Annual Report for Period: 07/2011 - 06/2012
Submitted on: 04/11/2012
Principal Investigator: Rastetter, Edward B.
Award ID: 0949420
Organization: Marine Biological Lab
Submitted By:
Rastetter, Edward - Principal Investigator
Title:
Collaborative Research: Nutrient co-limitation in young and mature northern hardwood forests

Project Participants

Senior Personnel

Name: Rastetter, Edward
Worked for more than 160 Hours: Yes
Contribution to Project:

Post-doc

Graduate Student

Undergraduate Student

Technician, Programmer

Other Participant

Research Experience for Undergraduates

Organizational Partners

Other Collaborators or Contacts

Steven Hamburg of Environmental Defence provided some data acquired while he was still at Brown University; Steve is included as a co author on the upcoming paper.

Activities and Findings

Research and Education Activities: (See PDF version submitted by PI at the end of the report)
see attached file

Findings:
Included in file attached under research and education activities

Training and Development:
To parameterize the MEL model, I have worked closely with R. Quinn Thomas, a graduate student of Christine Goodale's at Cornell University. Based on the graduate student training that has occurred through this project, Quinn is developing a collaboration with Gordon Bonan at National Center of Atmospheric Research to incorporate the resource optimization routine in MEL into the Community Land Model (CLM). The CLM is the land surface model in one of the global climate models (Community Earth System Model) that contributes to the Intergovernmental Panel on Climate Change report. Past work by others with the CLM has shown multiple element interactions (carbon and

nitrogen) to have an important influence on how elevated CO2 affects global climate in the absence of resource optimization. However, the influence of multiple resource optimization on climate change (including water and light in addition to carbon and nitrogen) is unknown, but the model development, parameterization, and application of the MEL model in this project will directly inform the model development needed to address this question.

Outreach Activities:

I gave a lecture on this work at Lehigh University on 6 April 2012 and discussed the work in a Senior Seminar class in Environmental Studies.

Journal Publications

Books or Other One-time Publications

Web/Internet Site

Other Specific Products

Contributions

Contributions within Discipline:

Temperate and boreal forests have long been thought to be N limited. Evidence is accumulating that multiple resources might be limiting including P. These simulations are our first attempts at unraveling the interactions among C, N, P, water, and light in the limitation of growth in northeastern hardwood forests.

Contributions to Other Disciplines:

Contributions to Human Resource Development:

Contributions to Resources for Research and Education:

The modeling approach to resource optimization will be applied more broadly to examine biosphere contributions to regulating global climate. See file attached under research activities.

Contributions Beyond Science and Engineering:

Conference Proceedings

Special Requirements

Special reporting requirements: None

Change in Objectives or Scope: None

Animal, Human Subjects, Biohazards: None

Categories for which nothing is reported:

Organizational Partners

Any Journal

Any Book

Any Web/Internet Site

Any Product

Contributions: To Any Other Disciplines
Contributions: To Any Human Resource Development
Contributions: To Any Beyond Science and Engineering
Any Conference

Activities and Findings 2011:
We have a manuscript 90% ready for submittal based on the modeling work.
Authors: Edward Rastetter, Tim Fahey, Melany Fisk, Steven Hamburg, Bonnie Kwiatkowski, R. Quinn Thomas, Matt Vadeboncoeur, and Ruth Yanai
Proposed venue: Ecological Applications.

A lecture based on this work is now a part of the SES modeling course.

Abstract:

Nitrogen (N) and phosphorus (P) are tightly cycled in most terrestrial ecosystems such that the uptake by plants is more than an order of magnitude higher than the rate of supply from deposition, weathering, and other external sources. This near-total dependence on recycled nutrients and the stoichiometric constraints on resource use by plants and microbes mean that the two cycles have to by closely synchronized. Disturbance can disrupt this synchronization because of a disproportionate loss of one nutrient relative to the other and the change in stoichiometric requirements between young and mature vegetation. We use a biogeochemical model to examine the resynchronization of the N and P cycles following harvest of a northeastern hardwood forest. We conclude that the loss of nutrient s in the harvest is small relative to the post-harvest losses associated with a low N:P ratio in the post harvest residue relative to the soil. This low N:P ratio results in a preferential soil release of P and retention of N. The P release is in excess of plant requirements and P is lost from the ecosystem early in succession. Because the external P supply is o slow, the resynchronization of the N and P cycles later in succession is achieved by a commensurate loss of N. Through succession the ecosystem undergoes a period of N limitation, P limitation, and eventually co-limitation as the two cycles resynchronize. However, the overall rate and extent of recovery should be limited by P unless a mechanism exists to prevent the P loss early in succession (e.g., a P store not stoichiometrically constrained by N) or to increase the supply of P to the ecosystem later in succession (e.g., biologically enhanced weathering of apatite).

