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Post-clearcutting Forest Floor N Dynamics in the CWH Wet Subzone: A Chronosequence Study

Introduction

Numerous studies have shown that forest ecosystems are 'biogeochemically tight' during periods of live biomass accumulation and organic matter accretion, but become 'biogeochemically leaky' for a short period following clearcutting. The timing and magnitude of the so-called 'assart flush' varies considerably for different environments. Few studies have prepared quantitative budgets of post-disturbance organic matter and N losses from the forest floor (FF), or have quantified the fate of the N that is released and its effects on the growth of crop and non-crop vegetation. Mechanisms of nutrient losses have generally focused on the soil NO_3^- leaching—streamflow export pathway and, until recently, there was little consideration of gaseous loss of N via denitrification. The objective of this study was to describe the dynamics and fates of post-clearcutting FF-N in a mid-elevation, humid, west coast, conifer forest, and to assess the importance of the possible gaseous loss of N by microbial denitrification.

Methods

The strategy of the study was to measure the following in an old-growth forest (ca. 400-year-old) and in an adjacent chronosequence of four (3- , 6- , 10- , and 26-year-old) unslashburned clearcut sites (Martin 1985): (1) FF mass, depth, and N content; (2) in situ FF decomposition rates of buried cellulose filter paper; (3) FF moisture, temperature, and pH; (4) in situ FF-N mineralization rates in buried bags; (5) adsorption of soil mineral-N on ion exchange resins (IER); (6) concentrations of inorganic and total N in soil solution; (7) N storage in the mineral soil; and (8) N accumulation in the overstory and understory vegetation. All sites had similar slopes, aspects, and soil characteristics and, according to pre-logging records, the four clearcuts had all carried a relatively uniform old-growth climax forest very similar to that of the old-growth site.

Results and Discussion

A detailed description of the results was given by Martin (1985). Briefly, in the first six years following clearcutting, FF mass and FF N-storage declined by about 33% (112 t ha^{-1} and 1007 kg N ha^{-1} respectively) whereas cellulose decomposition rates increased by about 300%. Thereafter, cellulose decomposition rates decreased, and FF mass and N-storage increased but still remained at about 20% below pre-clearcut values by year 26. The moisture and temperature of the FF were significantly higher in the younger clearcuts than in the old-growth forest, whereas soil pH remained constant across all five sites. In situ soil-N mineralization rates were relatively low in the old-growth plots, increased markedly 3 to 6 years after clearcutting, and gradually decreased afterwards. NO_3^--N adsorption, on IERs placed in the FF and in the mineral soil, was significantly higher in the 3-year-old clearcut than in the other sites. The main vector for N-movement in soil solution below the FF and at 60-cm depth in the mineral soil, was dissolved organic-N (DON). Potential NO_3^--N loss via leaching, calculated from a water balance model and solution concentrations at 60-cm depth, were estimated at about 4 and 3 kg N ha^{-1} yr^{-1} in the 3- and 6-year-old clearcuts respectively, and at less than 0.3 kg N ha^{-1} yr^{-1} in the other sites. The N capital of the mineral soil in the 3- , 6- , and 10-year-old clearcuts was 640, 396, and 23 kg N ha^{-1} higher, respectively, than in the old-growth forest. The N content of understory vegetation increased asymptotically between 3 and 10 years after clearcutting, reaching a maximum

51.1 kg N ha^{-1}. Accumulation of N in coniferous seedling advanced growth was only 54.9 kg N ha^{-1} in the 10-year-old clearcut—suggesting the overstory vegetation was a poor sink for N released during the assart flush—but increased to 632.6 kg N ha^{-1} in the 26-year-old clearcut.

Some of these data were synthesized into a simple model of annual inputs and outputs of N to the forest floor and compared to the actual N capital of the forest floor that was measured using numerous soil cores (Figure 1). The discrepancy between the calculated and measured forest floor N capital was no more than 10% for all sites except for the 6-year-old clearcut site where the model overestimated N capital by 78% (i.e. 1127 kg N ha^{-1}). To explain the fate of this missing N, actual and potential (i.e. Ar + NO_3^- amended) denitrification rates were measured in the old-growth, 3-year-old, and 10-year-old plots using the acetylene inhibition method. Both measured and potential denitrification rates increased after clearcutting. Potential denitrification rates on the 3- and 10-year-old clearcuts were within the same order of magnitude as the amount of N needed to balance the budget on the 6-year-old clearcut. The study offers presumptive evidence in support of the theory that the concomitance of NO_3^- release from the forest floor and microbial denitrification is an important mechanism for N loss during the post-clearcutting assart period. N inputs to the ecosystem by symbiotic or asymbiotic fixation were neither measured, estimated, nor included in this N-budget analysis.

