Annual Report for Period: 01/2008 - 12/2008
Submitted on: 10/21/2008
Principal Investigator: Fahey, Timothy J.
Award ID: 0423259
Organization: Cornell University State
Submitted By:
Fahey, Timothy - Principal Investigator
Title:
Long-Term Ecological Research (LTER) at Hubbard Brook Experimental Forest (HBR-LTER)

Project Participants

Senior Personnel

Name: Fahey, Timothy
Worked for more than 160 Hours: Yes
Contribution to Project:
Co-PI at Cornell University studying soil and root work.

Name: Driscoll, Charles
Worked for more than 160 Hours: Yes
Contribution to Project:
Co-PI at Syracuse University studying solution chemistry and modelling work.

Name: Groffman, Peter
Worked for more than 160 Hours: Yes
Contribution to Project:
Co-PI at Institute of Ecosystem Studies studying microbial ecology.

Name: Johnson, Christopher
Worked for more than 160 Hours: Yes
Contribution to Project:
Co-PI studying soil chemistry.

Name: Fisk, Melany
Worked for more than 160 Hours: Yes
Contribution to Project:
Co-PI at Appalachian University studying soil fungi.

Name: Ollinger, Scott
Worked for more than 160 Hours: Yes
Contribution to Project:
Co-PI at University of New Hampshire studying remote sensing and ecosystem modeling.

Name: Aber, John
Worked for more than 160 Hours: Yes
Contribution to Project:
Co-PI at University of New Hampshire studying ecosystem modelling.

Name: Martin, Mary
Worked for more than 160 Hours: Yes
Contribution to Project:
Co-PI at University of New Hampshire studying ecosystem modelling.

Name: Likens, Gene
Worked for more than 160 Hours: Yes
Contribution to Project:
Co-PI at Institute of Ecosystem Studies studying watershed dynamics.

Name: Battles, John
Worked for more than 160 Hours: Yes
Contribution to Project:
Co-PI at University of California-Berkeley studying vegetation dynamics.

Name: Joel, Blum
Worked for more than 160 Hours: Yes
Contribution to Project:
Co-PI at University of Michigan studying soil geochemistry.

Name: Lovett, Gary
Worked for more than 160 Hours: Yes
Contribution to Project:
Co-PI at Institute of Ecosystem Studies studying beech bark disease.

Name: Arthur, Mary
Worked for more than 160 Hours: Yes
Contribution to Project:
Co-PI at University of Kentucy studying beech bark disease.

Name: Fitzhugh, Ross
Worked for more than 160 Hours: Yes
Contribution to Project:
Co-PI at University of Illinois studying beech bark disease.

Name: Siccama, Thomas
Worked for more than 160 Hours: Yes
Contribution to Project:
Co-PI at Yale University studying vegetation ecology.

Name: Rodenhouse, Nicholas
Worked for more than 160 Hours: Yes
Contribution to Project:
Senior personnel at Wellesley College studying heterotroph populations.

Name: Mitchell, Myron
Worked for more than 160 Hours: Yes
Contribution to Project:
Co-PI at SUNY-ESF working on biogeochemistry with a particular focus on sulfate isotopes and climate change.

Name: Hamburg, Steven
Worked for more than 160 Hours: Yes
Contribution to Project:
Hamburg is Co-PI at Brown University working on land-use history and biogeochemistry.

Name: Richardson, Andrew
Worked for more than 160 Hours: Yes
Contribution to Project:
Dr. Richardson, University of New Hampshire, is a colleague of Dr. Scott Ollinger, studying carbon cycling and phenology.

Name: Gleason, Jamie
Worked for more than 160 Hours: Yes
Contribution to Project:
Jamie Gleason is a research scientist who worked on Ca isotope and Sr isotope analyses on the project.

Post-doc

Name: Cleavitt, Natalie

Worked for more than 160 Hours: Yes

Contribution to Project:

Post-doc with Fahey studying bryophytes and lichens.

Name: Wu, Wei

Worked for more than 160 Hours: Yes

Contribution to Project:

Wei Wu is a post-doc with Driscoll at Syracuse University applying the model PnET-BGC to investigate the response of forests and surface waters to changes in air pollution

Name: Lowe, Winsor

Worked for more than 160 Hours: Yes

Contribution to Project:

postdoctoral associate with Likens at IES; worked on salamanders in the HBEF.

Name: Bade, Darren

Worked for more than 160 Hours: Yes

Contribution to Project:

a postdoctoral associate with Likens at IES; worked on the biogeochemistry of Mirror Lake.

Name: Judd, Kristin

Worked for more than 160 Hours: Yes

Contribution to Project:

postdoctoral associate, with Likens at IES; worked on the biogeochemical interface between streams and uplands in the HBEF.

Name: Nezat, Carmen

Worked for more than 160 Hours: Yes

Contribution to Project:

Carmen Nezat moved from graduate student to postdoctoral fellow status in 2006-2007. In Fall 2007, she started as faculty at Eastern Washington University. In 2008, Carmen continued to work on publishing results from HB, but she is no longer receiving financial support on the project.

Name: Betts, Matthew

Worked for more than 160 Hours: Yes

Contribution to Project:

Matt lead the crew, including Adam, Mike and Benjamin, that conducted the valley-wide bird surveys and completed the beech-bark disease survey.

Name: Kiekbusch, Jana

Worked for more than 160 Hours: Yes

Contribution to Project:

Jana Kiekbusch is a post doctoral research associate with Charles Driscoll in the Department of Civil and Environmental Engineering at Syracuse University. She is working on evaluating critical loads of acidic deposition.

Graduate Student

Name: Christenson, Lynn

Worked for more than 160 Hours: Yes

Contribution to Project:

Ph.D. student at SUNY-ESF with Groffman and Mitchell studying moose and microbiology.

Name: Kulkarni, Madhura

Worked for more than 160 Hours: Yes

Contribution to Project:
PhD student at Cornell University (with Groffman) studying denitrification.

Name: Cho, Youngil

Worked for more than 160 Hours: Yes

Contribution to Project:
Youngil Cho is a Ph.D student with Johnson in Department of Civil Engineering at Syracuse University. He is evaluating the response of soil, soil solutions and streamwater to the wollastonite treatment.

Name: Fashu-Kanu, Samuel

Worked for more than 160 Hours: Yes

Contribution to Project:
Samuel Fashu-Kanu is a Ph.D student with Driscoll in Dept. of Civil Engineering at Syracuse University. He is evaluating soil solution response to soil freezing events.

Name: Naples, Brendan

Worked for more than 160 Hours: Yes

Contribution to Project:
Naples is a MS student at Appalachian State University. He is characterizing the soil fungal response to variations in local nutrient availability in several mature (70 year-old) and young (30 year-old) hardwood forest stands. He has completed an experiment in which soils amended with nitrogen, phosphorus, or calcium were incubated for one growing season to allow ingrowth of roots and fungi. He is now analyzing the fungal communities using a terminal restriction fragment length polymorphism (TRFLP) approach with the ITS region of the fungal rDNA genes.

Name: Littell, Aaron

Worked for more than 160 Hours: Yes

Contribution to Project:
Littell is a MS student at Appalachian State University. His thesis project tests patterns of fungal colonization and community development on decomposing fine roots. He trenched forest plots in 2003 to kill fine roots and has used TRFLP to analyze the fungal communities on these roots through summer 2005. Aaron is now writing his thesis.

Name: Dasch, Amanda

Worked for more than 160 Hours: Yes

Contribution to Project:
PhD candidate at University of Michigan, working with Blum; BA from Amherst College. PhD research on the uptake of alkaline earth elements by trees and their response to Ca fertilization at Hubbard Brook.

Name: Nezat, Carmen

Worked for more than 160 Hours: Yes

Contribution to Project:
Research assistant and PhD candidate at University of Michigan with Blum; BA from Univ of Lousiana. PhD research on the interaction between mycorrhizae and mineral weathering in soils at Hubbard Brook.

Name: Masters, Mike

Worked for more than 160 Hours: Yes

Contribution to Project:
Graduate research assistant, MS program in Plant Biology at University of Illinois with Fitzhugh

Name: Burke, Joshua

Worked for more than 160 Hours: Yes

Contribution to Project:
Joshua Burke is a Master's student at University of Illinois working on the relationship between soil chemistry and root chemistry in the Hubbard Brook Valley.

Name: Keller, Katy

Worked for more than 160 Hours: Yes

Contribution to Project:
Katy Keller worked on this project as a research assistant, but not as a part of her dissertation research.

Name: Miles, Gretchen
Worked for more than 160 Hours: Yes
Contribution to Project:
M.S. student at SUNY-ESF with Mitchell studying biogeochemistry on sulfur using sulfate isotopes.

Name: Solmonoff, Natalie
Worked for more than 160 Hours: Yes
Contribution to Project:
Natalie is an PhD student and crew leader working with John Battles at UC Berkeley. She has been researching the spatial and temporal changes in forest composition and biomass in Hubbard Brook Valley. This summer she started collecting data for a PhD dissertation, which will in part quantify neighborhood dynamics in Hubbard Brook Valley.

Name: Biasioli, Traynor
Worked for more than 160 Hours: Yes
Contribution to Project:
Tray was primarily responsible for banding male and female Black-throated Blue Warbler for the long-term demographic study.

Name: Kang, Phil-Goo
Worked for more than 160 Hours: Yes
Contribution to Project:
Mr. Kang began work in Fall 2007 working on aspects of sulfur biogeochemistry at Hubbard Brook. Mr. Kang is from Korea.

Name: Werner, Nicole
Worked for more than 160 Hours: Yes
Contribution to Project:
Nicole is a doctoral student in the Forest and Natural Resources Departmenat at SUNY-ESF. She attended the HB Cooperators Meeting in the first year of her studies.

Name: Pourmokhtarian, Afshin
Worked for more than 160 Hours: Yes
Contribution to Project:
Afshin Pourmokhtarian is a Ph.D. student with Charles Driscoll in the Department of Civil and Environmental Engineering at Syracuse University. He is working on climate change effects on soil and stream chemistry.

Name: Wang, Liang
Worked for more than 160 Hours: Yes
Contribution to Project:
Liang Wang is a M.S. student with Charles Driscoll in the Department of Civil and Environmental Engineering at Syracuse University. He is evaluating soil and stream response to air pollution controls.

Name: Yandik, William
Worked for more than 160 Hours: Yes
Contribution to Project:
Mr. Yandik is a MA student at Brown University with Steve Hamburg. Mr. Yandik is studying the effects of land use history and climate change on bird populations in Grafton County.

Name: Riechel, Celia
Worked for more than 160 Hours: Yes
Contribution to Project:
Ms. Riechel is a MA student at Brown University with Steve Hamburg. Ms. Riechel is studying the role of land owner demography in determining land fragmentation in Grafton County.

Name: Stange, Erik
Worked for more than 160 Hours: Yes

Contribution to Project:

Erik Stange is a Ph.D. at Wellesley College working on the studies of Lepidoptera population dynamics.

Name: Werner, Samuel

Worked for more than 160 Hours: Yes

Contribution to Project:

Samuel Werner is a M.S. student with Charles Driscoll in the Department of Civil and Environmental Engineering at Syracuse University. He is working on soil-stream atmosphere dynamics.

Undergraduate Student

Name: Sargent, Shavonne

Worked for more than 160 Hours: Yes

Contribution to Project:

Shavonne returned to Hubbard Brook as a field technician working with Tim Fahey at Cornell. She resuveyed Valley plots, mapped trees in the demography plot, collected soil samples and tagged trees in W1. She also helped enter data into a database.

Name: Minick, Kevan

Worked for more than 160 Hours: Yes

Contribution to Project:

Minick is an undergraduate student in the Biology Department at Appalachian State Univeristy. He is developing a sequence database of the ITS region of fungal rDNA genes, needed for our work on soil and fine root fungal communities. He has created clone libraries from soil and fine root DNA extracts and prepared representative clones for sequencing. He has also carried out restriction fragment length polymorphism analyses for our fungal fruitbody collection and is using these to match known fruitbodies with sequences from our database of fungal DNA.

Name: Lide, William

Worked for more than 160 Hours: Yes

Contribution to Project:

Lide is an undergraduate student in the Biology Department at Appalachian State University. He is testing root length and enzyme activity (phosphatases, lignin oxidases) responses to variations in local nutrient availability, as part of the ingrowth experiment carried out by Brendan Naples.

Name: Kies, Antonietta

Worked for more than 160 Hours: Yes

Contribution to Project:

Undergraduate employee assisting with management of environmental and ecological data and distribution via the Hubbard Brook web site.

Name: Nathan, Mayda

Worked for more than 160 Hours: Yes

Contribution to Project:

Mayda Nathan served as a research assistant at Wellesly College and assisted on the studies of Lepidoptera population dynamics.

Name: Eby-Bosler, Devin

Worked for more than 160 Hours: Yes

Contribution to Project:

Devin worked with Rodenhouse at Wellesley College. He conducted point counts of birds and when the point counts were completed, he assisted with the survey of beech bark disease.

Name: Eby-Bosler, Justin

Worked for more than 160 Hours: Yes

Contribution to Project:

Justin worked with Rodenhouse at Wellesley College. He conducted point counts of birds and when the point counts were completed, he assisted with the survey of beech bark disease.

Name: Griffith, Benjamin

Worked for more than 160 Hours: Yes

Contribution to Project:

Benjamin conducted point-counts of birds for half of the period of employment. When the point counts were completed, he assisted with the survey of beech bark disease.

Name: Cosentino, Brad

Worked for more than 160 Hours: Yes

Contribution to Project:

Research Support specialist with Likens at IES; worked on salamanders in the HBEF.

Name: Green, Brian

Worked for more than 160 Hours: Yes

Contribution to Project:

Research Support specialist with Likens at IES also worked on salamanders in the HBEF.

Name: Collins, Andrew

Worked for more than 160 Hours: Yes

Contribution to Project:

Collins worked with Battles at UC Berkley; as field technician revisited 203 plots and collected data pertaining to tree growth, species composition, mortality and recruitment.

Name: Manion, Caitlin

Worked for more than 160 Hours: Yes

Contribution to Project:

Caitlin Manion worked as field technician with Battles at UC Berkeley and revisited 203 plots and collected data pertaining to tree growth, species composition, mortality and recruitment.

Name: Manion, Meghan

Worked for more than 160 Hours: Yes

Contribution to Project:

Meghan Manion, BS student at Cornell University: as field technician at UC Berkeley, revisited 203 plots and collected data pertaining to tree growth, species composition, mortality and recruitment.

Name: Serlen, Rachel

Worked for more than 160 Hours: Yes

Contribution to Project:

Serlen worked with Battles at UC-Berkley as field technician and revisited 203 plots and collected data pertaining to tree growth, species composition, mortality and recruitment.

Name: Yee, Suk-Ann

Worked for more than 160 Hours: Yes

Contribution to Project:

Yee worked as a field technician with Battles at UC Berkely; revisited 203 plots and collected data pertaining to tree growth, species composition, mortality and recruitment.

Name: DeJaegher, Lewis

Worked for more than 160 Hours: Yes

Contribution to Project:

Undergraduate research assistant, BS program in Integrative Biology at University of Illinois with Fitzhugh.

Name: Steinweg, Megan

Worked for more than 160 Hours: Yes

Contribution to Project:

Steinweg received her undergraduate degree from the Biology Department at Appalachian State University in May, 2005. She quantified the effects of soil freezing on soil aggregate size distributions and particulate organic matter for her undergraduate honor's thesis.

Name: Worsham, Sara

Worked for more than 160 Hours: Yes

Contribution to Project:

Sara is working on the project for a senior honors thesis.

Name: Fahey, Cathy

Worked for more than 160 Hours: Yes

Contribution to Project:

Cathy Fahey worked as a field technician with Tim Fahey at Cornell. She surveyed Valley plots, mapped trees in the demography plot, collected soil samples and tagged trees in W1. She also helped enter the Valley data into a database.

Name: Johnson, Sam

Worked for more than 160 Hours: Yes

Contribution to Project:

Sam Johnson worked as a field technician with John battles at Berkeley. He led the W1 tree tagged inventory project and participated in the Valley plot resurveys, mapping project and soil sampling of W1. He also helped enter the W1 data into a database.

Name: Kaczowsky, Debra

Worked for more than 160 Hours: Yes

Contribution to Project:

Debra worked as a field technician with Tom Siccama at Yale. She resurveyed Valley plots, mapped trees in the demography plot, collected soil samples and tagged trees in W1. She helped enter the soil and mapping data into a database.

Name: Kelsen, Sarah

Worked for more than 160 Hours: Yes

Contribution to Project:

Sarah was a Binghamton University undergraduate student (now at SUNY-ESF); she worked as a field technician with Chris Johnson (Syracuse University) at Hubbard Brook in Summer 2006. She resurveyed Valley plots, mapped trees in the demography plot, collected soil samples and tagged trees in W1. In addition, she helped enter the Valley tree data into a database.

Name: Laua, Tami

Worked for more than 160 Hours: Yes

Contribution to Project:

Tami worked as a field technician with John Battles at Berkeley. She resurveyed Valley plots, mapped trees in the demography plot, collected soil samples and tagged trees in W1. She also helped enter W1 data into datbase.

Name: Lavalee, Jocelyn Marie

Worked for more than 160 Hours: Yes

Contribution to Project:

Jocelyn worked as a field technician with Tim Fahey at Cornell. She resurveyed Valley plots, mapped trees in the demography plot, collected soil samples and tagged trees in W1. She also helped enter Valley data into a database.

Name: Danyluk, Casey

Worked for more than 160 Hours: Yes

Contribution to Project:

Casey assisted Ph.D. candidate, Erik Strange, on the studies of Lepidoptera population dynamics.

