Annual Report for Period: 12/2004 - 12/2005
Principal Investigator: Williams, Mark W.
Organization: U of Colorado Boulder
Title:
Long Term Ecological Research: The Landscape Continuum Model: A Biogeochemical Paradigm for High Elevation Ecosystems

Project Participants

Senior Personnel

Name: Williams, Mark

Worked for more than 160 Hours: Yes

Contribution to Project:
Dr. Mark Williams is the current PI of the NWT LTER project and is project director. Provides overall project guidance and leadership. His research areas are in snow hydrology, surface-groundwater interactions, terrestrial-aquatic interactions, and biogeochemistry.

Name: McKnight, Diane

Worked for more than 160 Hours: Yes

Contribution to Project:
Dr. McKnight is a Co-I on the NWT LTER program. Her research focuses on limnology, aquatic ecology, reactive transport of metals and organic material in mountain streams and rivers. She is the NWT LTER lead on K-12 outreach activities.

Name: Seastedt, Timothy

Worked for more than 160 Hours: Yes

Contribution to Project:
Dr. Tim Seastedt is a Co-I on the NWT LTER program. He is the former lead PI of the NWT LTER program. He provides continuity in leadership as well as mentoring as M. Williams transitions to the lead PI position. His research interests focus on terrestrial ecosystem studies, including factors influencing primary productivity, soil carbon dynamics, decomposition and mineralization processes, and how these processes affect short- and long-term ecosystem-atmosphere interactions. Ongoing research collaborations involve cross-site comparisons of mechanisms controlling nutrient availability, carbon storage, and biotic productivity, invasive species, and ecosystem processes-biodiversity relationships.

Name: Bowman, William

Worked for more than 160 Hours: Yes

Contribution to Project:
Dr. William Bowman is a Co-I on the NWT LTER project. He is also director of the Mountain Research Station. His research has focused on the interaction between plants and their resources, broadly defined from plant adaptations to low resource availability to how plants influence soils and subsequently ecosystem function. Over the past decade his work has concentrated on the interaction between alpine plants and nutrients, examining the response of plants to low nutrient supply, as well as the influence that plants have on their nutrient environment.

Name: Townsend, Alan

Worked for more than 160 Hours: Yes

Contribution to Project:
Dr. Alan Townsend is a Co-I on the NWT LTER project. His research is largely within the fields of terrestrial ecosystem ecology and biogeochemistry, with a focus on tropical and alpine ecosystems which include: controls over nutrient limitation and carbon storage in moist tropical and alpine tundra ecosystems; the effects of human activity on regional to global scale carbon and nitrogen cycling, and the effects of changing biogeochemical cycles on human health.

Name: Blanken, Peter

Worked for more than 160 Hours: Yes

Contribution to Project:
Dr. Peter Blanken is new to the NWT LTER project. He is an associate professor in Geography and an expert in boundary layer climatology. He is the lead on installing and operating two eddy covariance towers at NWT LTER, beginning summer 2006.

Name: Bourgeron, Patrick
Dr. Bourgeron is a research scientist at INSTAAR and continues his involvement with the NWT LTER program. He co-chairs the US portion of ILTER activities. His research focuses on ecotone/Treeline studies.

Name: Caine, Nel

Contribution to Project:
Nel Caine is a former lead PI on the NWT LTER project. His involvement provides continuity in leadership as well as a historical perspective for the NWT LTER program. He is a hydrologist, glaciologist, and geomorphologist who is now looking at responses of these systems to changes in climate over the last several decades.

Name: Helmig, Detlev

Contribution to Project:
Detlev Helmig investigated the transfer and uptake of atmospheric ozone in seasonal, mid-latitude snowpack at a subalpine forest site at Niwot Ridge, Colorado. He is a research scientist based at CU-INSTAAR.

Name: Mast, M

Contribution to Project:
Dr. M. Alisa Mast is a senior scientist on the NWT LTER project. She is a hydrochemist with the USGS-WRD based out of Lakewood, CO, specializing in atmosphere-aquatic interactions. Alisa is a cooperating scientist with the USGS WEBB project at nearby Loch Vale watershed, the other major high-elevation research program in the US. Alisa's new involvement with the NWT LTER provides the opportunity for closer links with the USGS, while also facilitating the expansion of the NWT LTER research focus to the Rocky Mountain region.