Literature Cited

Martin, W.L. 1985. Post-clearcutting nitrogen dynamics and regeneration response in the coastal western hemlock wet subzone. Dept. For. Sci., Univ. British Columbia, Vancouver. Ph.D. Thesis. 350 p.

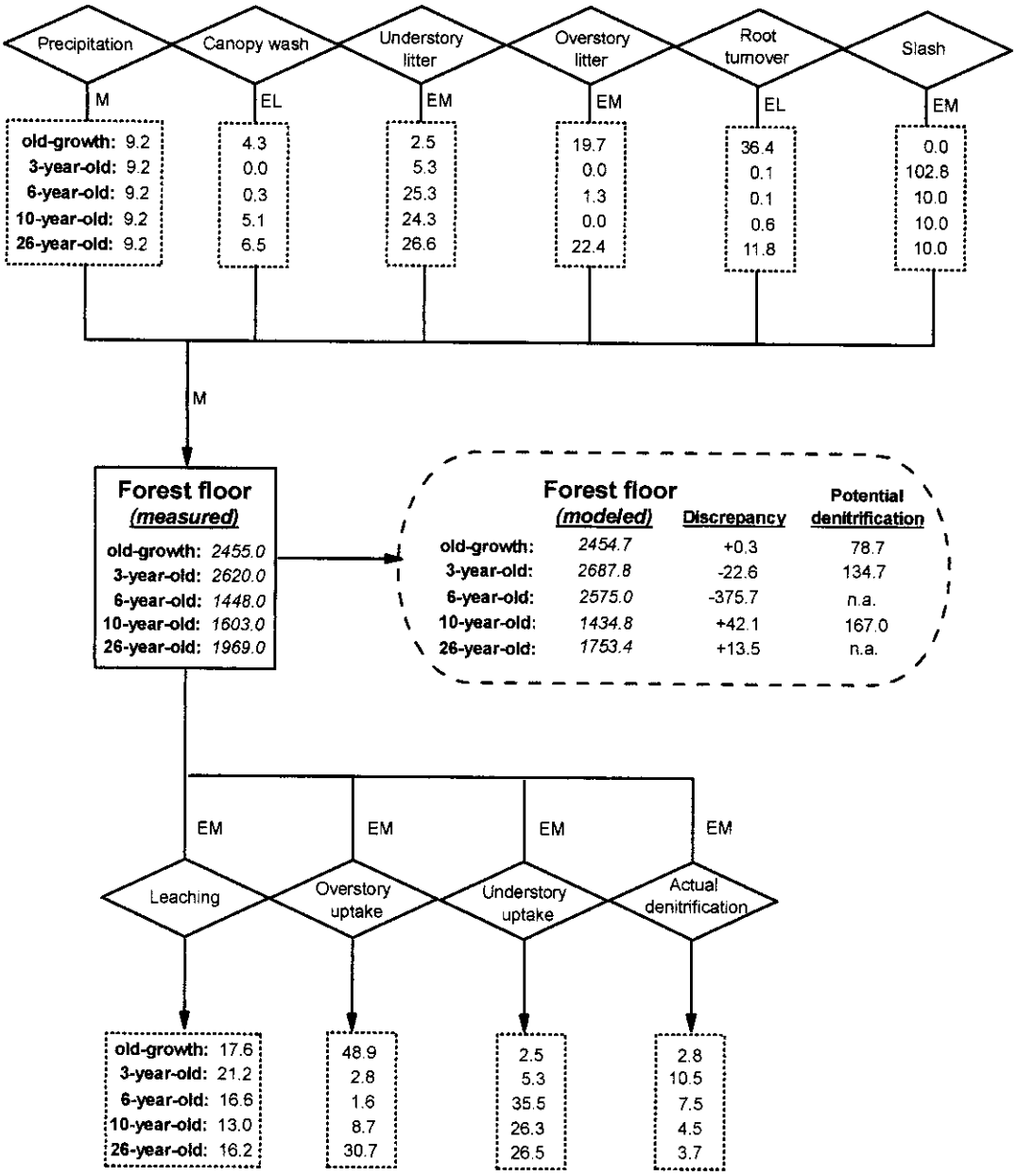

Figure 1. A simple model of annual inputs and outputs of N to the forest floor for the chronosequence of stands examined. M = measured. EM = estimated from measurements. EL = estimated from literature. n.a. = not available. Both measured and modeled forest floor N storage values (in italics) are reported in kg N ha^{-1}; all other values refer to fluxes and are reported in kg N ha^{-1} yr^{-1}. 'Discrepancy' refers to differences between measured and modeled FF-N capital divided by the number of years between adjacent age classes. Actual denitrification rates on the 6- and 26-year-old clearcuts are interpolated from measurement on proximate sites along the chronosequence. For more details, refer to Martin (1985).