Name: Harvey, Michael

Worked for more than 160 Hours: Yes

Contribution to Project:

Mike conducted point-counts of birds.

Name: Hausladen, Debra

Worked for more than 160 Hours: Yes

Contribution to Project:

Debra weighed malaise trap samples, entered those data, and organized the malaise trap samples and database.

Name: Bradford, Jonelle

Worked for more than 160 Hours: Yes

Contribution to Project:

Jonelle sorted litter samples to identify and count seeds of mast-bearing trees.

Name: Kelley, Elizabeth

Worked for more than 160 Hours: Yes

Contribution to Project:

Elizabeth assisted with data entry and verification.

Name: Ciurej, Katherine

Worked for more than 160 Hours: Yes

Contribution to Project:

Katherine assisted with sorting litter samples, weighing Malaise trap samples and exmained nests for evidence of botfly ectoparasites.

Name: Wallach, Leah

Worked for more than 160 Hours: Yes

Contribution to Project:

Wallach is an undergraduate student in the Biology Department at Appalachian State University studying soil microbial responses to calcium and phosphorus.

Name: Meyer, Natacha

Worked for more than 160 Hours: Yes

Contribution to Project:

Natacha is a Brown University student who monitored snail populations on W6 and W1.

Name: Feeser, Russell

Worked for more than 160 Hours: Yes

Contribution to Project:

Russell is a Rochester Institute of Technology student who worked on black locust influence on forest structure.

Name: Eaton, Derek

Worked for more than 160 Hours: Yes

Contribution to Project:

Name: Austin, Kemen

Worked for more than 160 Hours: Yes

Contribution to Project:

Kemen is a Brown University student who examined soil C changes associated with home construction around Hubbard Brook (senior thesis project).

Name: Fuller, Christopher

Worked for more than 160 Hours: Yes

Contribution to Project:

Christopher is a Brown University student who worked on soil carbon changes following abandonment of agricultural lands -- a 25 y retrospective.

Name: Tang, Christina

Worked for more than 160 Hours: Yes

Contribution to Project:

Christina is a Brown University student who assisted with sample processing in the lab.

Name: Anderson, Christa

Worked for more than 160 Hours: Yes

Contribution to Project:
Christa worked on the field crew of PI Thomas Siccama (Yale)in the summer of 2007. Christa graduated from Yale in May 2007 and will return for her Master's in 2008.

Name: O'Neill, William

Worked for more than 160 Hours: Yes

Contribution to Project:
Bill is an undergraduate student in the Environmental and Forest Biology Department at SUNY-ESF. He has been sorting and verifying samples collected by Farrah Fatemi.

Name: Deull, David

Worked for more than 160 Hours: Yes

Contribution to Project:
David served as a summer assistant to Will Yandik, graduate student at Brown University.

Name: Burkhardt, Jennifer

Worked for more than 160 Hours: Yes

Contribution to Project:
Jennifer assisted Ph.D. candidate Erik Stange on the studies of Lepidoptera population dynamics during summer 2007.

Name: Sheridan, Caroline

Worked for more than 160 Hours: Yes

Contribution to Project:
Caroline, under the direction of PI, Nicholas Rodenhouse at Wellesley College, sorted litter samples to identify and count seeds of mast-bearing trees during the academic year.

Name: Wyman, Katherine

Worked for more than 160 Hours: Yes

Contribution to Project:
Katherine worked at Wellesley College under the direction of PI, Nicholas Rodenhouse. She weighed malaise trap samples and entered those data; sorted litter samples to identify and count seeds of mast-bearing trees and assisted with data entry and verification during the academic year.

Name: Schneider, Rachel

Worked for more than 160 Hours: Yes

Contribution to Project:
Rachel worked with PI, N. Rodenhouse, at Wellesley College assisting with data entry and verification during the academic year.

Name: Foley, Catherine

Worked for more than 160 Hours: Yes

Contribution to Project:
Catherine worked with PI, N. Rodenhouse, at Wellesley College weighing malaise trap samples; assisted with data entry and verification during the academic year.

Name: Baumgartner, Alice

Worked for more than 160 Hours: Yes

Contribution to Project:
Alice was hired as a field technician through Tom Siccama at Yale University. She resurveyed the Valley-wide tagged-tree inventory, mapped and cored trees in the demography plot, conducted a moose density survey and tagged trees for the fertilization 'Shoestring' project. In addition, she entered data into a database and completed quality control checks on the entered data.

Name: Rudstam, Per

Worked for more than 160 Hours: Yes

Contribution to Project:
Per Rudstam was hired through Tim Fahey at Cornell University. He helped with the resurvey of the Valley plots. He mapped trees in the demography plot and entered the data into a database. He also completed quality control checks on the entered data.

Name: Tane, Zachary

Worked for more than 160 Hours: Yes

Contribution to Project:

Zachary worked as a field technician for John Battles (UC Berkeley). He resurveyed Valley plots, mapped and cored trees in the demography plot, conducted a moose density survey and tagged trees for the fertilization 'Shoestrong' project. In addition, he entered data into a database and performed quality control checks.

Name: Shafer, Devaja

Worked for more than 160 Hours: Yes

Contribution to Project:

Devaja Shafer sorted litter samples to identify and count seeds of mast-bearing trees, weighed malaise trap samples; assisted with data entry and verification during the academic year.

Name: Mallama, Celeste

Worked for more than 160 Hours: Yes

Contribution to Project:

Celeste Mallama began pilot study of the spatial distribution and abundance of vespid wasps across the elevation gradient within the HBEF.

Name: Stenquist, Asha

Worked for more than 160 Hours: Yes

Contribution to Project:

Asha Stenquist began a pilot study on the use of digitally recorded song as a method of surveying forest bird abundance.

Name: Wright, Charles

Worked for more than 160 Hours: Yes

Contribution to Project:

Mr. Wright conducted point counts of birds and assisted with vegetation sampling during summer 2007.

Technician, Programmer

Name: Martel, Lisa

Worked for more than 160 Hours: Yes

Contribution to Project:

Martel: technician based at Hubbard Brook in summer, IES in winter. Does field and laboratory analysis associated with long-term monitoring of microbial biomass and activity.

Name: Lewis, David

Worked for more than 160 Hours: Yes

Contribution to Project:

Lewis: technician based at Institute of Ecosystem Studies. Does laboratory analysis associated with long-term monitoring of microbial biomass and activity, specializing in gas chromatography.

Name: Koppers, Mary Margaret

Worked for more than 160 Hours: Yes

Contribution to Project:

Mary Margaret Koppers is a technician examining soil chemistry at Syracuse University.

Name: Fuss, Colin

Worked for more than 160 Hours: Yes

Contribution to Project:

Colin Fuss is studying long term soil solution and stream chemistry patterns at Syracuse University.

Name: Montesdeoca, Mario

Worked for more than 160 Hours: Yes

Contribution to Project:

Mario Montesdeoca supervises laboratory activities at Syracuse University, Department of Civil Engineering.

Name: Day, Michelle

Worked for more than 160 Hours: Yes

Contribution to Project:

Research technician at University of New Hampshire working on remote sensing and carbon cycling.

Name: Jessen, Brita

Worked for more than 160 Hours: Yes

Contribution to Project:

Brita (working with Rodenhouse at Wellesley College) weighed malaise trap samples, entered those data, and organized the malaise trap samples and database for the period late 1970s to the present.

Name: Webster, Raymond

Worked for more than 160 Hours: Yes

Contribution to Project:

Ray (working with Rodenhouse at Wellesley College)lead the crew of undergraduates conducting the valley wide bird census and the beech bark disease survey.

Name: Simon, Katherine

Worked for more than 160 Hours: Yes

Contribution to Project:

Kate (working with Rodenhouse at Wellesley College) lead the crew that carried out demographic studies of Black-throated Blue Warbler on the Ridge plot.

Name: Andrikova, Irina

Worked for more than 160 Hours: Yes

Contribution to Project:

Laboratory technician responsible for soil and vegetation extractions and digestions, analysis of soil, vegetation and streamwater for major and trace elements by ICP-OES, and Sr isotope separations and analysis by TIMS.

Name: Mellen, Brent

Worked for more than 160 Hours: Yes

Contribution to Project:

Brent Mellen is a technician at Institute of Ecosystem Studies responsible for the field sampling and chenmical analysis of soils associated with the Hubbard Brook 'valley-wide' watershed analysis project at Hubbard Brook. He has also been managing the dataset on valley-wide stream chemistry and watershed characteristics.

Name: Juice, Stephanie

Worked for more than 160 Hours: Yes

Contribution to Project:

Stephen worked on long-term analysis of microbial biomass and activity and how this responds to calcium additions.

Name: Ward, Margaret

Worked for more than 160 Hours: Yes

Contribution to Project:

Margaret Ward is a technician at IES who is working on the beech bark disease project.

Name: Hoskinson, Sarah

Worked for more than 160 Hours: Yes

Contribution to Project:

Sarah Hoskinson is a temporary project assistant at IES who worked in the summer and fall of 2006 on the beech bark disease project.

Name: Pudner, Rebecca

Worked for more than 160 Hours: Yes

Contribution to Project:
Rebecca Pudner is a project assistant at University of Kentucky who worked during the summer of 2006 on the beech bark disease project.

Name: Prescott, Howard
Worked for more than 160 Hours: Yes
Contribution to Project:
Howard worked as a field technician with Tim Fahey at Cornell. He resurveyed Valley plots, mapped trees in the demography plot, collected soil samples and tagged trees in W1. He also performed quality control checks on data entered into databases.

Name: Hadley, Adam
Worked for more than 160 Hours: Yes
Contribution to Project:
Adam conducted point counts of birds.

Name: Vadeboncoeur, Matthew
Worked for more than 160 Hours: Yes
Contribution to Project:
Matthew is employed through Brown University, under the direction of PI Steven Hamburg, to oversee LAI, snail and soil C field work and data analysis.

Name: Oakley, Clinton
Worked for more than 160 Hours: Yes
Contribution to Project:
Clinton is employed through Brown University, under the direction of PI Steven Hamburg, to process soil samples in the laboratory.

Name: Buso, Donald
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Minicucci, Brenda
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Starr, Emily
Worked for more than 160 Hours: Yes
Contribution to Project:
Under the direction of PI, Peter Groffman, Emily did field sampling at HBR, lab work at both HBR and IES.

Name: Schmidt, Robin
Worked for more than 160 Hours: Yes
Contribution to Project:
Under the direction of PI, Peter Groffman, Robin did field sampling at HBR and lab work at both HBR and IES.

Name: Brennan, Peter
Worked for more than 160 Hours: Yes
Contribution to Project:
Mr. Brennan worked as a research assistant at Brown University (part-time).

Name: Wiedman, Toni
Worked for more than 160 Hours: Yes
Contribution to Project:

Under the direction of PI, N. Rodenhouse (Wellesley College), Toni conducted point counts of birds and assisted with vegetation sampling during summer 2007.

Name: Smith, Megan

Worked for more than 160 Hours: Yes

Contribution to Project:

Under the direction of PI, N. Rodenhouse (Wellesley College), Megan conducted point counts of birds and assisted with vegetation sampling during summer 2007.

Name: Whidden, Erin

Worked for more than 160 Hours: Yes

Contribution to Project:

Under the direction of PI, N. Rodenhouse (Wellesley College), Erin conducted point counts of birds and assisted with vegetation sampling during summer 2007.

Name: Wilson, Geoff

Worked for more than 160 Hours: Yes

Contribution to Project:

Geoff Wilson coordinated the undergraduate research program, which included undergraduates supported by an REU site grant administered through Plymouth State University, as well as undergraduates supported by the REU supplements on the LTER grant and undergraduates with Hubbard Brook Consortium support.

Name: McGarry, Mary Ann

Worked for more than 160 Hours: Yes

Contribution to Project:

Mary Ann McGarry is the Education Director for the Hubbard Brook Research Foundation. She worked on school and teacher outreach and curriculum development. Also Director of Hubbard Brook's Environmental Literacy Program (ELP).

Name: Worsham, Sara

Worked for more than 160 Hours: Yes

Contribution to Project:

Sara Worsham finished as an undergraduate thesis student and became a technician on the project conducting geochemical analyses.

Name: Ratliff, Tera

Worked for more than 160 Hours: Yes

Contribution to Project:

Ratliff is a graduate of Miami University currently working as a technician on projects studying nutrient limitation of microbial activity, fine root responses to nutrients, and soil fungal communities.

Other Participant

Name: Kaczowski, Debra

Worked for more than 160 Hours: Yes

Contribution to Project:

Debra is a May 2006 graduate from Mass. College of Liberal Arts in Williamstown, Massachusetts. Her work was on the Hubbard Brook field crew which involved several projects specifically related to the work of Thomas Siccama (Yale) -- mainly the collection and preliminary processing (drying) of the quantitative forest floor 5-year sampling from W1- the Ca addition watershed and secondly the measuring and tagging of the ~8000 trees on W1 as part of the 5-year reinventory of the forest.

Name: Likens, Phyllis

Worked for more than 160 Hours: Yes

Contribution to Project:

Phyllis provides administrative support for the programs of Dr. Gene Likens (co-PI) at Institute of Ecosystem Studies.

Name: Wu, Wei

Worked for more than 160 Hours: Yes

Contribution to Project:
Wei Wu is a Research Associate working PI Driscoll at Syracuse University applying the model PnET-BGC to investigate the response of forests and surface waters to changes in air pollution.

Name: Gontarz, Gerald
Worked for more than 160 Hours: Yes
Contribution to Project:
Gerald worked on the Mirror Lake website for elementary and junior high school students.

Research Experience for Undergraduates

Name: Mayack, Christopher
Worked for more than 160 Hours: Yes
Contribution to Project:
Mayack was an IES REU student, who worked on fish parasites in Mirror Lake.

Years of schooling completed: Freshman
Home Institution: Same as Research Site
Home Institution if Other:
Home Institution Highest Degree Granted(in fields supported by NSF): Bachelor's Degree
Fiscal year(s) REU Participant supported: 2005
REU Funding: REU site award

Name: Bouchard, Krystle
Worked for more than 160 Hours: Yes
Contribution to Project:
Bouchard was an IES REU student, who worked on phytoplankton productivity in Mirror Lake.

Years of schooling completed: Freshman
Home Institution: Same as Research Site
Home Institution if Other:
Home Institution Highest Degree Granted(in fields supported by NSF): Bachelor's Degree
Fiscal year(s) REU Participant supported: 2005
REU Funding: REU site award

Name: Dorovskoy, Pavel
Worked for more than 160 Hours: Yes
Contribution to Project:
Pavel Dorovsky is an undergraduate student at the University of New Hampshire majoring in computer science. Pavel did research on wireless sensor networks and helped establish the current network at Hubbard Brook. He also worked on a web interface for displaying real-time data.

Years of schooling completed: Sophomore
Home Institution: Same as Research Site
Home Institution if Other: University of New Hampshire
Home Institution Highest Degree Granted(in fields supported by NSF): Bachelor's Degree
Fiscal year(s) REU Participant supported: 2006
REU Funding: REU supplement

Name: Wollenburg, Stephan
Worked for more than 160 Hours: Yes
Contribution to Project:
Stephan is a Brown University student (hired as an REU through Brown, supplement through SUNY ESF) who helped monitor changes in LAI.

Years of schooling completed: Sophomore

Home Institution: Same as Research Site

Home Institution if Other: Brown University

Home Institution Highest Degree Granted(in fields supported by NSF): Bachelor's Degree

Fiscal year(s) REU Participant supported: 2006

REU Funding: REU supplement

Name: Berwick, Rebecca

Worked for more than 160 Hours: Yes

Contribution to Project:

Rebecca is a Brown University student (hired as an REU through Cornell University supplement)who monitored LAI changes.

Years of schooling completed: Sophomore

Home Institution: Same as Research Site

Home Institution if Other: Brown University

Home Institution Highest Degree Granted(in fields supported by NSF): Bachelor's Degree

Fiscal year(s) REU Participant supported: 2006

REU Funding: REU supplement

Name: Powell, Sylvia

Worked for more than 160 Hours: Yes

Contribution to Project:

Sylvia worked on the stream salamander project in the Hubbard Brook Experimental Forest.

Years of schooling completed: Freshman

Home Institution: Other than Research Site

Home Institution if Other: Institute of Ecosystem Studies

Home Institution Highest Degree Granted(in fields supported by NSF): Bachelor's Degree

Fiscal year(s) REU Participant supported: 2007

REU Funding: REU supplement

Name: Little, Neith

Worked for more than 160 Hours: Yes

Contribution to Project:

Neith worked on the stream salamander project in the Hubbard Brook Expermental Forest.

Years of schooling completed: Freshman

Home Institution: Other than Research Site

Home Institution if Other: Institute of Ecosystem Studies

Home Institution Highest Degree Granted(in fields supported by NSF): Bachelor's Degree

Fiscal year(s) REU Participant supported: 2007

REU Funding: REU supplement

Name: Lide, William

Worked for more than 160 Hours: Yes

Contribution to Project:

Under the direction of PI, Melany Fisk (Appalachian State University), William identified fine roots of trees based on DNA sequence information to contribute to a project comparing root depth distributions of different tree species.

Years of schooling completed: Junior

Home Institution: Same as Research Site

Home Institution if Other:

Home Institution Highest Degree Granted(in fields supported by NSF): Doctoral Degree

Fiscal year(s) REU Participant supported: 2007

REU Funding: REU supplement

Name: Hunter, Erin

Worked for more than 160 Hours: Yes

Contribution to Project:

Erin Hunter is an undergraduate in Environmental Engineering in the Department of Civil and Environmental Engineering at Syracuse University. She is evaluating throughfall and stream chemistry of watershed calcium treatment.

