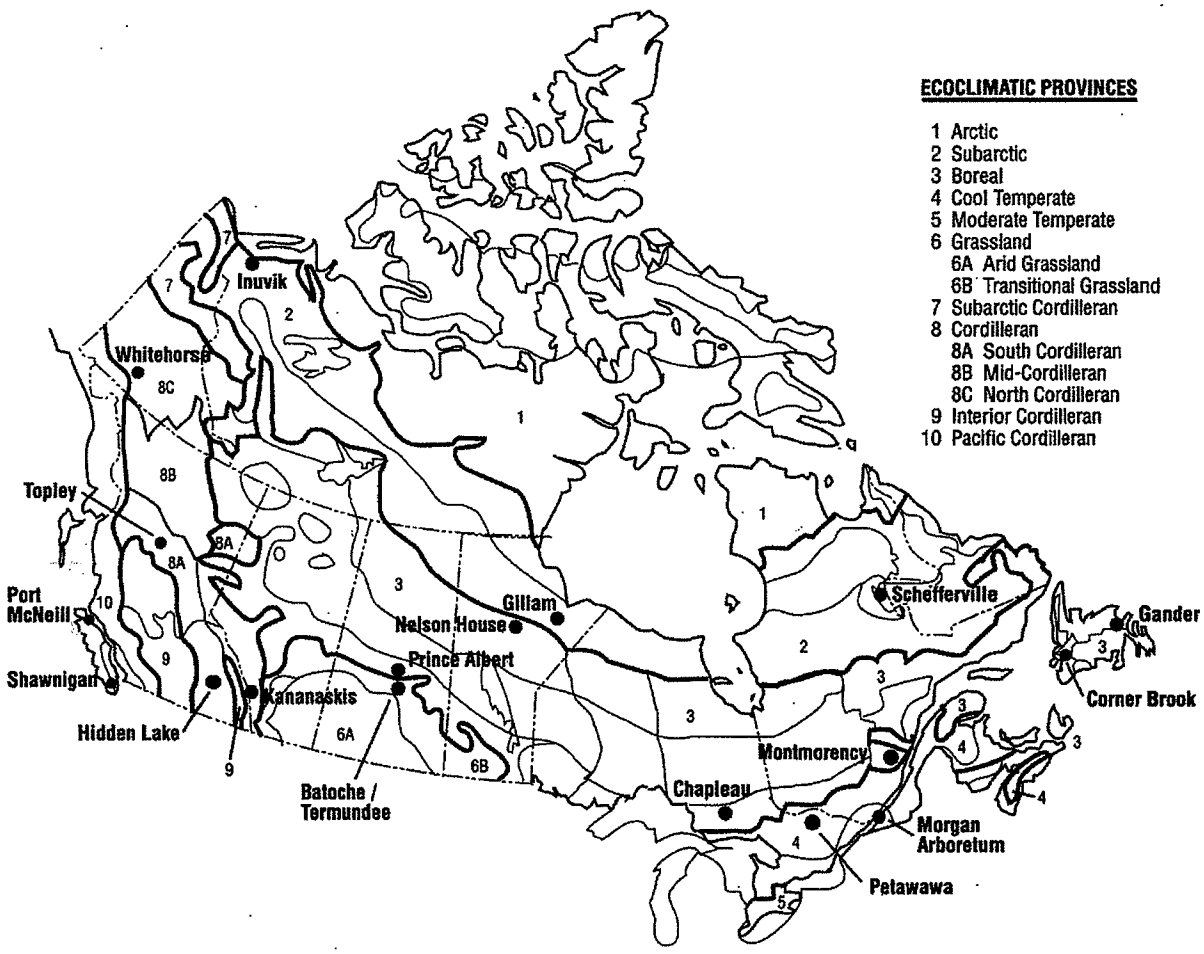

FIGURE 1. Distribution of experimental sites across the ecoclimatic regions of Canada (after Ecoregions Working Group 1989). Batoche/ Termundee, Nelson House and Gillam have paired upland/ wetland sites.

TABLE 1. Litter type and species used in the decomposition experiment

Common name	Binomial	Collector
Leaves		
Aspen	*Populus tremuloides*	Visser
Beech	*Fagus grandifolia*	Fyles
Douglas-fir	*Pseudotsuga menziesii*	Trofymow
Black spruce	*Picea mariana*	Titus
Tamarack	*Larix laricina*	Zoltai
Bracken fern	*Pteridium aquilinum*	Duchesne
Fescue	*Fescue occidentalis*	Monreal
Western redcedar	*Thuja plicata*	Prescott
Jack pine	*Pinus banksiana*	Weber
White birch	*Betula papyrifera*	Titus
Wood		
Western hemlock	*Tsuga heterophylla*	Trofymow

Substrate quality and climate

To extend the results to other regions, decay rates can be related to climate (Bunnell *et al.* 1977; Meentenmeyer 1978) and substrate quality (Melillo *et al.* 1989). Previous studies often confounded the effects of climate and substrate quality because of limitations in the number of substrates or sites used. Regression models will be used to develop a response surface, with measures of substrate quality and climate as independent variables. Dependent variables will include mass remaining, nitrogen content, and the mass loss rate constant. Climatic independent variables include annual temperature, degree days, total precipitation, and actual evapotranspiration. Substrate quality independent variables include lignin/nitrogen ratio, C/N and C/P ratios, extractive content, and fractions of soluble, structural and phenolic C, determined by chemical analysis and ^{13}C NMR.

Microenvironment and site factors

General decomposition models using macroclimate and substrate quality alone can be criticized in that site specific factors may play as large a role in determining decay rates. Regression models will be developed using the dependent variables as above, along with site factor independent variables such as vegetative cover, slope, aspect and soil depth, nutrient contents and concentrations, and microclimate independent variables including soil temperature and moisture.

Site specific moisture regimes

As moisture regimes can greatly affect decay rates, we propose to test for effects of moisture by comparing decay rates at two spatial levels: at the macrosite level by comparing decay rates of all 11 litter types in 3 paired lowland/wetland boreal forest sites, and at the microsite level by comparing the effects of placement, above- or belowground, of wood blocks.

Patterns of litter decay

Results from this experiment can also be used to examine specific models of litter decay. Several groups (Paul and Voroney 1980; Parton *et al.* 1987; Harmon and Melillo 1990) have suggested that as a first approximation, long-term decomposition of fine litter can be described as the sum of exponential decay curves for each different chemical fraction (Soluble, Structural, Lignin), as in the following equation which will be used as a null model in the analysis of the data:

$$Mass(T) = SolubleC * e^{-KfT} + StructuralC * e^{-KsT} + LigninC * e^{-KmT}$$

Temperature and moisture conditions are assumed to influence the rate constants (Kf, Ks, Km). Based on this model, Harmon and Melillo (1990) suggest that the overall decay curve of fine litter can be divided into three phases, each corresponding to the loss of specific litter fractions. We hypothesize that with annual sampling, only two stages of litter decay will be observed, the first corresponding to a combination of phases 1 and 2, and a second corresponding to phase 3. We also hypothesize that exogenous N availability, microclimate, and initial substrate concentrations will affect specific rates of mass loss more in the first stage of decay than in the final stage. Finally, Melillo *et al.* (1989) have hypothesized that a specific ratio (lignin/ lignin+cellulose = 0.5) marks the transition from the first to last stage of litter decay.

Results

Plot establishment and litterbag installations were completed in October, 1992. Soil samples, site descriptions and site maps have been completed for about half the sites, with the remainder to be completed by June 1993. Macronutrient contents, characterization by NMR, and proximate analysis of the 11 litter types will be completed by March 1993.

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