Name: Losleben, Mark

Contribution to Project:
Mark Losleben continues as climatologist at the NWT LTER, a position he has held continuously since 1982. This year his position was changed from 50% LTER and 50% MRS to 100% LTER, with the 50% that was previously supported by the MRS now supported by INSTAAR. Mark now reports directly to the NWT LTER PI.

Name: Monson, Russel

Contribution to Project:
Russ Monson is a professor of EEB at CU-Boulder and continues his involvement with the NWT LTER. He is PI of the Niwot Ridge Ameriflux Site, located at the subalpine forest on Niwot Ridge. His involvement assures good cooperation between alpine and subalpine systems at NWT ridge.

Name: Neff, Jason

Contribution to Project:
Dr. Neff is an assistant professor in Geosciences at CU-Boulder. His involvement brings new energy, enthusiasm, and direction to the NWT LTER program. His research focuses on fundamental studies of terrestrial biogeochemistry, working toward an understanding of how ecosystems work and how human activities can influence the service and function ecosystems provide humanity.

Name: Sanford, Robert (Buck)

Contribution to Project:
Dr. Sanford is a professor in Biology at the University of Denver and continues his involvement with the NWT LTER program. His research focuses on nutrient cycling in terrestrial soils. He is also director of the Mt Evans Research Program and provides complementary high-altitude research areas.

Name: Schmidt, Steven
Worked for more than 160 Hours: Yes
Contribution to Project:
Steve Schmidt is a professor of EEB and continues his involvement with the NWT LTER program. He is PI on the recently-funded Alpine Microbial Observatory and studies micorbial activity at Niwot Ridge.

Name: Sievering, Herman
Worked for more than 160 Hours: Yes
Contribution to Project:
Dr. Sievering is a Professor in Atmospheric Chemistry at CU-Denver and continues his involvement with the NWT LTER program. He is investigating the influence of canopy N uptake on chlorophyll fluorescence and gas exchange.

Name: Suding, Katharine
Worked for more than 160 Hours: Yes
Contribution to Project:
Dr. Suding is a new assistant professor at the University of California at Irvine. She conducted her Post-Doc work at Niwot Ridge. We are happy to welcome Katie as a new senior personnel on the NWT LTER program. Katie is working on feedbacks between plant species and ecosystem processes which may enhance community diversity and stability.

Name: Tonnessen, Kathy
Worked for more than 160 Hours: Yes
Contribution to Project:
Dr. Kathy Tonnessen is the lead scientist for the Rocky Mountain Cooperative Ecosystem Study Unit, and is based at the University of Montana, Missoula, Montana. She directs and funds much of the National Park Service research in the Rocky Mountain region. Her involvement helps expand the NWT LTER to a regional focus in the Rocky Mountains.

Post-doc

Graduate Student

Name: Anderson, Sheena
Worked for more than 160 Hours: Yes
Contribution to Project: Buck Sanford's Graduate Student

Name: Abood, Paul
Worked for more than 160 Hours: Yes
Contribution to Project: Mark Williams's Graduate Student

Name: Bocquet, Florence
Worked for more than 160 Hours: Yes
Contribution to Project: Detlev Helmig's Graduate Student

Name: Cohen, Lana
Worked for more than 160 Hours: Yes
Contribution to Project: Detlev Helmig's Graduate Student

Name: Costello, Elizabeth
Worked for more than 160 Hours: Yes
Contribution to Project: William Bowman's Graduate Student

Name: Flanagan, Colleen
Worked for more than 160 Hours: Yes
Contribution to Project: Diane McKnight's Graduate Student
Name: Freeman, Kristen
Worked for more than 160 Hours: Yes

Contribution to Project: Steven Schmidt's Graduate Student
Name: Hill, Ken
Worked for more than 160 Hours: Yes

Contribution to Project: Mark Williams's Graduate Student
Name: King, Andrew
Worked for more than 160 Hours: Yes

Contribution to Project: Steven Schmidt's Graduate Student
Name: Lawton, Charles
Worked for more than 160 Hours: Yes