Years of schooling completed: Junior

Home Institution: Same as Research Site

Home Institution if Other: Syracuse University

Home Institution Highest Degree Granted(in fields supported by NSF): Doctoral Degree

Fiscal year(s) REU Participant supported: 2007

REU Funding: REU supplement

Name: Metcalf, Cassidy

Worked for more than 160 Hours: Yes

Contribution to Project:

Cassidy is a summer 2007 REU participant -- worked on characterizing vegetation among differing land-use histories in Grafton County.

Years of schooling completed: Junior

Home Institution: Same as Research Site

Home Institution if Other:

Home Institution Highest Degree Granted(in fields supported by NSF): Doctoral Degree

Fiscal year(s) REU Participant supported: 2007

REU Funding: REU supplement

Name: Wheat, Ian

Worked for more than 160 Hours: Yes

Contribution to Project:

Ian was a participant in the Hubbard Brook Undergraduate Research Program and worked with John Battles and Tim Fahey on Beech Bark disease effects on Beech sprout and seed reproduction. He also partner with the Society for the Protection of New Hampshire Forests, a non-profit, to do an outreach project on carbon sequestration.

Years of schooling completed: Junior

Home Institution: Other than Research Site

Home Institution if Other: Dartmouth College

Home Institution Highest Degree Granted(in fields supported by NSF): Doctoral Degree

Fiscal year(s) REU Participant supported: 2008

REU Funding: REU supplement

Name: Santangelo, Sharon

Worked for more than 160 Hours: Yes

Contribution to Project:

Santangelo is an undergraduate in the Microbiology Department at Miami University. She is studying soil nutrient availability and limitations to soil microbial activity in young and old forests.

Years of schooling completed: Sophomore

Home Institution: Other than Research Site

Home Institution if Other: Miami University

Home Institution Highest Degree Granted(in fields supported by NSF): Bachelor's Degree

Fiscal year(s) REU Participant supported: 2008

REU Funding: REU supplement

Organizational Partners

University of California - Berkeley

Institute of Ecosystem Studies

Wellesley College

University of New Hampshire

Appalachian State University

Syracuse University

University of Michigan

Brown University

University of Kentucky

University of Illinois

SUNY Environmental Science & Forestry

Yale University

Hubbard Brook Research Foundation
This 'Friends' group helps fund and run our facilities, outreach and educational programs.

Other Collaborators or Contacts

Dr. Scott Bailey, USDA Forest Service
Dr. Emily Bernhardt, Duke University
Dr. Daniel Conley, National Environmental Research Institute, Roskilde, Denmark
Dr. Tom Winter, US Geological Survey
Dr. Christine Goodale, Cornell University
Dr. Joseph Yavitt, Cornell University
Dr. Clifford Kraft, Cornell University
Dr. Lars Hedin, Princeton University
Dr. Laura Schneider, Rutgers University
Dr. Jamie Shanley, USGS
Dr. Winsor Lowe, University of Montana
Dr. Mary Arthur, University of Kentucky
Dr. Pam Templer, Boston University

Activities and Findings

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

Findings: (See PDF version submitted by PI at the end of the report)
See attached file.

Training and Development:

TRAINING AND DEVELOPMENT 2008: The senior scientists in our project take very seriously the responsibility and opportunity of training and development for junior colleagues, and we take pride in their professional accomplishments and career advancement. We utilize a variety of formal and informal approaches to accomplish this goal. In particular, training and development at Hubbard Brook relies on the active interactions among PIs and senior scientists, junior researchers, post-docs, graduate students and undergraduates and technicians. These interactions are fostered by frequent formal and informal events that encourage both cross-disciplinary discussions and communication and learning across the academic hierarchy: the HBES Cooperators' Meeting, weekly science nights at our dormitory, Pleasant View Farm (PVF), weekly potluck dinners at PVF, quarterly LTER planning meetings at the Institute of Ecosystem Studies. We believe that the potentially debilitating separation that comes with the distribution of our project among a dozen institutions actually has proven to stimulate a higher level of interaction among all levels of our project because we must actively promote communication and training. In addition, the remoteness of our site from our academic institutions results in the concentration of intellectual activity while scientists are on-site away from their routine obligations.

During the past year we embarked on a new dimension of undergraduate research training in the form of a NSF Research Experiences for Undergraduates site project. This program provides an exceptional opportunity for interaction between senior scientists, junior scientists and students in the HBR LTER. Our REU project fosters a combination of scientific discovery and public outreach, as described below. The active involvement of a dozen senior scientists as well as post-docs, graduate students and technicians in the REU project has been both a boon to student learning and to scientific interaction within the overall LTER program. We hope to continue this training and development enterprise in the indefinite future.

Outreach Activities:

OUTREACH ACTIVITIES: 2008

The Hubbard Brook LTER project has an extremely active program of outreach and public education activities, coordinated through the Hubbard Brook Research Foundation (HBRF). Outlets of these activities include: 1) a new undergraduate research program emphasizing science outreach by matching students with management agencies and non-profits engaged with the public on ecosystem-related issues, as well as with researchers for a separate independent research project 2) our Environmental Literacy Program (ELP), which is a cooperative effort with the USDA-Forest Service aimed at supporting secondary science teachers through training events and the development of teaching resources, as well as direct student contact with neighboring schools, 3) posting of related educational-support material on our web page (www.hubbardbrook.org), 4) cooperation with other regional groups engaged in secondary education teacher development, 5) presentations of research findings in formats and at forums for general audiences, 6) discussions of research findings with reporters and policymakers, and 7) conducting field trips at the site for visiting schools and the general public.

Undergraduate Research Program: In 2008 we initiated an undergraduate research program titled 'Investigating and Communicating Change in Ecosystems.' Eleven undergraduates from around the country were paired with Hubbard Brook researchers and developed and conducted independent research projects on topics representing the range of research at the Hubbard Brook LTER. In addition, the students were matched with government management agencies and non-profits engaged in translating ecosystem concepts to general audiences. Students designed and produced projects such as brochures, posters, and web content at the request of their partner organization with the aim of aiding that organization's mission of public engagement. Partners included: The USDA-Forest Service, the Natural Resource Conservation Service, the U.S. Geological Survey, the New Hampshire Department of Environmental Services, The Society for the Protection of New Hampshire Forests, The Margaret and H.A. Rey Center, Plymouth State University's Center for the Environment, and the Squam Lakes Natural Science Center.

Environmental Literacy Program (ELP): ELP is a joint project of the HBRF and the USDA Forest Service Northern Research Station to use ecological knowledge to promote informed decision-making for a sustainable future. ELP focuses on middle- and high school teachers and their students through the following three programs:

Science Links teaching guides: The first Science Links teaching guide, Exploring Acid Rain, was completed in 2007. It is available electronically by request and work is underway to make it web-accessible. The second teaching guide, Mystery Migratory Birds, Here in the Summer, Where in the Winter?, is a collaboration with the Smithsonian Institution and is also complete. Both are supported by teacher workshops, on-going interactions with HBRF staff, and a wiki-site (http://hbrf.pbwiki.com/) for teachers and HBRF educators.

Teacher training events: We held three teacher workshops focusing on Acid Rain and the use of Exploring Acid Rain in the classroom, as well as two events showcasing Mystery Migratory Birds. The acid rain workshops were attended by 30 science teachers and the migratory birds workshops were attended by 16. All were aimed at middle- and high school teachers.

School partnerships: We are currently actively involved with six schools in the region, in addition to the schools which visit us for tours (described below). Our regional partner schools are: LinWood School (k-12), Campton Elementary, Plymouth Elementary, Profile School (6-12); Littleton High School (9-12), and Plymouth Regional High School (9-12). Together these represent the 4 school districts closest to Hubbard Brook.

Other K-12 support activities: We are a partner with A Forest For Every Classroom, New Hampshire (FFEC). FFEC is a year-long professional development course conducted in collaboration with HBRF, Project Learning Tree, the USDA Forest Service White Mountain National Forest, USDA Forest Service State and Private Forestry, the National Wildlife Federation, and Plymouth State University. Workshops are held at Hubbard Brook facilities and Hubbard Brook staff give presentations and conduct skill-building sessions. Teachers write curriculum units based on the FFEC program as final projects and these are made available for use by other teachers. Additionally, HBRF and USDA Forest Service staff give elementary and secondary school tours of the site upon request.

Presentation of research findings for general audiences:

In addition to tours conducted at Hubbard Brook, scientists and staff have presented research findings to general and non-scientific audiences throughout 2007-8. Organizations included: the International Society of Arboriculture; the Pemigewasset chapter of the National Audubon Society, and a Symposium on Migratory Birds held in cooperation with Plymouth State University and attended by over 80 members of the general public.

Another major public education program in the HBR-LTER is Science Links. Together with experts from other institutions, LTER scientists translate scientific information from the HBES and related research projects for policymakers at regional and national levels. In 2008 we continued to work on the fourth major Science Links project, a regional analysis of carbon sources, sinks, and mitigation strategies. In conjunction with colleagues from the BES, HFR and PIE LTER sites, we are comparing the costs and potential for C emission reductions across several regional settings.

We produced a major public report in 2008 on the effects of air pollution on ecosystems, entitled 'Threats from Above: Air Pollution Impacts of Ecosystems and Biological Diversity in the Eastern United States.' Hubbard Brook Co-PI Gary Lovett is the lead author and PI Charles Driscoll is a contributor to the report, which draws heavily on past Hubbard Brook research and synthesis studies, and represents a collaboration with The Nature Conservancy, the nation's largest conservation organization. The report summarizes the effects of four air pollutants -- sulfur, nitrogen, mercury and ozoneùon major ecosystem types in the eastern U.S. and calls for adoption of a 'critical loads' approach to assessing air pollution damage and for strengthened long-term monitoring programs. The report received significant attention by traditional and web-based media, and was the basis for a two-day series of meetings by Lovett and Nature Conservancy staff with Congressional offices in July 2008. A copy of the report is available at www.ecostudies.org/threats_from_above.pdf.

We also completed two smaller Science Links projects in 2008. The first completed was a project on Long-term monitoring. The products consisted of a synthesis article in Frontiers in Ecology and a professionally formatted and printed version of GTR NRS-17, Long-term Trends from Ecosystem Research at the Hubbard Brook Experimental Forest (Campbell et al, 2007). Both were used as support documents for outreach visits with policymakers. Also completed was a project conducted in collaboration with colleagues from Sweden applying the European forest ecosystem model, ForSAFE, to data from the HBES.

Journal Publications

Rhoads, A.G., S.P. Hamburg, T.J. Fahey, T.G. Siccama and R. Kobe., "Comparing direct and indirect methods of assessing canopy structure in a northern hardwood forest.", Can. J. For. Res., p. 584, vol. 34, (2004). Published,

Fahey, T.J., G.L. Tierney, R.D. Fitzhugh and G.F. Wilson. 2005., "Soil Respiration and Soil Carbon Balance in a Northern Hardwood Forest Ecosystem.", Can. J. For. Res., p. 244, vol. 35, (2005). Published,

Fahey, T.J. and J.B. Yavitt., "An in situ Approach for Measuring Root-Associated Respiration and Nitrate Uptake of Forest Trees.", Plant and Soil, p. 125, vol. 272, (2005). Published,

Phillips, R.P. and T.J. Fahey., "Patterns of rhizosphere carbon flux in sugar maple (Acer saccharum) and yellow birch (Betula allegheniensis) saplings.", Global Change Biology, p. 983, vol. 11, (2005). Published,

Campbell, J.L., J.W. Hornbeck, M.J. Mitchell, M.B. Adams, M.S. Castro, C.T. Driscoll, J.S. Kahl, J.N. Kochenderfer, G.E. Likens, J.A. Lynch, P.S. Murdoch, S.J. Nelson and J.B. Shanley., "Input-output budgets of inorganic nitrogen for 24 forest watersheds in the northeastern United States.", Water Air Soil Pollut., p. 373, vol. 151, (2004). Published,

Groffman, P.M., C.T. Driscoll, G.E. Likens, T.J. Fahey, R.T. Holmes, C. Eagar and J.D. Aber., "Nor gloom of night: a new conceptual model for the Hubbard Brook Ecosystem Study.", BioScience., p. 139, vol. 54, (2004). Published,

Johnson, C.E., R.J. Smernik, T.G. Siccama, D.M. Keimle, Z. Xu, and D.J. Vogt., "Using 13C nuclear magnetic resonance spectroscopy for the study of northern hardwood tissues.", Can. J. For. Res., p. 1821, vol. 35, (2005). Published,

Peters, S., J. Blum, C.T. Driscoll and G.E. Likens., "Dissolution of wollastonite during the experimental manipulation of Hubbard Brook Watershed 1.", Biogeochemistry, p. 309, vol. 67, (2004). Published,

Palmer, S.M., C.T. Driscoll and C.E. Johnson., "Long-term trends in soil solution and stream water chemistry at the Hubbard Brook Experimental Forest: relationship with landscape position.", Biogeochemistry, p. 51, vol. 68, (2004). Published,

Whitall, D., M. Castro and C. Driscoll., "Evaluation of management strategies for reducing nitrogen loadings to four U.S. estuaries.", Sci. Total Environ., p. 25, vol. 333, (2004). Published,

Wellington, B.I. and C.T. Driscoll., "The episodic acidification of a stream with elevated concentrations of dissolved organic carbon.", Hydrol. Proc., p. 2663, vol. 18, (2004). Published,

Palmer, S.M., B.I. Wellington, C.E. Johnson and C.T. Driscoll., "Landscape influences on aluminum and dissolved organic carbon in streams draining the Hubbard Brook valley, New Hampshire, USA.", Hydrol. Proc., p. 1751, vol. 19, (2005). Published,

Warby, R.A.F., C.E. Johnson, and C.T. Driscoll., "Chemical recovery of surface waters across the northeastern U.S. from reduced inputs of acidic deposition: 1984-2001.", Environ. Sci. Technol., p. 6548, vol. 39, (2005). Published,

Ollinger, S.V., "Biodiversity and Ecosystem Function in Forests. Review of: Forest diversity and function: temperate and boreal systems. Scherer-Lorenzen, Michael, Christian Körner, and Ernst-Detlef Schulze, editors.", Ecology., p. 2256, vol. 86 (8), (2005). Published,

Turner, D.P, S.V. Ollinger and J.S. Kimball., "Integrating Remote Sensing and Ecosystem Process Models for Landscape to Regional Scale Analysis of the Carbon Cycle.", BioScience., p. 573, vol. 54(6), (2004). Published,

Turner, D.P., S.V. Ollinger, M.L. Smith, O. Krankina and M. Gregory., "Scaling net primary production to a MODIS footprint in support of earth observing system product validation.", International Journal of Remote Sensing., p. 1961, vol. 25(10), (2004). Published,

Melany C. Fisk, Will R. Kessler, Ava Goodale, Timothy J. Fahey,
Peter M. Groffman, and Charles T. Driscoll., "Landscape variation in microarthropod response to calcium addition in a northern hardwood forest.", Pedobiologia., p. 69, vol. 50, (2006). Published,

Fisk, M.C., T.J. Fahey and P.M. Groffman., "Carbon resources, soil organisms, and nitrogen availability: landscape patterns in a northern hardwood forest.", Ecology, p. , vol. , ( ). Submitted,

Doran, P. J., and R. T. Holmes., "Habitat occupancy patterns of a forest dwelling songbird: causes and consequences.", Canadian Journal of Zoology, p. 1297, vol. 83, (2005). Published,

Ellison, AM, MS Bank, BD Clinton, EA Colburn, K Elliot, CR Ford, DR Foster, BD Kloeppel, JC Knoepp, GM Lovett, J Mohan, DA Orwig, NL Rodenhouse, WV Sobczak, KA Stinson, JK Stone, CM Swan, J Thompson, B Von Holle, and JR Webster., "Loss of foundation species: consequences for the structure and dynamics of forested ecosystems.", Frontiers in Ecology and Environment., p. 479, vol. 9, (2005). Published,

Holmes, R.T., N. L. Rodenhouse and T. S. Sillett., "Black-throated Blue Warbler (Dendroica caerulescens). The Birds of North America Online

(A. Poole, Ed.).", Ithaca: Cornell Laboratory of Ornithology; Retrieved from The Birds of North American Online database: http://bna.birds.cornell.edu/BNA/account/Black-throated_Blue_Warbler/doi:10.2173/bna.87, p. 0, vol. , (2005). Published,

Bernhardt, E. S. and G. E. Likens., "Controls on periphyton biomass in heterotrophic streams.", Freshwater Biology, p. 14, vol. 49, (2004). Published,

Campbell, J. L., J. W. Hornbeck, M. J. Mitchell, M. B. Adams, M. S. Castro, C. T. Driscoll, J. S. Kahl, J. N. Kochenderfer, G. E. Likens, J. A. Lynch, P. S. Murdoch, S. J. Nelson, J.B. Shanley., "Input-output budgets of inorganic nitrogen for 24 forest watersheds in the Northeastern United States: A review.", Water, Air, & Soil Pollution, p. 373, vol. 151, (2004). Published,

Groffman, P. M., C. T. Driscoll, C. Eagar, M. C. Fisk, T. J. Fahey, R. T. Holmes, G. E. Likens and L. Pardo., "A new governance structure for the Hubbard Brook Ecosystem Study.", Bull. Ecol. Soc. Amer., p. 139, vol. 85(1), (2004). Published,

Likens, G. E. 2004., "Some opportunities and challenges for the future.", Water, Air and Soil Pollution: Focus, p. 5, vol. 4(2-3), (2004). Published,

Likens, G.E., "Some perspectives on long-term biogeochemical research from the Hubbard Brook Ecosystem Study.", Ecology, p. 2355, vol. 85(9), (2004). Published,