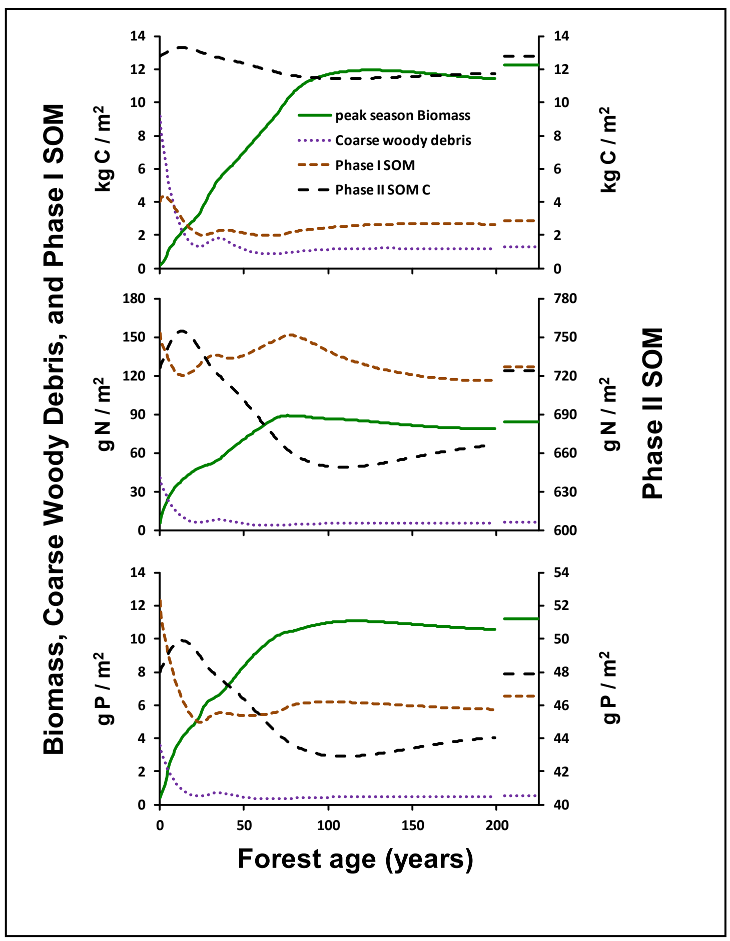

Figure 1: Simulated recovery from a bole-only harvest. Biomass recovery is

fueled predominantly by nutrients derived from sources within the ecosystem. During early succession, those nutrients come from the coarse and fine slash left as coarse woody debris and phase I soil organic matter (SOM). During mid to late succession, the nutrients come from older phase II SOM. During early succession, Phase II SOM serves as a "capacitor" storing nutrients that are used later in recovery.

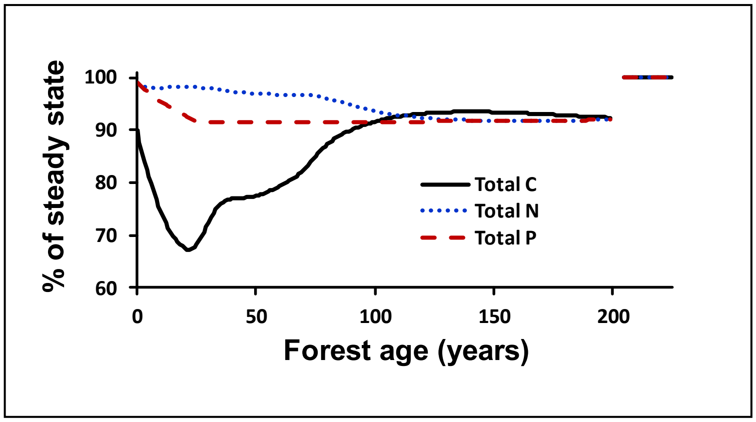

Figure 2: Total-ecosystem element budget following a bole-only harvest. About 10% of the C and 1% of the N & P are removed at harvest. Most of the C, N, & P losses are during the post-harvest recovery, first of C & P and much later by N. The C is easily recovered from a readily available outside source, N & P are not. The early P loss is necessary to resynchronize the early-succession N and P cycles. The later N loss is necessary to resynchronize the late-succession N and P cycles.