Likens, G. E., B. K. Dresser and D. C. Buso., "Short-term, temperature response in forest floor and soil to ice storm disturbance in a northern hardwood forest.", Northern Journal of Applied Forestry, p. 209, vol. 21(4), (2004). Published,

Likens, G. E., D. C. Buso, B. K. Dresser, E. S. Bernhardt, R. O. Hall, Jr., K. H. Macneale and S. W. Bailey., "Buffering an acidic stream in New Hampshire with a silicate mineral.", Restoration Ecology, p. 419, vol. 12(3), (2004). Published,

Macneale, K. H., B. L. Peckarsky and G. E. Likens., "Contradictory results from different methods for measuring direction of insect flight.", Freshwater Biology, p. 1260, vol. 49, (2004). Published,

Peters, S. C., J. D. Blum, C. T. Driscoll and G. E. Likens., "Dissolution of wollastonite during the experimental manipulation of Hubbard Brook Watershed 1.", Biogeochemistry, p. 309, vol. 67, (2004). Published,

Bernhardt, E. S., G. E. Likens, R. O. Hall, Jr., D. C. Buso, S. G. Fisher, T. M. Burton, J. L. Meyer, W. H. McDowell, M. S. Mayer, W. B. Bowden, S.E.G. Findlay, K. H. Macneale, R. S. Stelzer and W. H. Lowe., "Can't see the forest for the stream? In-stream processing and terrestrial nitrogen exports.", BioScience., p. 219, vol. 55(3), (2005). Published,

Butler, T. J., G. E. Likens, F. M. Vermeylen and B.J.B. Stunder., "The impact of changing nitrogen oxide emissions on wet and dry nitrogen deposition in the northeastern USA.", Atmospheric Environment., p. 4851, vol. 39, (2005). Published,

Kaushal, S. S., P. M. Groffman, G. E. Likens, K. T. Belt, W. P. Stack, V. R. Kelly, L. E. Band and G. T. Fisher., "Increased salinization of fresh water in the northeastern United States.", Proc. National Academy of Sciences, p. 13517, vol. 102(38), (2005). Published,

Likens, G. E., D. C. Buso and T. J. Butler., "Long-term relationships between SO2 and NOX emissions and SO42- and NO3- concentration in bulk deposition at the Hubbard Brook Experimental Forest, New Hampshire.", J. Environ. Monitoring, p. 964, vol. 7(10), (2005). Published,

Lovett, G. M., G. E. Likens, D. C. Buso, C. T. Driscoll and S. W. Bailey., "The biogeochemistry of chlorine at Hubbard Brook, New Hampshire, USA.", Biogeochemistry, p. 191, vol. 72, (2005). Published,

Lowe, W. and G.E. Likens., "Moving headwater streams to the head of the class.", BioScience, p. 196, vol. 55(3), (2005). Published,

Lowe, W. H., K. H. Nislow and G. E. Likens., "Forest structure and stream salamander diets: implications for terrestrial-aquatic connectivity.", Verh. Internat. Verein. Limnol., p. 279, vol. 29(1), (2005). Published,

Macneale, K. H., B. L. Peckarsky and G. E. Likens., "Stable isotopes identify dispersal patterns of stonefly populations living along stream corridors.", Freshwater Biology., p. 11178, vol. 50, (2005). Published,

Nezat, C.A., Blum, J.D. Klaue, A., Johnson, C.E., and Siccama, T.G., "Influence of landscape position and vegetation on long-term weathering rates at Hubbard Brook, New Hampshire, USA.", Geochimica et Cosmochimica Acta., p. 3065, vol. 68, (2004). Published,

Peters, S.C., Blum, J.D., Driscoll, C.T. and Likens, G.E., "Dissolution of wollastonite during the experimental manipulation of a forested catchment.", Biogeochemistry., p. 309, vol. 67, (2004). Published,

Anderson, S.P., Blum, J.D., Brandtley, S.L., Chadwick, O., Chorover, J., Derry, L.A., Drever, J.I., Hering, J.G., Kirchner, W., Kump, L.R., Richter, D., White, A.F., "A proposed initiative to study Earth's weathering engine.", EOS, p. 265, vol. 85, (2004). Published,

Yanai, R.D., Blum, J.D., Hamburg, S.P., Arthur, M.A., Nezat, C.A. and Siccama, T.G., "New insight into calcium depletion in northeastern forests.", Journal of Forestry., p. 14, vol. 103, (2005). Published,

Erel, Y., Blum, J.D., Roueff, E. and Ganor, J., "Lead and strontium isotopes as monitors of experimental granitoid mineral dissolution.", Geochimica et Cosmochimica Acta., p. 607, vol. 69, (2005). Published,

Fisk, M.C., W.R. Kessler, A. Goodale, T.J. Fahey, P.M. Groffman, and C.T. Driscoll., "Landscape variation in microarthropod response to calcium addition in a northern hardwood forest ecosystem.", Pedobiologica, p. 69, vol. 50, (2006). Published,

Groffman, P.M., J.P Hardy, C.T. Drisoll and T.J. Fahey., "Snow depth, soil freezing and trace gas fluxes in a northern hardwood forest.", Global Change Biology, p. 1748, vol. 12, (2006). Published,

Pardo, L.H., P.Templer, C.Goodale, S.Duke, P.Groffman, et. al., "Regional Assessment of N saturation using foliar ä15N.", Biogeochemistry, p. 143, vol. 80, (2006). Published,

Peters, S.C., Blum, J.D., Karagas, M., Chamberlain, C.P. and Sjostrom, D.J., "Sources and Exposure of the New Hampshire Population to Arsenic in Public and Private Drinking Water Supplies.", Chemical Geology, p. 72, vol. 228, (2006). Published,

Campbell, J.L., M. J. Mitchell, P. M. Groffman, L. M. Christenson., "Winter in northeastern North America: An often overlooked but critical period for ecological processes.", Frontiers in Ecology, p. 314, vol. 3(6), (2005). Published,

Mitchell, M.J., "Review of Book: "E. Matzner (editor): Biogeochemistry of Forested Catchments in A Changing Environment, A German Case Study".", Journal of Plant Nutrition and Soil Science., p. 145, vol. 168, (2005). Published,

Watmough, S.A., J. Aherne, C. Alewell, P. Arp, S. Bailey, T. Clair, P. Dillon, L. Duschesne, C. Eimers, I. Fernandez, N. Foster, T. Larsson, E. Miller, M. Mitchell and S. Page., "Sulphate, nitrogen and base cation budgets at 21 forested catchments in Canada, the United States and Europe.", Environmental Monitoring and Assessment, p. 1, vol. 109, (2005). Published,

Chen, L. and C.T. Driscoll., "Regional application of an integrated biogeochemical model to northern New England and Maine.", Ecol. Appl., p. 1783, vol. 15(5), (2005). Published,

Chen, L. and C.T. Driscoll., "A two-layer model to simulate variations in surface water chemistry draining a northern forest watershed.", Water Resour. Res., p. 8, vol. 41, (2005). Published,

Chen, L. and C.T. Driscoll., "Strategies for emission controls to mitigate snowmelt acidification.", Geophys. Res. Lett., p. L20401, vol. 32, (2005). Published,

Dasch, A.A., J.D. Blum, C. Eagar, T.J. Fahey, C.T. Driscoll, and T.G. Siccama., "The relative uptake of Ca and Sr into tree foliage using a whole-watershed calcium addition.", Biogeochemistry., p. 41, vol. 80, (2006). Published,

Fahey, T.J., T.G. Siccama, C.T. Driscoll, G.E. Likens, J. Campbell, C.E. Johnson, J.J. Battles, J.D. Aber, J.J. Cole, M.C. Fisk, P.M. Groffman, S.P. Hamburg, R.T. Holmes, P.A. Schwarz, and R.D. Yanai., "The biogeochemistry of carbon at Hubbard Brook.", Biogeochemistry., p. 109, vol. 75, (2005). Published,

Groffman, P.M., J.P. Hardy, C.T. Driscoll, and T.J. Fahey., "Snow depth, soil freezing, and fluxes of carbon dioxide, nitrous oxide and methane in a northern hardwood forest.", Glob. Change Biol., p. 1, vol. 12, (2006). Published,

Johnson, C.E., R.J. Smernik, T.G. Siccama, D.M. Keimle, Z. Xu, and D.J. Vogt., "Using 13C nuclear magnetic resonance spectroscopy for the study of northern hardwood tissues.", Can.J. For. Res., p. 1821, vol. 35, (2005). Published,

Joslin, J. C., and C.E. Johnson., "Factors influencing trace metal concentrations in remote ponds of the White Mountain National Forest, USA.", Science of the Total Environment, p. , vol. , ( ). Accepted,

Lovett, G.M., G.E. Likens, D.C. Buso, C.T. Driscoll and S.W. Bailey., "The biogeochemistry of chlorine at Hubbard Brook, New Hampshire, USA.", Biogeochemistry, p. 191, vol. 72, (2005). Published,

Palmer, S.M., B.I. Wellington, C.E. Johnson and C.T. Driscoll., "Landscape influences on aluminum and dissolved organic carbon in streams draining the Hubbard Brook valley, New Hampshire, USA.", Hydrol. Proc., p. 1751, vol. 19, (2005). Published,

Warby, R.A.F., C.E. Johnson, and C.T. Driscoll., "Chemical recovery of surface waters across the northeastern U.S. from reduced inputs of acidic deposition: 1984-2001.", Environ. Sci. Technol., p. 6548, vol. 39, (2005). Published,

Yavitt, J.B., T.J. Fahey, R. Long, and C.T. Driscoll., "Solution chemistry and soil in an in-stream wetland on the Hubbard Brook Experimental Forest, New Hampshire.", Wetlands., p. 376, vol. 26(2), (2006). Published,

Campbell, J.L., Mitchell, M.J., Mayer, B., "Isotopic assessment of NO3- and SO42- mobility during winter in two adjacent watersheds in the Adirondack Mountains, New York, USA.", Journal of Geophysical Research - Biogeosciences, p. , vol. 111, (2006). Published, 10.1029/2006JG000208

Campbell, J.L., Mitchell, M.J., Mayer, B., Groffman, P.M. and Christenson, L.M., "Recovery of nitrogen-15-labeled nitrate and sulfur-34-labeled sulfate during snowmelt.", Soil Science Society of America Journal, p. 1934, vol. 71, (2007). Published,

Campbell, J.L., Driscoll, C.T., Eagar, C., Likens, G.E., Siccama, T.G., Johnson, C.E., Fahey, T.J., Hamburg, S.P., Holmes, R.T., Bailey, A.S., and Busco, D.C., "Long-term trends from ecosystem research in the Hubbard Brook Experimental Forest.", USDA Forest Service, Technical Report, p. , vol. NRS-17, (2007). Published,

Groffman, PM; Fisk, MC; Driscoll, CT; Likens, GE; Fahey, TJ; Eagar, C; Pardo, LH, "Calcium additions and microbial nitrogen cycle processes in a northern hardwood forest", ECOSYSTEMS, p. 1289, vol. 9, (2006). Published, 10.1007/s10021-006-0177-

Lowe, WH; Likens, GE; Cosentino, BJ, "Self-organisation in streams: the relationship between movement behaviour and body condition in a headwater salamander", FRESHWATER BIOLOGY, p. 2052, vol. 51, (2006). Published, 10.1111/j.1365-2427.2006.01635.

Lovett, GM; Burns, DA; Driscoll, CT; Jenkins, JC; Mitchell, MJ; Rustad, L; Shanley, JB; Likens, GE; Haeuber, R, "Who needs environmental monitoring?", FRONTIERS IN ECOLOGY AND THE ENVIRONMENT, p. 253, vol. 5, (2007). Published,

Lowe, L.H., G.E. Likens and B.J. Cosentino., "Self-organisation in streams: the relationship between movement behaviour and body condition in a headwater salamander.", Freshwater Biology, p. 2052, vol. 11, (2006). Published,

Judd, K.E., G.E. Likens, and P.M. Groffman., "High nitrate retention during winter in soils of the Hubbard Brook Experimental Forest.", Ecosystems, p. 217, vol. 10, (2007). Published,

Siccama, T.G., T.J. Fahey, C.E. Johnson, T. Sherry, E.G. Denny, E.B. Girdler, G.E. Likens and P. Schwarz., "Population and biomass dynamics of trees in a northern hardwood forest at Hubbard Brook", Canadian Journal of Forest Research, p. 737, vol. 37, (2007). Published,

Warren, D.R., E.S. Bernhardt, R.O. Hall, Jr. and G.E. Likens., "Forest age, wood and nutrient dynamics in headwater streams of the Hubbard Brook Experimental Forest, NH.", Earth Surface Processes and Landforms, p. 1154, vol. 32, (2007). Published,

Novak, M; Mitchell, MJ; Jackova, I; Buzek, F; Schweigstillova, J; Erbanova, L; Prikryl, R; Fottova, D, "Processes affecting oxygen isotope ratios of atmospheric and ecosystem sulfate in two contrasting forest catchments in Central Europe", ENVIRONMENTAL SCIENCE & TECHNOLOGY, p. 703, vol. 41, (2007). Published, 10.1021/es061002

Schroth, A.W., B.C. Bostick, M. Graham, J.M. Kaste, M.J. Mitchell and A.J. Friedland., "Sulfur species behavior in soil organic matter during decomposition.", Journal of Geophysical Research - Biogeosciences, p. , vol. , ( ). Accepted,

Blum, J.D., Dasch, A.A., Hamburg, S.P., Yanai, R.D. and Arthur, M.A., "Use of foliar Ca/Sr discrimination and 87Sr/86Sr ratios to determine soil Ca sources to sugar maple foliage in a northern hardwood forest.", Biogeochemistry, p. , vol. , ( ). Submitted,

Dasch, AA; Blum, JD; Eagar, C; Fahey, TJ; Driscoll, CT; Siccama, TG, "The relative uptake of Ca and Sr into tree foliage using a whole-watershed calcium addition", BIOGEOCHEMISTRY, p. 21, vol. 80, (2006). Published, 10.1007/s10533-005-6008-

Peters, SC; Blum, JD; Karagas, MR; Chamberlain, CP; Sjostrom, DJ, "Sources and exposure of the New Hampshire population to arsenic in public and private drinking water supplies", CHEMICAL GEOLOGY, p. 72, vol. 228, (2006). Published, 10.1016/j.chemgeo.2005.11.02

Yanai, RD; Park, BB; Hamburg, SP, "The vertical and horizontal distribution of roots in northern hardwood stands of varying age", CANADIAN JOURNAL OF FOREST RESEARCH-REVUE CANADIENNE DE RECHERCHE FORESTIERE, p. 450, vol. 36, (2006). Published, 10.1139/X05-25

Dittman, JA; Driscoll, CT; Groffman, PM; Fahey, TJ, "Dynamics of nitrogen and dissolved organic carbon at the Hubbard Brook Experimental Forest", ECOLOGY, p. 1153, vol. 88, (2007). Published,

Driscoll, CT; Han, YJ; Chen, CY; Evers, DC; Lambert, KF; Holsen, TM; Kamman, NC; Munson, RK, "Mercury contamination in forest and freshwater ecosystems in the Northeastern United States", BIOSCIENCE, p. 17, vol. 57, (2007). Published, 10.1641/B57010

Evers, DC; Han, YJ; Driscoll, CT; Kamman, NC; Goodale, MW; Lambert, KF; Holsen, TM; Chen, CY; Clair, TA; Butler, T, "Biological mercury hotspots in the northeastern United States and southeastern Canada", BIOSCIENCE, p. 29, vol. 57, (2007). Published, 10.1641/B57010

Fisk, MC; Kessler, WR; Goodale, A; Fahey, TJ; Groffman, PM; Driscoll, CT, "Landscape variation in microarthropod response to calcium addition in a northern hardwood forest ecosystem", PEDOBIOLOGIA, p. 69, vol. 50, (2006). Published, 10.1016/j.pedobi.2005.11.00

Evers, D.C. and C.T. Driscoll, "The Danger Downwind", The New York Times Op Ed, p. , vol. , (2007). Published,

Groffman, PM; Altabet, MA; Bohlke, JK; Butterbach-Bahl, K; David, MB; Firestone, MK; Giblin, AE; Kana, TM; Nielsen, LP; Voytek, MA, "Methods for measuring denitrification: Diverse approaches to a difficult problem", ECOLOGICAL APPLICATIONS, p. 2091, vol. 16, (2006). Published,

Juice, SM; Fahey, TJ; Siccama, TG; Driscoll, CT; Denny, EG; Eagar, C; Cleavitt, NL; Minocha, R; Richardson, AD, "Response of sugar maple to calcium addition to Northern Hardwood Forest", ECOLOGY, p. 1267, vol. 87, (2006). Published,

Phillips, RP; Fahey, TJ, "Tree species and mycorrhizal associations influence the magnitude of rhizosphere effects", ECOLOGY, p. 1302, vol. 87, (2006). Published,

Yavitt, JB; Fahey, TJ; Long, R; Driscoll, CT, "Solutes and soil in and around an in-stream wetland on the Hubbard Brook Experimental Forest, New Hampshire, USA", WETLANDS, p. 376, vol. 26, (2006). Published,

Cleavitt, N.L., K.L. Klima and T.J. Fahey., "The role of water availability in seasonal growth of Bazzania trilobata on boulders in ean eastern hemlock stand.", The Bryologist, p. 295, vol. 110, (2007). Published,

Dobbs, RC; Sillett, TS; Rodenhouse, NL; Holmes, RT, "Population density affects foraging behavior of male Black-throated Blue Warblers during the breeding season", JOURNAL OF FIELD ORNITHOLOGY, p. 133, vol. 78, (2007). Published, 10.1111/j.1557-9263.2007.00096.

Pardo, LH; Templer, PH; Goodale, CL; Duke, S; Groffman, PM; Adams, MB; Boeckx, P; Boggs, J; Campbell, J; Colman, B; Compton, J; Emmett, B; Gundersen, P; Kjonaas, J; Lovett, G; Mack, M; Magill, A; Mbila, M; Mitchell, MJ; McGee, G; McNulty, S; Nadelhoffer,, "Regional assessment of N saturation using foliar and root delta N-15", BIOGEOCHEMISTRY, p. 143, vol. 80, (2006). Published, 10.1007/s10533-006-9015-

Richardson, AD; Bailey, AS; Denny, EG; Martin, CW; O'Keefe, J, "Phenology of a northern hardwood forest canopy", GLOBAL CHANGE BIOLOGY, p. 1174, vol. 12, (2006). Published, 10.1111/j.1365-2486.2006.01164.

Dukes, J., Pontius, J., Orwig, D., Brazee, N., Garnas, J., Rodgers, V., Theoharides, K., Harrington, R., Cooke, B., Stange, E., Ehrenfeld, J., Furevitch, J., Lerdau, M., Stinson, K., Hopkins, A., Wick, R., Ayres, M.P. and Warren, G., "Responses of pests, pathogens and invasive species to climate change in the forests of Northeastern North America: What can we predict?", Canadian Journal of Forest Research, p. , vol. , (2007). Accepted,

Holmes, R.T., "Understanding population change in migratory songbirds: long-term and experimental studies of Neotropical migrants in breeding and wintering areas.", IBIS, p. , vol. , (2007). Published, 10.1111/j.1474-919X.2007.00685.x

Rodenhouse, N.L., L.M. Christenson, D. Parry, L.E. Green., "Climate change effects on native fauna of Northeastern forests.", Canadian Journal of Forest Research, p. , vol. , (2008). Accepted,

Anderson, J.E., M.E. Martin, M.L. Smith, R. Dubayah, M. Hofton, P. Hyde, B. Peterson, J.B. Blair, and R. Knox., "The use of waveform lidar to measure temperate deciduous forest structure in New Hampshire.", Remote Sensing of Environment, p. 248, vol. 105(3), (2006). Published,

Jenkins, J.P., A.D. Richardson, B.H. Braswell, S.V. Ollinger, D.Y. Hollinger, and M-L. Smith., "Refining light-use efficiency calculations for a deciduous forest canopy using simultaneous tower-based carbon flux and radiometric measurements.", Journal of Forest and Agricultural Meteorology, p. 64, vol. 143, (2007). Published,

Ollinger, S.V., C.L. Goodale, K. Hayhoe and J.P. Jenkins., "Effects of predicted changes in climate and atmospheric composition on ecosystem processes in Northeastern U.S. forests.", Mitigation and Adaptation Strategies for Global Change, p. , vol. , ( ). Accepted,

Plourde, L.C., S.V. Ollinger, M.E. Martin and M-L. Smith., "Estimating species abundance in a northern temperate forest using spectral mixture analysis.", Photogrammetric Engineering and Remote Sensing, p. 829, vol. 73(7), (2007). Published,

Ollinger, SV; Smith, ML, "Net primary production and canopy nitrogen in a temperate forest landscape: An analysis using imaging spectroscopy, modeling and field data", ECOSYSTEMS, p. 760, vol. 8, (2005). Published, 10.1007/s10021-005-0079-

Lowe, WH; Likens, GE; McPeek, MA; Buso, DC, "Linking direct and indirect data on dispersal: Isolation by slope in a headwater stream salamander", ECOLOGY, p. 334, vol. 87, (2006). Published,

Judd, KE; Likens, GE; Groffman, PM, "High nitrate retention during winter in soils of the hubbard brook experimental forest", ECOSYSTEMS, p. 217, vol. 10, (2007). Published, 10.1007/s10021-007-9027-

Reynolds, LV; Ayres, MP; Siccama, TG; Holmes, RT, "Climatic effects on caterpillar fluctuations in northern hardwood forests", CANADIAN JOURNAL OF FOREST RESEARCH-REVUE CANADIENNE DE RECHERCHE FORESTIERE, p. 481, vol. 37, (2007). Published, 10.1139/X06-21

Likens, GE; Buso, DC, "Variation in streamwater chemistry throughout the Hubbard Brook Valley", BIOGEOCHEMISTRY, p. 1, vol. 78, (2006). Published, 10.1007/s10533-005-2024-

Rosenberry, DO; Winter, TC; Buso, DC; Likens, GE, "Comparison of 15 evaporation methods applied to a small mountain lake in the northeastern USA", JOURNAL OF HYDROLOGY, p. 149, vol. 340, (2007). Published, 10.1016/j.jhydrol.2007.03.01

Rosenberry, DO; Winter, TC; Buso, DC; Likens, GE, "Reply to comment by J. Szilagyi on "Comparison of 15 evaporation methods applied to a small mountain take in the northeastern USA" [J. Hydrol. 340 (3-4) (2007) 149-166]", JOURNAL OF HYDROLOGY, p. 566, vol. 348, (2008). Published, 10.1016/j.jhydrot.2007.09.05

Campbell, J.L., C.T. Driscoll, C. Eagar, G.E. Likens, T.G. Siccama, C.E. Johnson, T.J. Fahey, S.P. Hamburg, R.T. Holmes, A.S. Bailey and D.C. Buso., "Long-term trends from ecosystem research at the Hubbard Brook Experimental Forest.", Gen. Tech. Rep. USDA., p. , vol. NRS-17, (2007). Published,

Likens, G. E., "Understanding, using and protecting inland waters of the world. SIL Presidential Address, 2007 Montreal.", Verh. Internat. Verein. Limnol., p. 165, vol. 30(2), (2008). Published,

Winter, T. C., D. Buso, P. C. Shattuck, P. T. Harte, D. A. Vroblesky and D. J. Goode., "The effect of terrace geology on ground-water movement and on the interaction of ground water and surface water on a mountainside near Mirror Lake, New Hampshire, USA.", Hydrol. Proc., p. 21, vol. 22, (2008). Published,

Bade, D. L., K. Bouchard and G. E. Likens., "Algal co-limitation by nitrogen and phosphorus persists after 30 years in Mirror Lake (New Hampshire, USA).", Verh. Internat. Verein. Limnol., p. , vol. , (2008). Accepted,

Conley, D. J., G. E. Likens, D. C. Buso, L. Saccone, S. W. Bailey and C. Johnson., "Deforestation causes increased dissolved silicate losses in North Temperate hardwood ecosystems.", Global Change Biology, p. , vol. , (2008). Accepted,

Cosentino, B. J., W. H. Lowe and G. E. Likens., "Demography and movement of the Northern spring salamander in four New Hampshire headwater streams.", Verh. Internat. Verein. Limnol., p. , vol. , (2008). Accepted,

Greene, B. T., W. H. Lowe and G. E. Likens., "Out to eat: prey availability and terrestrial habitat use by a headwater salamander.", Freshwater Biology, p. , vol. , (2008). Accepted,

Likens, G. E. and D. C. Buso., "Long-term changes in streamwater chemistry following disturbance in the Hubbard Brook Experimental Forest, USA.", Verh. Internat. Verein. Limnol., p. , vol. , (2008). Accepted,

Lowe, W., M. McPeek, G. E. Likens and B. Cosentino., "Linking movement behavior to dispersal and divergence in plethodontid salamanders.", Molecular Ecology, p. , vol. , (2008). Accepted,

Saccone, L., D. J. Conley, G. E. Likens, S. W. Bailey, D. C. Buso and C. E. Johnson., "Factors that control the range and variability of amorphous silica in soils in the Hubbard Brook Experimental Forest.", Soil Science Soc. Am. J., p. , vol. , (2008). Accepted,

Steinweg, JM, MC Fisk, B McAlexander, PM Groffman and JP Hardy., "Experimental snowpack reduction alters organic matter and net N mineralization potential of soil macroaggregates in a northern hardwood forest.", Biology and Fertility of Soils, p. , vol. , (2008). Published, 10.1007/s00374-008-0305-3

Yanai, RD, MC Fisk, TJ Fahey, N Cleavitt and BB Park., "Identifying roots of northern hardwood species: patterns with diameter and depth.", Canadian Journal of Forest Research, p. , vol. , (2008). Accepted,

Cleavitt, N.L., T. J. Fahey P.M. Groffman, J.P. Hardy, K.S. Henry, and C.T. Driscoll., "Effects of soil freezing on fine roots in a northern hardwood forest.", Canadian Journal of Forest Research, p. 82, vol. 38, (2008). Published,

Kulkarni, MV, P.M. Groffman and J.B. Yavitt., "Solving the global nitrogen problem: It?s a gas!", Frontiers in Ecology and Environment, p. 199, vol. 4, (2008). Published,

Peters, D.P.C., P.M. Groffman, K. Nadelhoffer, N.B. Grimm, S.Collins, W. Michener and M. Huston., "Living in an increasingly connected world: a framework for continental-scale environmental science.", Frontiers in Ecology and Environmental Science, p. 229, vol. 6, (2008). Published,

Campbell, J.L. L.E. Rustad, E.W. Boyer, S.F. Christopher, C.T. Driscoll, I.J. Fernandez, P.M. Groffman, D. Houle, J. Kiekbusch, A.H. Magill, M.J. Mitchell and S.V. Ollinger., "Consequences of climate change for biogeochemical cycling in forests of northeastern North America.", Canadian Journal of Forest Research., p. , vol. , (2008). Accepted,

Steinweg, J.M., M.C. Fisk, B. McAlexander, P.M. Groffman and J. P. Hardy., "Effects of soil freezing on soil particle size distributions and organic matter mineralization in a northern hardwood forest.", Biology and Fertility of Soils., p. , vol. , (2008). Accepted,

Kulkarni, M.V., P.M. Groffman and J.B. Yavitt., "A comparison of denitrification rates as measured using direct flux and 15N tracer methods in northeastern forest soils.", Soil Biology & Biochemistry, p. , vol. , (2008). Submitted,

Campbell JL, Rustad LE, Boyer EW, Christopher SF, Driscoll CT, Fernandez IJ, Groffman PM, Houle D, Kiekbusch J, Magill AH, Mitchell MJ, and Ollinger SV., "Consequences of climate change for biogeochemical cycling in forests of northeastern North America.", Canadian Journal of Forest Research, p. , vol. , (2008). Accepted,

Jaffe R, McKnight D, Maie N, Cory R, McDowell WH and Campbell JL., "Spatial and temporal variations in DOM composition in ecosystems: The importance of long-term monitoring of optical properties.", Journal of Geophysical Research-Biogeosciences., p. , vol. , (2008). Accepted,

Ross DS, Wemple BC, Jamison AE, Fredriksen G, Shanley JB, Lawrence GB, Bailey SW, and Campbell JL., "A cross-site comparison of factors influencing soil nitrification rates in northeastern USA forested watersheds.", Ecosystems, p. , vol. , (2008). Accepted,

Warren, DR, GE Likens, DC Buso and CE Kraft., "Status and distribution of fish in an acid-impacted watershed of the Northeastern United States (Hubbard Brook, NY).", Northeast Naturalist, p. , vol. , (2008). Accepted,

Yee, S-A., "Effect of a soil calcium addition on the extension and radial growth rates of American beech (Fagus grandifolia) saplings.", Berkeley Scientific, p. 42, vol. 11, (2007). Published,

Ollinger, S.V, C.L. Goodale, K. Hayhoe and J.P Jenkins., "Effects of Predicted Changes in Climate and Atmospheric Composition on Ecosystem Processes in Northeastern U.S. Forests.", Mitigation and Adaptation Strategies for Global Change., p. 467, vol. 13, (2008). Published,

Martin, M.E., L.C. Plourde, S.V.,Ollinger, ML., Smith, B.E. McNeil., "A generalizeable method for remote sensing of canopy nitrogen across a wide range of forest ecosystems.", Remote Sensing and Environment, p. 3511, vol. 112, (2008). Published,

Anderson, J.E, M.E. Martin, M.L. Smith, R. Dubayah, M. Hofton, P. Hyde, B. Peterson, J.B. Blair, and R. Knox., "The use of waveform lidar to measure temperate deciduous forest structure in New Hampshire.", Remote Sensing of Environment., p. 1856, vol. 112, (2008). Published,

R.F. Kokaly, G.P. Asner, M.E. Martin, S.V. Ollinger, C.A. Wessman., "Characterizing canopy biochemistry from imaging spectrometer data for studying ecosystem processes.", Remote Sensing and Environment, p. , vol. , (2008). Accepted,

Plourde L.C., S.V. Ollinger, M.E. Martin and M-L. Smith., "Estimating species abundance in a northern temperate forest using spectral mixture analysis.", Photogrammetric Engineering and Remote Sensing, p. 829, vol. 73(7), (2007). Published,

Ollinger, S.V., A.D. Richardson, M.E. Martin, D.Y. Hollinger, S. Frolking, P.B. Reich, L.C. Plourde, M-L. Smith, P.V. Bolstad, G.G. Katul, T.A. Martin, R.K. Monson, J.W. Munger, R. Oren, K.T. Paw U, H.P. Schmid., "Canopy nitrogen, carbon assimilation and the albedo of temperate and boreal forests.", Proceedings of the National Academy of Science, p. , vol. , (2008). In revision,

J. Bradford, P. Weishampel, M-L Smith, R.Kolka, R. Birdsey, S.V. Ollinger and M.G. Ryan., "Carbon pools and fluxes in temperate forest landscapes: spatial variability and implications for sampling design.", Landscape Ecology, p. , vol. , (2008). Submitted,

J. Bradford, P. Weishampel, M-L Smith, R.Kolka, R. Birdsey, S.V. Ollinger and M.G. Ryan., "Detrital carbon pools in temperate forests: importance and potential for landscape-scale assessment.", Canadian Journal of Forest Research, p. , vol. , (2008). Submitted,

Betts, M.G., N.L. Rodenhouse, T. S. Sillett, P. J. Doran and R. T. Holmes., "Dynamic occupancy models reveal within-breeding season movement up a habitat quality gradient by a migrant songbird.", Ecography, p. , vol. , (2008). Published, 10.1111/j.2008.0906-7590.05490.x

Rodenhouse, NL, LM Christenson, D. Parry, and LE Green., "Climate change effects on native fauna of northeastern forests.", Canadian Journal of Forestry Research, p. , vol. , (2008). Accepted,

Rodenhouse, N.L., S.N. Matthews, K.P. McFarland, J.D. Lambert, L.R. Iverson, A. Prasad, T.S. Sillett, and R.T. Holmes, "Potential effects of climate change on birds of the Northeast.", Mitigation and Adaptation Strategies for Global Change, p. 517, vol. 13, (2008). Published,

Lovett, GM; Canham, CD; Arthur, MA; Weathers, KC; Fitzhugh, RD, "Forest ecosystem responses to exotic pests and pathogens in eastern North America", BIOSCIENCE, p. 395, vol. 56, (2006). Published,

Park, B.B., R.D. Yanai, M.A. Vadeboncoeur, and S.P. Hamburg., "Estimating root biomass in rocky soils using pits, cores and allometric equations.", Soil Sci. Soc. Am. J., p. 206, vol. 71, (2007). Published,

Yanai, R.D., B.B. Park and S.P. Hamburg., "The vertical and horizontal distribution of roots in northern hardwood stands of varying age.", Canadian Journal of Forest Research, p. 450, vol. 36, (2007). Published,

Blum, J.D., Dasch, A.A., Hamburg, S.P., Yanai, R.D. and Arthur, M.A., "Use of foliar Ca/Sr discrimination and 87Sr/86Sr ratios to determine soil Ca sources to sugar maple foliage in a northern hardwood forest.", Biogeochemistry, p. 287, vol. 87, (2008). Published,

Nezat, C.A., Blum, J.D., Yanai, R.D. and Park, B.B., "Mineral sources of calcium and phosphorus in soils of the northeastern USA", Soil Sci Soc Amer J., p. , vol. , (2008). Accepted,

Nezat, C.A., Blum, J. D., Yanai, R.D. and Hamburg, S.P., "A sequential extraction to selectively dissolve apatite for determination of soil nutrient pools with an application to Hubbard Brook Experimental Forest, New Hampshire, USA.", Applied Geochemistry., p. 2406, vol. 22, (2007). Published,

Skeldon, M., Vadeboncoeur, M.A., Hamburg, S.P. and Blum, J.D., "Terrestrial Gastropod Distribution in the Northern Hardwood Forest: The Role of Calcium and Forest Composition.", Canad J of Zoology., p. 994, vol. 85, (2007). Published,

Biswas, A., Blum, J.D., Bergquist, B.A., Keeler, G.J. and Xie, Z., "Natural mercury isotope variation in coal deposits and organic soils.", Env. Sci and Tech., p. , vol. , (2008). Accepted,

Mitchell, M.J. , S.W. Bailey, J.B. Shanley and B. Mayer., "Evaluating Storm Events for Three Watersheds in the Northeastern United States: a Combined Hydrological, Chemical and Isotopic Approach.", Hydrological Processes, p. , vol. , (2008). Accepted,

Shanley, J.B., B. Mayer, M.J. Mitchell and S.W. Bailey., "Annual and event variations in 34S values of stream sulfate in a Vermont forested catchment: implications for S sources and cycling.", Science of the Total Environment., p. , vol. , (2008). Accepted,

Campbell, J.L., Mitchell, M.J., Mayer, B., Groffman, P.M., Christenson, L.M., "Mobility of nitrogen-15-labeled nitrate and sulfur-34-labeled sulfate during snowmelt.", Soil Science Society of America Journal, p. 1934, vol. 71, (2007). Published,

Lovett, G.M., D.A. Burns, C.T. Driscoll, J.C. Jenkins, M.J. Mitchell, L. Rustad, J.B. Shanley, G.E. Likens and R. Haeuber., "Who Needs Environmental Monitoring?", Frontiers in Ecology and the Environment, p. 253, vol. 5, (2007). Published,

Novák, M. M. J. Mitchell, I. Jacková, F. Buzek, J. Schweigstillová, L. Erbanová, R. Prikryl and D. Fottová., "Processes affecting oxygen isotope ratios of atmospheric and ecosystem sulfate in two contrasting forest catchments in Central Europe.", ES&T, p. 703, vol. 41(3), (2007). Published, 10.1021/es0610028

Schroth, A. W., B. C. Bostick, M. Graham, J M. Kaste, M. J. Mitchell, and A. J. Friedland., "Sulfur species behavior in soil organic matter during decomposition.", J. Geophys. Res., p. G04011, vol. 112, (2007). Published, 10.1029/2007JG000538.

Guo, DL; Li, H; Mitchell, RJ; Han, WX; Hendricks, JJ; Fahey, TJ; Hendrick, RL, "Fine root heterogeneity by branch order: exploring the discrepancy in root turnover estimates between minirhizotron and carbon isotopic methods", NEW PHYTOLOGIST, p. 443, vol. 177, (2008). Published, 10.1111/j.1469-8137.2007.02242.

Cleavitt, NL; Fahey, TJ; Groffman, PM; Hardy, JP; Henry, KS; Driscoll, CT, "Effects of soil freezing on fine roots in a northern hardwood forest", CANADIAN JOURNAL OF FOREST RESEARCH-REVUE CANADIENNE DE RECHERCHE FORESTIERE, p. 82, vol. 38, (2008). Published, 10.1139/X07-13

Nezat, CA; Blum, JD; Yanai, RD; Hamburg, SP, "A sequential extraction to determine the distribution of apatite in granitoid soil mineral pools with application to weathering at the Hubbard Brook Experimental Forest, NH, USA", APPLIED GEOCHEMISTRY, p. 2406, vol. 22, (2007). Published, 10.1016/j.apgeochem.2007.06.01

Skeldon, MA; Vadeboncoeur, MA; Hamburg, SP; Slum, JD, "Terrestrial gastropod responses to ecosystem-level calcium manipulation a northern hardwood forest", CANADIAN JOURNAL OF ZOOLOGY-REVUE CANADIENNE DE ZOOLOGIE, p. 994, vol. 85, (2007). Published, 10.1139/Z07-08

Vadeboncoeur, MA; Hamburg, SP; Yanai, RD, "Validation and refinement of allometric equations for roots of northern hardwoods", CANADIAN JOURNAL OF FOREST RESEARCH-REVUE CANADIENNE DE RECHERCHE FORESTIERE, p. 1777, vol. 37, (2007). Published, 10.1139/X07-03

Kulkarni, MV; Groffman, PM; Yavitt, JB, "Solving the global nitrogen problem: it's a gas!", FRONTIERS IN ECOLOGY AND THE ENVIRONMENT, p. 199, vol. 6, (2008). Published, 10.1890/06016

Peters, DPC; Groffman, PM; Nadelhoffer, KJ; Grimm, NB; Coffins, SL; Michener, WK; Huston, MA, "Living in an increasingly connected world: a framework for continental-scale environmental science", FRONTIERS IN ECOLOGY AND THE ENVIRONMENT, p. 229, vol. 6, (2008). Published, 10.1890/07009

Jones, J; Doran, PJ; Holmes, RT, "Spatial scaling of avian population dynamics: Population abundance, growth rate, and variability", ECOLOGY, p. 2505, vol. 88, (2007). Published,

Phillips, RP; Fahey, TJ, "The influence of soil fertility on rhizosphere effects in northern hardwood forest soils", SOIL SCIENCE SOCIETY OF AMERICA JOURNAL, p. 453, vol. 72, (2008). Published, 10.2136/sssaj2006.038

Cleavitt, N.L., M. Fairbairn and T.J. Fahey., "Growth and survivorship of American beech (Fagus grandifolia Ehrh.) seedlings in a northern hardwood forest following a mast event.", Journal of the Torrey Botanical Society., p. 328, vol. 135(3), (2008). Published,

Books or Other One-time Publications

Schwenk, S., "Interactions among birds, insects, trees, and the environment in a northern forest ecosystem.", ( ). Thesis, in progress
Bibliography: Dissertation, in progress. University of Vermont, Burlington, VT

Driscoll, C. T., G. B. Lawrence, A. J. Bulger, T. J. Butler, C. S. Cronan, C. Eagar, K. F. Lambert, G. E. Likens, J. L. Stoddard and K. C. Weathers., "Acidic deposition in the northeastern United States: Sources and inputs, ecosystem effects and management strategies.", (2004). Book, Published
Editor(s): In: J. M. Gunn, R. J. Steedman, and R. A. Ryder (eds.).
Collection: Boreal Shield Watersheds, Section III: Biological Effects and Management Reactions.
Bibliography: Lewis Publishers.

Mitchell, M.J. and C. Alewell., "Sulfur Transformations and Fluxes.", (2007). Book, Accepted
Editor(s): W. Chesworth (ed.)
Collection: The Encyclopedia of Soil Science
Bibliography: Springer-Verlag.

Mitchell, M.J., "Episodic Acidification", (2005). Book, Published
Editor(s): Jay H. Lehr and Jack Keeley (eds.)
Collection: Water Encyclopedia: Surface and Agricultural Water.
Bibliography: John Kiley and Sons. p. 3-5.

Damon, Lisa., "Mercury concentrations of Black-throated Blue Warbler eggs in the Hubbard Brook Experimental lForest, New Hampshire.", (2006). undergraduate research, Published
Bibliography: Independent research, Wellesley College.

Polfus, J.L., "Do trees respond to insect attack? Effects of induced tree resistance on caterpillar performance and foraging dispersion.", (2006). Senior Honors Thesis, Published
Bibliography: Senior Honors Thesis, Dartmouth College.

Driscoll, C.T., K. F. Lambert, and L. Chen., "Acidic deposition: Sources and effects.", (2005). Book, Published
Editor(s): M. G. Anderson (ed)
Collection: Encyclopedia of Hydrological Sciences.
Bibliography: John Wiley & Sons, Ltd., Chichester, England. P. 1441-1457.

Driscoll, C.T., K.F. Lambert, and L. Chen., "Acidic deposition: Sources and ecological effects.", (2006). Book, Published
Editor(s): G. R. Visgilio and D. M. Whitelaw (eds.)
Collection: Acid in the Environment: Lessons Learned and Future Prospects.
Bibliography: Springer Science + Business Media, Inc.

Mitchell, M.J. and C. Alewell., "Sulfur transformations and fluxes", ( ). Book, Accepted
Editor(s): In: W. Chesworth (ed.).
Collection: The Encyclopedia of Soil Science
Bibliography: Springer-Verlag

Likens, G.E., "Meromictic lake.", (2006). Book, Published
Collection: McGraw-Hill Encyclopedia.
Bibliography: pp. 679-681.

Likens, G.E., "Surprises from long-term studies at the Hubbard Brook Experimental Forest, USA.", (2008). Book, Published
Editor(s): Asahi Glass Foundation, Tokyo, Japan
Collection: A Better Future for the Planet Earth Vol. III -- Commemorative Book for Blue Planet Prize Winners
Bibliography: pp. 68-77

McLauchlan, K.K., J.M. Craine, W.W. Oswald, P.R. Leavitt and G.E. Likens., "Changes in nitrogen cycling during the past century in a northern hardwood forest.", (2007). Book, Published
Collection: Proceedings of the National Academy of Sciences
Bibliography: 104(18): 7466-7470

Groffman, P.M., R.T. Venterea, L.V. Verchot and C.S. Potter., "Landscape and regional scale studies of nitrogen gas fluxes.", (2006). Book, Published
Editor(s): J. Wu, K.B. Jones, H. Li and O.L. Loucks, editors.
Collection: Scaling and Uncertainty Analysis in Ecology: Methods and Applications.
Bibliography: p 191-203. Springer, New York.

Biasiolli, T.G., "Using stable isotopes to determine connections in the annual cycle of the black-throated blue warbler.", ( ). Thesis, in progress
Bibliography: Masters Thesis, University of Vermont, Burlingt, VT

Colbeck, G., "Genetic structure, song behavior, and mating system of a migratory songbird.", ( ). Thesis, in progress
Bibliography: Ph.D. Dissertation, Washington State University.

Hof, D., "Mate attractiveness and daptive sex ratio adjustment in a migrant songbird.", ( ). Thesis, in progress
Bibliography: Ph.D. Dissertation, University of Massachusetts, Amherst.

Schwenk, S., "Interactions among birds, insects, trees, and the environment in a northern forest ecosystem.", ( ). Thesis, in progress.
Bibliography: Dissertation, University of Vermont, Burlington, VT

Stange, E., "The nature of northern hardwood Lepidoptera population fluctuations and mechanisms producing spatially correlated temporal dynamics.", ( ). Thesis, in progress
Bibliography: Ph.D. Dissertation, Dartmouth College, Hanover, NH.

Betts, M.G., A.S. Hadley, J.J. Nocera, and N.L. Rodenhouse., "Use of public information versus location cues in habitat selection by black-throated warblers.", (2007). paper/poster presentation, Published
Bibliography: 92nd Annual Meeting of the Ecological Society of America, San Hose, CA.

Rodenhouse, N.L., T.S. Sillett, P.J. Doran and R.T. Holmes., "Effects of weather on a neotropical-nearctic migrant songbird: Implications for climate change.", (2007). paper/poster presentation, Published
Bibliography: 92nd Annnual Meeting of the Ecological Society of America, San Jose, CA.

Stange, E., "Climate-generated interspecific synchrony in northern hardwood forest Lepidoptera.", (2007). paper/poster presentation, Published
Bibliography: 2007 Meeting of the Northeast Forest Pest Council, Fairlee, VT.

Stange, E., "Climate-generated interspecific synchrony in northern hardwood forest Lepidoptera.", (2007). paper/poster presentation, Published
Bibliography: 13th Symposium on Insect-Plant Relationships, Uppsala, Sweden.

Ciurej, K., "Blowfly parasitism of Black-throated Blue Warblers: Effects of climate and microclimate.", (2007). indepdent research, Published
Bibliography: Undergraduate Independent Research. Wellesley College.

Asner, G.P. and S.V. Ollinger., "Remote Sensing for Terrestrial Biogeochemical Modeling.", ( ). Book, Accepted
Editor(s): Warner, T., Nellis, M.D. and Foody, G.
Collection: The Handbook of Remote Sensing.
Bibliography: SAGE Publications, U.K.

Ollinger, S.V., R.N. Treuhaft, B.H. Braswell, J.E. Anderson, M.E. Martin, M-L. Smith., "The Role of Remote Sensing in the Study of Terrestrial Net Primary Production.", (2007). Book, Published
Editor(s): T.J. Fahey and A.K. Knapp
Collection: Principles and Standards for Measuring Net Primary Production in Long-term Ecological Studies.
Bibliography: Oxford University Press, London.

Anderson, J., "Remote Detection of Forest Structure in the White Mountains of New Hampshire: An Integration of Waveforem Lidar and Hyperspectral Remote Sensing Data.", (2006). Thesis, Published
Bibliography: Dissertation, University of New Hampshire.

Silverberg, S., "Patterns and processes of soil carbon dynamics in a northeastern united state forest.", (2006). Thesis, Published
Bibliography: M.S. Thesis, Natural Resources, University of New Hampshire

Thomas, Q., "Consequences of fine-scale heterogeneity for predictions of the carbon cycle using lidar data and a height-structured ecosystem model.", (2007). Thesis, Published
Bibliography: M.S. Thesis, Natural Resources, University of New Hampshire.

Fahey, T.J. and A.K. Knapp (Eds.)., "Principles and Standards for Measuring Primary Production.", (2007). Book, Published
Bibliography: Oxford University Press, Inc., New York.

Fahey, T.J. and A.K. Knapp., "Primary Production: Guiding principles and standards for measurement.", (2007). Book, Published
Editor(s): T.J. Fahey and A.K. Knapp (eds.)
Collection: Principles and Standards for Measuring Primary Production.
Bibliography: Pages 3-11. Oxford University Press, Inc., New York.

Kloeppel, B.D., M.E. Harmon and T.J. Fahey., "Estimating aboveground net primary productivity in forest-dominated ecosystems.", (2007). Book, Published
Editor(s): T.J. Fahey and A.K. Knapp (eds.)
Collection: Principles and Standards for Measuring Primary Production.
Bibliography: Pages 63-81. Oxford University Press, Inc., New York.

Tierney, G.T. and T.J. Fahey., "Estimating belowground primary productivity.", (2007). Book, Published
Editor(s): T.J. Fahey and A.K. Knapp (eds.)
Collection: Principles and Standards for Measuring Primary Production.
Bibliography: Pages 120-141. Oxford University Press, Inc., New York.

Groffman PM., "Nitrogen balances at ecosystem, landscape, regional and global scales.", (2008). Book, Published
Editor(s): J. Schepers and W. Raun, editors
Collection: Nitrogen in Agricultural Soils
Bibliography: Pages 731 - 758. Soil Science Society of America, Madison WI.

Likens GE and FH Bormann., "Environmental Challenges in the Twenty-First Century and our respect for nature.", (2008). Book, Published
Collection: 2003 Blue Planet Prize Commemorative Lecture.
Bibliography: A Better Future for the Planet Earth Vol. III -- Commemorative Book for Blue Planet Prize Winners, Asahi Glass Foundation, Tokyo, Japan. pp. 78-95

Buso DC, GE Likens, J LaBaugh and D Bade., "Nutrient dynamics of Mirror Lake, 1982-2000.", (2008). Book, Accepted
Editor(s): T.C. Winter and G.E. Likens.
Collection: Dynamics of Lake, Watershed and Atmospheric Linkages.
Bibliography: Chapter 3. University of California Press.

LeBaugh, JW, DC Buso and GE Likens., "Evaluation of methods and uncertainties in the chemical budgets of Mirror Lake.", (2008). Book, Accepted
Editor(s): TC Winter and GE Likens.
Collection: Dynamics of Lake, Watershed and Atmospheric Linkages.
Bibliography: Chapter 5. University of California Press.

Likens, GE., "Inland waters.", (2008). Book, Accepted
Editor(s): GE Likens.
Collection: Encyclopedia of Inland Waters.
Bibliography: Chapter 1. Elsevier, Academic Press.

Likens, GE., "A limnological introduction to Mirror Lake.", (2008). Book, Accepted
Editor(s): TC Winter and GE Likens.
Collection: Dynamics of Lake, Watershed and Atmospheric Linkages.
Bibliography: Chapter 1. University of California Press.

Winter, TC and GE Likens., "Summary and Conclusions.", (2008). Book, Accepted
Editor(s): TC Winter and GE Likens.
Collection: Dynamics of Lake, Watershed and Atmospheric Linkages.
Bibliography: Chapter 7. University of California Press.

Asner, G.P. and S.V. Ollinger., "Remote Sensing for Terrestrial Biogeochemical Modeling", (2008). Book, Accepted
Editor(s): Warner, T., Nellis, M.D. and Foody, G.
Collection: The Handbook of Remote Sensing.
Bibliography: SAGE Publications, UK.

Colbeck, G., "Genetic structure, song behavior, and mating system of a migratory songbird.", ( ). Thesis, In progress.
Bibliography: Ph.D. Dissertation, Washington State University.

Kaiser, S., "Trade-offs in Male Reproductive Behaviors: Examination of their Regulatory Mechanism and Fitness Consequences in Response to Experimentally Manipulated Food Availability in Black-throated Blue Warblers.", ( ). Thesis, In progress.
Bibliography: Ph.D. Dissertation. Washington State University, Pullman.

Stange, E., "The nature of northern hardwood Lepidoptera population fluctuations and mechanisms producing spatially correlated temporal

dynamics.", ( ). Thesis, In progress.
Bibliography: Ph.D. Dissertation. Dartmouth College, Hanover, NH

Rodenhouse, N.L., T.S. Sillett and R.T. Holmes., "Climate sensitivity of a migratory songbird.", (2008). Paper/poster presented at meeting, Published
Bibliography: 126th Meeting of the American Ornithologists' Union, 4-8 August, Portland, Oregon.

Betts, M.G., N.L. Rodenhouse, T.S. Sillett, P.J. Doran and R.T. Holmes., "Dynamic occupancy models reveal within-breeding season movement up a habitat quality gradient by a migratory songbird.", (2008). paper/poster presented at meeting, Published
Bibliography: 126th Meeting of the American Ornithologists' Union, 4-8 August, Portland, Oregon.

Mitchell, M.J. and C. Alewell., "Sulfur Transformations and Fluxes.", (2007). Book, Published
Editor(s): W. Chesworth.
Collection: The Encyclopedia of Soil Science.
Bibliography: p. 757-764. Springer-Verlag, Dordrecht.

Web/Internet Site

URL(s):

www.hubbardbrook.org

Description:

An internet home page (HBES website: www.hubbardbrook.org) continued to be provided during 2008, under the supervision of the USDA Forest Service's Data Manager and the HBES IOC. The website was revamped and updated in 2007.

The announcement of registration for the 2008 HBES Annual Cooperator's Meeting and agenda for the meeting has been provided on the HBES website, as is done annually. Personnel CVs and HBES publications are now updated interactively on the web site, and a section devoted to current research for each investigators has been added.

All of the HBES monthly volume-weighted chemical data were updated and submitted to the Data Manager, according to standard HBES policy. The IOC policy for access to HBES chemical data continued to be enforced in order to promote an ethical and professional relationship with serious users of these HBES data.

All of the HBES website chemical data have been updated to the end of water-year or calendar-year 2006. The primary data sets are the monthly volume-weighted average concentration values for deposition and export at all nine watersheds in HBEF. Other data sets added to the website include: weighted average streamwater concentration values for all nine watersheds for the most recent years, unweighted, weekly chemical concentration data from the Mirror Lake inlets and outlets, seasonal profile chemistry from the lake itself, annual lake ice-cover duration data, and monthly lake profile temperature values.

We have developed a new web site for Mirror Lake to feature a virtual tour of Mirror Lake and its watershed as part of our outreach activities. A sixth-grade teacher, Mr. Gerry Gontarz, in the Plymouth School System, NH worked on this virtual tour project as an NSF-supported Research Experiences for Teachers (RET) in the summer of 2005, and has been updating and perfecting this virtual tour through the 2005-2007 school year with his sixth-grade students. http://www.hubbardbrook.org/ mirrorlake_tour/index.html

Other Specific Products

Product Type:

Physical collection (samples, etc.)

Product Description:

There are now over 31,000 water samples in the HBES Archives Building, located at the USDA Forest Service Headquarters at the Hubbard Brook Experimental Forest. A HBES document archive continues to be maintained in the library at the Institute of Ecosystem Studies by P.C. Likens.

Sharing Information:

All samples will be handled individually by the scientist who submits them.

Product Type:

Teaching aids

Product Description:

During 2007 we introduced a new website for Mirror Lake to feature a virtual tour of Mirror Lake and its watershed as part of our outreach activities. A sixth-grade teacher, Mr. Gerry Gontarz, in the Plymouth School System, NH worked on this virtual tour project as an NSF-supported Research Experiences for Teachers (RET) and has been updating and perfecting this virtual tour through the 2005-2006 and 2006-2007 school years with his sixth-grade students. http://www.hubbardbrook.org/mirrorlake_tour/index.html

Sharing Information:

As with our website and the Hubbard Brook virtual tour, this new site will be refined on the basis of the past year's experience and then more widely disseminated, first to school groups who visit the HBEF for field trips.

Product Type:

Presentation

Product Description:

Powerpoint presentation by Natalie Solomonoff entitled: "Changes in tree species composition and biomass in Hubbard Brook Valley: 1995-2005"

Sharing Information:

This presentation was presented at the annual HBES Cooperator's meeting.

Product Type:

Data or databases

Product Description:

Three databases: W1 inventory, demography plot, Valley plots.

Sharing Information:

databases are being shared with other researchers at the HB-LTER.

Product Type:

Data or databases

Product Description:

Developed a searchable database making the taxonomic and ecological information on the HBEF Lepidoptera accessible to the general public. This FileMaker database includes images and abundance data for close to 200 species and morphospecies.

Sharing Information:

Via the web:

http://www.hubbardbrook.org/data/dataset_search.php
http://www.dartmouth.edu/~estange/mothbd.htm

Product Type:

website

Product Description:

http://nationalzoo.si.edu/ConservationAndScience/MigratoryBirds/Research/Climate_Change/

Sharing Information:

The effect of climate change on migratory birds.

Product Type:

Teaching Aides

Product Description:

Two teaching guides have been completed by the Hubbard Brook Research Foundation, with extensive involvement of the Hubbard Brook

Committee of Scientists. Both rely heavily on Hubbard Brook data and emphasize major themes of research at the site (Acid Rain and Migratory Birds).

Sharing Information:

The teaching guides are supported by HBRF hosted teacher training events, as well as staff attendance and presentation at conventions for secondary science teachers, including the annual meetings of the New Hampshire Science Teachers Association and the New England Environmental Educators Association.

Product Type:

Website

Product Description:

http://www.hubbardbrook.org/research/animals/bird/holmes-intro03.htm

Sharing Information:

The site describes long-term research on birds at the HBEF, including studies at the population, community and ecosystem level. Recent reasearch in avian ecology is highlighted on the Current Research pages.

Product Type:

Data or databases

Product Description:

Database of mapped tree locations in 9 ha forest demography plot in the hemlock-hardwood community in Hubbard Brook Valley (2^nd of 3 demography planned).

Sharing Information:

The mapped demography data is being processed and checked for consistency. The data will be made available to all internal HB collaborators by Summer 2009. Data will be posted on HB LTER network site after the PhD student finishes her dissertation. Expected May 2010

Product Type:

Data or databases

Product Description:

Database of 10-yr remeasurement of the valley-wide forest plots. Will permit landscape scale exploration of spatial patterns in biomass accumulation and tree productivity.

Sharing Information:

Most of the remeasured valley-wide forest plot data is already available to HB collaborators. The full 10-yr data will be posted to the HB LTER network site by Summer 2009.

Product Type:

Data or databases

Product Description:

?Dear Associates? Letter: Hubbard Brook valley-wide survey of moose winter density and browsing impact for 2007/08.

Sharing Information:

We are currently working with the data archivist and web manager to provide a repository of all "Dear Associates" letters that summarize interim results and procedures for the Hubbard Brook Valley vegetation analyses.

Contributions

Contributions within Discipline:

Research in the Hubbard Brook LTER program seeks a better basic understanding of the discipline of ecosystem biology, especially biogeochemistry and energy flow. Our long-term measurements of a suite of large-scale experiments has contributed to refined understanding of the interactions between ecological processes and biogeochemical cycles, as elucidated in our series of six monographs on particular chemical elements in the Hubbard Brook landscape. Our studies of energy flow through the complex herbivore and detrital food webs integrates knowledge across sub-disciplinary lines including vegetation dynamics, microbial ecology and heterotroph population dynamics.

Contributions to Other Disciplines:

Beyond the core disciplines of ecosystem biology and biogeochemistry, the HBR LTER Program contributes to allied research disciplines in the physical and biological sciences. Our work attracts the interest of geochemists and physical hydrologists as well as that of molecular and cell biologists. The continuity of standardized and well-documented data collection is a hallmark of the HBR LTER; this aspect of the long-term studies at our site provides an internationally recognized benchmark for many disciplines of field-oriented research.

Contributions to Human Resource Development:

The Hubbard Brook LTER Project makes an active effort to develop human resources at many stages of development, from K-12 through post-doctoral. Most recently we have undertaken a REU Site project designed to provide students with both an understanding of basic science research and its application to societal needs. Through our educational and research activities numerous students and technicians have advanced their capacity for addressing the environmental problems that face 21st Century society. A continuous stream of researchers has been nurtured in the HBR LTER, eventually to reach prominent positions in academic, governmental and private sector institutions. We have encouraged the participation of females and minorities in our project through recruitment at our participating Universities and throughout the world.

Contributions to Resources for Research and Education:

Building upon its tradition of contributing to public education and policy development, the Hubbard Brook LTER project has developed two principal outreach and educational programs: the Science Links and Environmental Literacy programs. Science Links is designed to communicate scientific results to policy makers and the general public in areas such as acid rain, nitrogen deposition and mercury pollution. Most recently we have been working on Science Links projects concerning Long-term Environmental Monitoring and Forest Carbon. By providing a politically-neutral scientific appraisals of the state of research on these topics, Science Links performs a public service that is not easily accomplished either by government agencies or by environmental NGO's. The Environmental Literacy program is a cooperative effort with the USDA Forest Service to train K-12 teachers in northeastern states in the fundamentals of forest ecology. The Forest in Every Classroom initiative is achieving this goal through teacher training workshops and curriculum development.

Contributions Beyond Science and Engineering:

Society is confronted with difficult choices about the degree of pollution abatement that is necessary to achieve desirable outcomes in terms of environmental quality. The long-term data sets from HBEF provide among the best objective information available on which to base judgments about the threats of pollution to forest health, soil and water quality, and about the effectiveness of pollution abatement efforts in reducing those threats. Temporal trends can be evaluated against the backdrop of natural variation in reference and manipulated catchments, providing both parameter values and validation data for predictive models. Cost-effective environmental protection depends upon using these models to project the benefits of particular pollution abatement strategies. Hubbard Brook is a cornerstone of such efforts.

Special Requirements

Special reporting requirements: None

Change in Objectives or Scope: None

Animal, Human Subjects, Biohazards: None

Categories for which nothing is reported:

Research Activities: 2008

The HBR LTER program utilizes experiments, surveys and long-term monitoring to improve overall understanding of the structure and function of northern hardwood forests and coupled aquatic ecosystems. During the past year we have continued to pursue a suite of biogeochemical and ecological questions that can be classified into seven major areas of study. In the following summary we explain our principal results and insights that have been completed during 2007-2008 in each of these areas.

1. Long-term studies of biogeochemical cycles

a. *Sampling frequency analysis*. Systematic weekly collections of precipitation and stream water continued from sites in the Hubbard Brook Experimental Forest (HBEF) and Mirror Lake in the Hubbard Brook Valley of the White Mountains of New Hampshire. Sites consist of south-facing, gauged Watersheds 1, 2, 3, 4, 5 and 6, north-facing, gauged Watersheds 7, 8 and 9, and Mirror Lake and its three gauged Inlets and outlet. Bulk precipitation collectors are also maintained at four sites, ranging in elevation from 256 to 665 m.

Our long-term research has required a large investment in funding and time resources to maintain this systematic, weekly regimen. Using our long-term stream chemistry database, we did a comparison between annual watershed solute exports calculated two ways: (1) using all of our routine weekly data from a year, and (2) derived from a single monthly sample chosen from the middle of each month. The two wettest years (1973 and 1995), the driest year (1964), and one year with near average precipitation (1985) were chosen. The results of this test of sampling frequency clearly showed highly variable and large (15% to 150%) differences in the annual export of hydrogen ion, nitrate, and silicate, in particular, but smaller differences (5 to 15%) in the estimation of calcium and sulfate export. This sensitivity test also revealed that the differences were highly dependent on the timing of water flux as well, and not simply on an annual basis, but seasonally as well. We concluded from this comparison that while our log-term commitment to regular weekly samples is the highest frequency we can maintain from a logistical and financial standpoint, the weekly approach is absolutely necessary to derive the most accurate solute export estimates.

b. *Nitrogen retention*. Stream export of nitrogen (N) as nitrate (NO_3^-; the most mobile form of N) from forest ecosystems is thought to be controlled largely by plant uptake of inorganic N, such that reduced demand for plant N during the non-growing season and following disturbances results in increased stream NO_3^- export. The roles of microbes and soils in ecosystem N retention are less clear, but are the dominant controls on N export when plant uptake is low. We used a mass balance approach to investigate soil N retention during winter (December through March) at the HBEF by comparing NO_3^- inputs (atmospheric deposition), internal production (soil microbial nitrification), and stream output. We focused on months when plant N uptake is nearly zero and the potential for N export is high. Although winter months accounted for only 10-15% of annual net nitrification, soil NO_3^- production (0.8-1.0 g N m^{-2} $winter^{-1}$) was much

greater than stream export (0.03-0.19 N m^{-2} $winter^{-1}$). Soil NO_3^- retention in two consecutive winters was high (96% of combined NO_3^- deposition and soil production; year 1), even following severe plant disturbance caused by an ice-storm (84%; year 2). We show that soil NO_3^- retention is surprisingly high even when N demand by plants is low. Our study highlights the need to better understand mechanisms of N retention during the non-growing season in order to predict how ecosystems will respond to high inputs of atmospheric N, disturbance, and climate change.

c. *Silica dynamics.* In terrestrial ecosystems the largest pool of amorphous silica (ASi) is stored in soils and is an important reservoir of biologically active Si for the global biogeochemical cycling of Si. Only limited data are available that quantify the size of this reservoir and often these estimates are made from the physical separation of silt-sized phytoliths, which can underestimate the ASi pool. Soil samples from five watersheds in the Hubbard Brook Experimental Forest were analyzed for ASi using alkaline digestion. Soils from two of the watersheds were analyzed after forest removal. In undisturbed watersheds ASi is concentrated at the surface of the soil profile, similar to organic matter, and then progressively decreases with depth. In watersheds disturbed by forest removal, ASi was lost from the upper soil horizons and was translocated down the soil profile. Although significant decreases in ASi concentrations were observed in the upper soil profile, estimates of the ASi pool before and after harvesting show that the total ASi pool remained essentially unchanged. The ASi pool was estimated to be 17400 Kg/ha prior to harvesting (1983) and 17500 Kg/ha after harvesting (1986). More studies are needed, as significant increases in the transport of dissolved silicate by rivers have been observed with deforestation, and the ASi pool in soils may play an important role.

d. *Dynamics of iron.* Iron (Fe) is abundant among trace elements in forest ecosystems and is important in the development and function of soils. We used measurements from the biogeochemical reference watershed (w6) to better understand the biogeochemical behavior of Fe. We developed a series of mass balance calculations to track to the fluxes of Fe through the forest ecosystem to drainage waters. This includes the examination of Fe speciation, the distribution between oxidized (ferric iron, Fe(III)) and reduced (ferrous iron, Fe(II)) species, in litterfall inputs to the forest floor, freely draining soil solutions, and stream water. In solutions draining through the soil profile we found a general pattern of higher total Fe and Fe(II) concentrations in solutions draining the organic (Oa) horizon relative to the underlying mineral (Bh and Bs) horizons, except in the higher elevation spruce-fir zone where pH is lower and dissolved organic carbon (DOC) inputs to the mineral soil are greater. The portion of total Fe as Fe(II) in soil solutions ranges from approximately 10-60%, seemingly high for soils that are considered well drained and oxidizing. The Fe(II) in leaf litter extract was approximately 50% of total Fe. These results, coupled with measures of dissolved oxygen in soil solutions, suggest that Fe(II) persists in soil solutions despite relatively oxidizing conditions in the soil. Complexation with DOC compounds could explain the occurrence of Fe(II) in solution. Additionally, periods of reducing conditions or anaerobic microsites may account for elevated concentrations of Fe(II). While Fe was present in relatively high concentration in soil solution, it was minimal in stream water

except at the upper reach of the watersheds in the spruce-fir zone. This pattern suggests that Fe enters the streams complexed with DOC and is co-precipitated or oxidized to less soluble forms relatively rapidly.

e. *Acid base chemistry in relation to mercury*. We quantified acid-base chemistry, dissolved organic carbon (DOC) dynamics, hydrologic flow paths and source areas, and mercury mobilization during snowmelt at the biogeochemical reference watershed (w6). We showed that: (1) episodic acidification during snowmelt at the HBEF is controlled by multiple mechanisms (base cation dilution, mobilization of nitrate, aluminum, and natural organic acids) and persists despite recent decreases in acidic deposition; (2) episodic acidification continues to result in mobilization of inorganic monomeric aluminum to levels toxic to fish; (3) DOC mobilized from shallow organic soils during snowmelt results in the mobilization of mercury from these same sources; (4) methyl mercury is produced in the forest floor over winter and flushed from soils during snowmelt; (5) the amount of mercury released during snowmelt likely represents a large portion of annual mercury export; and (6) hydrologic flow paths and source areas, and DOC dynamics, strongly influence both episodic acidification and mercury mobilization, even in a watershed with low stream water DOC concentrations and export (Demers et al., in press).

2. **Ecosystem modeling and remote sensing**

We employ a suite of ecosystem models based upon the original formulation of PnET as well as satellite-based remote sensing to provide integrated analyses of long-term and large-scale behavior of ecosystem dynamics. During the last year three principal new scale-up efforts were completed.

a. *Response of a forest watershed to changing climate*. Climate is a key regulator of forest ecosystems, and climate change has complex direct and indirect effects on the structure and function of ecosystems. Ecosystem responses to climate change have been studied by long-term monitoring, cross-site analysis, laboratory and field studies; however, biogeochemical models are the only practical approach to assess the long-term effects of climate change on ecosystems along with other drivers of global change such as atmospheric deposition and land disturbance. We used a biogeochemical model (PnET-BGC) to evaluate the effects of predicted changes in temperature, precipitation, PAR and atmospheric CO_2 concentration on pools and fluxes of major elements at the biogeochemical reference watershed (w6). Future emissions scenarios are monthly output from two atmosphere-ocean general circulation models (AO-GCM; HadCM3 and PCM) which were statistically downscaled, in conjunction with potential lower and upper bounds of projected atmospheric CO_2 (550 and 970 ppm by 2099, respectively). The AO-GCM outputs showed an average increase in temperature ranging from 1.9 to 6.7°C over 21st century and a 3.7 to 19.5 cm average increase in precipitation. PnET-BGC simulations of w6 under a changing climate showed a marked shift in the watershed nitrogen budget (NO_3^- and NH_4^+) from a net sink to a net source, indicating a net nitrogen loss between 2 to 10 kg N/ha- yr under different scenarios. This net loss of nitrate coincided with marked acidification of

soil and streamwater. Streamwater pH decreased from a 0.24 to 0.64 units. The soil base saturation and Al/Ca ratio showed an average decrease ranging from 1.30% to 5.25%, and 0.07% to 0.53%, respectively.

b. *Regional forest carbon accounting*. Accurate accounting of standing carbon stocks in vegetation is critically important for calculation of existing carbon budgets and estimation of future carbon storage potential. In light of the Regional Greenhouse Gas Initiative (RGGI), which has been ratified by 10 northeastern US states, this issue has become significantly more important regionally. RGGI provides mechanisms for participating states to trade carbon credits based on calculated emission and sequestration of this important greenhouse gas. However, within each state, budgetary estimates are generally computed on a county basis due to the nature of forest surveying techniques and tax/census records. While the USDA Forest Service Forest Inventory Analysis (FIA) program provides estimates of existing biomass for all states/counties within the region, estimating maximum biomass and future sequestration potential is substantially more challenging.

   We derived county-level estimates of live biomass stocks for the state of New Hampshire from FIA and contrasted these with potential storage generated by PnET. The model uses information on climate, soils and county-level species composition to estimate maximum biomass at forest maturation (assuming no change in climate or total forest area). A wide range carbon storage potential among counties results from differences in both forested land area and mean stand age. Future work will extend estimates to other counties across the Northeast and to future projections of changes in climate and land use.

c. *Regional analysis of canopy nitrogen, carbon assimilation and forest-climate feedbacks*. Remote sensing work focuses on assessing patterns of ecosystem composition, structure and function and extending rates of C and N cycling in forests from local to regional scales. At Hubbard Brook and the Bartlett Experimental Forest, much of the image data come from NASA's hyperspectral AVIRIS and Hyperion instruments, as well as NASA's LVIS Lidar instrument. Both sites have recently been incorporated into a core project of the North American Carbon Program intended to examine the degree to which canopy nitrogen concentrations influence spatial patterns in C assimilation across a range of forest ecosystem types at a continental scale.

   Field measurements from Hubbard Brook, Bartlett and several additional sites within the AmeriFlux network have been combined with hyperspectral remote sensing data from the AVIRIS and Hyperion instruments. Results from a cross-site synthesis indicate a positive relationship between canopy N and the maximum rate of carbon assimilation, as measured by flux towers.

   Although existing methods of canopy N detection are restricted to small landscapes, a parallel investigation involves developing generalizeable canopy N detection methods that would enable regional to continental application of these results. Results of this effort show that a substantial fraction of the variation in canopy N can be related to

simple spectral features, largely within the NIR region, and to the overall image brightness, determined as the mean reflectance across the entire solar reflectance spectrum.

Because mean reflectance is functionally similar to shortwave surface albedo, we also examined relationships between site-level canopy N and albedo estimates obtained from the MODIS instrument. A strong, positive relationship between these two variables suggests that nitrogen plays an important and previously unrecognized role in the Earth's climate system through its influence on surface energy exchange as well as on rates of CO_2 assimilation. These results also suggest that we already possess the capacity to estimate canopy nitrogen and maximum C assimilation over large areas, using the observed relationships with surface reflectance.

3. **Fine root dynamics**

During the last year we have continued to refine our understanding of fine root dynamics in northern hardwood forest ecosystems using both surveys and experimental approaches. Fertilization of forest plots at HBR and a complementary site reduced microbial biomass and activity in soil, and the magnitude of this effect was greater in the rhizosphere than bulk soil. Hence, soil fertility appears to mediate the effect of roots on microbial activity in northern hardwood soil, probably in part because of shifts in belowground carbon supply (Phillips and Fahey 2008). We compared fine root biomass, production and turnover across a soil calcium availability (Park et al. 2008) that included sites at HBR. Fine root turnover increased with increasing soil Ca, suggesting that continuing soil cation depletion might lead to reduced C allocation to fine roots in these forests. Earlier experimental studies at HBR had indicated that soil freezing increased root mortality. We examined the mechanism of soil freezing effects on fine roots using field experiment (Cleavitt et al. 2008). Results indicated that direct cellular damage was the principal mechanism of root injury. Winter damage to roots also stimulated compensatory increases in root growth and a pulse of soil nitrate leaching. In the future more frequent soil freezing events could play an important role in forest ecosystem dynamics in a changing climate. Finally, we quantified the depth distribution of fine roots of the dominant northern hardwood tree species at HBR and at a complementary site (Yanai et al. 2008) based on gross morphology differences between species and verified by genetic methods. The vertical distribution of fine roots differed slightly but significantly among species, providing a first step towards better understanding the nature and intensity of interspecific competition belowground in northern hardwood forest ecosystems.

4. **New studies of denitrification**

a. *Methods development*. Denitrification is an anaerobic microbial process that leads to the production of the gases nitric oxide, nitrous oxide and dinitrogen. There is great interest in the production of these gases as humans have more than doubled the global circulation of “reactive” nitrogen (N), leading to degradation of air and water quality and coastal ecosystems in many areas. The development of solutions to N

pollution problems has been hindered by large amounts of "missing N" that dominate N balances at all scales. A major question is if the production of gases can account for a significant percentage of the missing N in balances. However, the fluxes of these gases are difficult to quantify because of problematic measurement techniques (especially for dinitrogen), high spatial and temporal variability, and a lack of methods for scaling point measurements to larger areas.

The two new methods; a gas flow soil core incubation system and an *in situ* ^{15}N tracer method, were developed and applied at eight sites in and around Hubbard Brook. Gas-flow soil core systems connect containers for soil cores to gas chromatographs (GCs) via gas-tight tubing and fittings. The GCs are equipped with detectors that can analyze both N_2 and N_2O. The incubations are run after the cores' headspaces have been replaced with an N_2- and N_2O-free atmosphere and accumulation of these two gases in the core containers is measured over time. By using sensitive detectors and high quality stainless steel tubing and fittings, gas-flow soil core systems allow for precise measurements of N_2 and N_2O at very low levels. This method allows for measurement of denitrification fluxes without modification or destruction of the soil core.

^{15}N tracer methods have the great advantage of providing *in situ* measurements that can be run over considerably shorter time periods than gas flow soil core incubation methods. These methods require addition of nitrate to the soil as the tracer along with water to carry the label into the soil. Such additions can artificially increase denitrification rates, but tracer level additions (~5%) are not thought to have a significant effect on rates. A major challenge is achieving and assessing uniform distribution of the labeled nitrogen in the soil. Accurate calculation of denitrification rates requires measuring the true enrichment of the pool of nitrate that is actively being reduced in denitrification.

b. <u>*Recent observations of denitrification*</u>. N_2 levels always increased in direct flux method incubations, but N_2O levels sometimes decreased after accumulating, indicating consumption of N_2O later in the incubation. N_2:N_2O ratios measured by the direct flux method were very high (> 10:1).

Extrapolating measured direct flux rates over a 180 day growing season produced estimates of denitrification (116 kg N ha^{-1} y^{-1}) that are very (too!) high relative to atmospheric deposition to the site (~ 10 kg N ha^{-1} y^{-1}). We suspect that these high estimates arise from the fact that we incubated all cores at 5% O_2, and extrapolated measured rates over a 180 day growing season. In laboratory experiments, we varied the O_2 level of the recirculating gas and found that N_2 fluxes dropped to zero and N_2O fluxes were also dramatically reduced at 10% O_2 in the headspace. So the question is, how many days of low (5%) O_2 levels do we have at Hubbard Brook? If we assume that soil O_2 levels only go as low as 5% following rainfall events > 2 cm, then we would extrapolate rates measured under 5% O_2 headspace to only 38 days of the season (# days with > 2 cm rain in 2005). This produces a more reasonable, but still high, seasonal N_2 flux of ~24 kg N/ha.

Several different ^{15}N and $^{15}N_2O$ accumulation patterns emerged in the incubations for the isotope tracer method. The simplest pattern was a linear increase from ambient levels of ^{15}N, indicating biological denitrification of the ^{15}N that we added. The most complex patterns we observed were time 0 values above ambient. We considered the source of this initial burst of ^{15}N production to be chemodenitrification, induced by our addition of NO_3^- and water. In some cases, headspace ^{15}N decreased after the initial burst. When this occurred with N_2, we assumed a zero biological N_2 flux rate. For N_2O, we calculated decreases in enrichment as negative fluxes, or biological consumption of N_2O. In other cases, we observed increases in headspace ^{15}N after the initial burst suggesting that both abiotic and biotic production were occurring. The abiotic production suggests that bursts of chemodenitrification can occur when water and nitrate are added to these soils. The relevance of these results to atmospheric deposition during actual rainfall events warrants further investigation.

5. **Vegetation dynamics**

We use a suite of permanent plots arranged at various scales to address key questions about the demography, productivity and nutrient dynamics of vegetation.

a. *Valley-wide forest dynamics*. A 500-m grid of tagged tree plots was established over Hubbard Brook Valley between the summers 1995-1998. In 2007, we completed the 10-year resurvey, as all 431 plots have now been revisited. The results from the main grid of 371 plots were presented in a master's thesis filed in December 2007 and a resulting publication has been submitted. During the ten-year period from 1995/6 to 2005/6, there was no significant change in total live tree biomass. Valley-wide, live tree biomass held steady with a mean of 245 $\pm$ 11 $Mg \cdot ha^{-1}$. Annual mortality during the period for trees ≥ 10-cm diameter at breast height (1.37 m) averaged 9.7 $trees \cdot ha^{-1} \cdot yr^{-1}$ (95% CI of annual mortality rate = 1.36 – 1.84 % yr^{-1}). Tree recruitment into the census pool was 8.4 $trees \cdot ha^{-1} yr^{-1}$ (95% CI = 5.8-10.6).

Despite constancy in overall aboveground biomass, there were species-level shifts across the Valley. Of the 19 species, three experienced significant declines in aboveground biomass while four increased in biomass. Balsam fir, eastern hemlock, red spruce and white ash increased in biomass. Only three species, mountain ash, striped maple, and yellow birch experienced declines. The most significant net change occurred in yellow birch [4.57 $Mg \cdot ha^{-1}$ (95% CI: -8.42, -0.92)]. This represents a 7% decline over ten years. However, yellow birch remains the single most abundant species in the Valley (18% of total density).

b. *Paper birch decline*. Long-term datasets collected at HBR have provided valuable insights into the nature and causes of a recent forest decline in the Northeast. Exceptionally high mortality of mountain paper birch (*Betula papyrifera* var. *cordifolia*) has been observed during the past several years in the mountains of northern New England. At HBR we observed very high mortality in permanent plots on experimental watersheds 1 and 6 between 2002-2007, and similarly high mortality was observed

sporadically across the wider HBR valley. Analysis of leaf litterfall and tree rings from permanent plots indicated that birch trees injured by the 1998 ice storm were steadily recovering through 2002 when a severe late summer drought caused pre-mature leaf senescence. Thereafter, nearly all trees went into steady decline and died over the next 4-5 years. These observations provide an explicit and quantitative example of how repeated disturbances incite decline of forest trees and inform general models of the decline process.

c. *Reproduction of American beech.* Despite the recognized importance of root sprout production in northern populations of American beech (*Fagus grandifolia* Ehrh.), further consideration of the relative role of regeneration from seed in this species appears warranted and timely. A careful examination of the literature revealed that seed- and sprouts-origin individuals co-occurred within all published study sites where the two were differentiated and that presence of a seedling bank may be the rule rather than the exception for American beech. We compared the effects of canopy gaps and root trenching on the growth and survival of a cohort of beech seedlings. Seedlings in gap plots became larger both above- and belowground. Foliar nitrogen concentrations were affected by both above- and belowground treatments and increased the most for seedlings in trenched gap plots. Seedling height and canopy treatment were important predictors of seedling survivorship with the highest survival in gap locations. The relationship between seedling height and survival was more complex. In the first two years, taller seedlings had a higher probability of dying, while after the second year taller seedlings were more likely to survive to be four-years old. The relatively high survivorship of seedlings at HBEF and their response to gap openings taken together with literature documentation of the long-term presence of seed-origin beech stems in the understory strongly suggest the presence of a beech seedling bank in this forest. This is one of a few manipulative studies on naturally regenerating American beech seedlings, and the first study to relate the likelihood of survival to seedling traits for this important species in the northern hardwood forest (Cleavitt et al. 2008).

6. **Heterotroph populations**

a. *Lepidoptera dynamics*. During 2008 we completed a study of Lepidoptera community dynamics. The completed project focused on how climate influences the spatial and temporal fluctuations in Lepidoptera abundance and biomass. It addresses three specific questions. 1) Are inter-annual fluctuations in abundance and biomass the result of population growth rates that are correlated across numerous species? 2) Do specific ecological attributes of the community's species contribute to correlated dynamics of groups of species such that the causal mechanisms shaping population dynamics can be identified? 3) Can inter-annual climatic variability alter soil nutrient availability such that it produces bottom-up effects on the demography of Lepidoptera? Three years of moth trapping showed evidence of some synchrony in Lepidoptera community dynamics. The mean interannual population growth rate (ind. • ind.-1 • year-1) for species represented by > 5 captures in either year was significantly less than zero for 2004-5, but not for 2005-2006 (N = 100 species). This sampling effort

was accompanied by ongoing work cataloging all relevant ecological information for the identified species to determine if certain definitions of functional groups (based on phenology, host plants, life history strategies, etc.) within the community exhibit particularly strong interannual population synchrony, thereby indicating how climatic conditions may be driving population dynamics of this community. Last, numerous Lepidoptera species showed significant and correlated interannual differences in adult body size, suggesting that Lepidoptera community dynamics may originate from interannual variation in nutritional quality of host plants. Current work includes foliar analyses to investigate whether foliage P-content, condensed tannins, or total phenolics varied interannually. Growth trials revealed interannual differences in the growth rates of forest tent caterpillars on sugar maple and beech foliage, and chemical analyses of foliage from the four dominant hardwood species (*Acer pensylvanicum, Acer saccharum, Fagus grandifolia and Viburnum alnifolium*) indicated that foliar nitrogen content varied meaningfully across years, affecting both the rate at which leaves mature and the final composition of mature leaves. However, experimental manipulation soil nutrients did not affect growth of white-marked tussock moth (WMTM) in bioassays.

We developed a searchable database with the intention of making the taxonomic and ecological information on the HBEF Lepidoptera accessible to the general public. This FileMaker database includes images and abundance data for close to 200 species and morphospecies.

b. *Food webs and beech bark disease*. Reductions in beech abundance and average tree size due resulting from beech bark disease should reduce the quantity and frequency of beech seed production ("mast"), which would cause cascading effects throughout the herbivore food chain, including decreases in small mammals and their predators, and fluctuation or decline in nest predation of songbirds by small mammals. In summer 2008, we again carried out a valley-wide survey of small mammals and songbirds. Three surveys of birds and of diurnally active small mammal were conducted at 300+ points distributed in a spatially stratified manner through out the valley. In addition, seed-fall surveys were conducted in the long-term avian demography study areas to quantify relationships between mast production, small mammal abundance and bird demography.

c. *Efficacy of point-count bird abundance estimates*. Our valley-wide survey data for birds is being used to assess the efficacy of using the point-count data to assess abundance accurately and to monitor spatial and temporal fluctuations in abundance. In 2008, we made significant progress by publishing on patterns of occupancy across a habitat quality gradient (Betts et al. 2008), and by beginning a pilot study of the efficacy of digitally recorded song for assessing bird density. The latter has the potential to revolutionize bird surveys if the methods can be improved and generalized from our test species, the black-throated blue warbler to all species breeding in the HBEF.

7. **Studies on Mirror Lake**

a. *Persistence of algal co-limitation*. Mirror Lake, a small clearwater oligotrophic lake in the White Mountains of New Hampshire was shown to be co-limited by both nitrogen and phosphorus in the early 1970s. Because of continued interest in limits to ecosystem productivity, cultural eutrophication and issues related to atmospheric nitrogen pollution, we repeated a similar study to determine if limits to algal productivity had changed during the subsequent 30 years. We used *in situ* mesocosms to study the response of algae to nitrogen and phosphorus additions. We hypothesized that after 30 years of increased atmospheric nitrogen input that Mirror Lake would no longer be limited by nitrogen, but would be solely limited by phosphorus. Our results were remarkably similar to the original experiment and clearly showed continued limitation by both nitrogen and phosphorus. It also appears that another undetermined factor may be limiting phytoplankton productivity, as Chl-*a* concentrations in the enclosure with added nitrogen and phosphorus only increased to about 6 µg/L, similar to the results in the original experiment (Bade et al. 2008).

b. *Evaporation comparisons*. Monthly evaporation from Mirror Lake, was determined using fourteen alternate evaporation models during six open-water seasons and compared with values from the Bowen-ratio energy-budget (BREB) model, considered the standard. Values from the Priestley-Taylor, deBruin-Keijman, and Penman models compared most favorably with BREB-determined values. Differences from BREB values averaged 0.19, 0.27, and 0.20 mm d^{-1}, respectively, and results were within 20 percent of BREB values during more than 90 percent of the 37 monthly-comparison periods. All three models require measurement of net radiation, air temperature, change in heat stored in the lake, and vapor pressure, making them relatively data intensive. Several of the models exhibited substantial bias when compared with BREB values and were modified to eliminate bias. Models that rely only on measurement of air temperature, or air temperature and solar radiation, were relatively cost-effective options for measuring evaporation at this small New England lake, outperforming some models that require measurement of a greater number of variables.

Research and education activities: 2008

The LTER project at Hubbard Brook Experimental Forest is designed to address basic and applied problems in forest ecosystem biology with an emphasis on biogeochemical cycling and the role of natural and anthropogenic disturbance in shaping ecosystem dynamics. Many of our research activities are focused at the scale of small, headwater catchments where experimental manipulations have been conducted to examine ecosystem structure and function. Over the past several decades we have developed a suite of core environmental and biotic monitoring programs designed to provide essential information for better understanding ecosystem dynamics. These sampling programs include 1) vegetation biomass, productivity and element dynamics, 2) microbial biomass and activity, 3) the chemical composition of bulk precipitation, soils, soil water, vegetation and stream water, and 4) abundance of a variety of heterotrophic organisms: birds, small mammals, fungi, microarthropods, lepidopteran insects, and salamanders. Increasingly our research has expanded to include the scale of the whole Hubbard Brook Valley as well as the regional forested landscape. The long-term records from our site provide a basis for interpreting regional and global observations of ecosystem dynamics, and we are contributing to interpretation of these observations by synthesizing the state of knowledge for lay audiences. In the following report we highlight several prominent recent results and new initiatives funded primarily by the LTER program in the past year.