Contribution to Project: Tim Seastedt's Graduate Student
Name: Liptzin, Dan
Worked for more than 160 Hours: Yes

Contribution to Project: William Bowman's Graduate Student
Name: Meier, Courtney
Worked for more than 160 Hours: Yes

Contribution to Project: Diane Mc Knight's Graduate Student
Name: Tomaszewski, Tim
Worked for more than 160 Hours: Yes

Contribution to Project: Herman Seivering's Graduate Student

Undergraduate Student
Name: Gurung, Anobha
Worked for more than 160 Hours: Yes

Contribution to Project: Anobha is an undergraduate student worker assisting Dr. Sievering and Todd Ackerman.

Technician, Programmer
Name: Ackerman, Todd
Worked for more than 160 Hours: Yes

Contribution to Project: Todd Ackerman is the NWT LTER Information Manager and GIS Coordinator.
Name: Chowanski, Kurt
Worked for more than 160 Hours: Yes
Contribution to Project:
Kurt is the Field Technician for the NWT LTER project.

Name: Seibold, Christine
Worked for more than 160 Hours: Yes
Contribution to Project:
Christine Seibold supervises the Kiowa Wet Chemistry Laboratory of the NWT LTER program.

Other Participant
Name: Clippenger, Norman
Worked for more than 160 Hours: Yes
Contribution to Project:
Dr. Clippenger is a research associate for the EEB Department at CU-Boulder. He is conducting research on small mammals at the NWT LTER program and is supported in part with NWT LTER funds.

Name: Rosenbaum, Barry
Worked for more than 160 Hours: Yes
Contribution to Project:
Dr. Barry Rosenbaum is a research associate with the EEB Department at CU-Boulder. He is conducting research on small mammals at NWT LTER, along with Dr. Norm Clippenger. He is supported in part by NWT LTER.

Research Experience for Undergraduates
Name: Abbey, Rebecca
Worked for more than 160 Hours: Yes
Contribution to Project:
From Pomona College. Advised by McKnight.

- Years of schooling completed: Junior
- Home Institution: Other than Research Site
- Home Institution if Other: Pomona College
- Home Institution Highest Degree Granted(in fields supported by NSF): Bachelor's Degree
- Fiscal year(s) REU Participant supported: 2005
- REU Funding: REU supplement

Name: Burns, Mercedes
Worked for more than 160 Hours: Yes
Contribution to Project:
From Macalaster College. Advised by Breed.

- Years of schooling completed: Junior
- Home Institution: Other than Research Site
- Home Institution if Other: Macalaster College
- Home Institution Highest Degree Granted(in fields supported by NSF): Bachelor's Degree
- Fiscal year(s) REU Participant supported: 2005
- REU Funding: REU supplement

Name: Fulkerson, Justin
Worked for more than 160 Hours: Yes
Contribution to Project:
From Humboldt State University. Advised by Bowers.

- Years of schooling completed: Sophomore
Home Institution: Other than Research Site
Home Institution if Other: Humboldt State University
Home Institution Highest Degree Granted (in fields supported by NSF): Doctoral Degree
Fiscal year(s) REU Participant supported: 2005
REU Funding: REU supplement

Name: Grisby, Hershel
Worked for more than 160 Hours: Yes
Contribution to Project:

   Years of schooling completed: Junior
   Home Institution: Other than Research Site
   Home Institution if Other: Westminster College
   Home Institution Highest Degree Granted (in fields supported by NSF): Bachelor's Degree
   Fiscal year(s) REU Participant supported: 2005
   REU Funding: REU supplement

Name: Merrell, Andrew
Worked for more than 160 Hours: Yes
Contribution to Project:
From Lewis and Clark College. Advised by Breed/Sanchez.

   Years of schooling completed: Sophomore
   Home Institution: Other than Research Site
   Home Institution if Other: Lewis and Clark College
   Home Institution Highest Degree Granted (in fields supported by NSF): Doctoral Degree
   Fiscal year(s) REU Participant supported: 2005
   REU Funding: REU supplement

Name: Meriwether, Rachel
Worked for more than 160 Hours: Yes
Contribution to Project:
From University of Louisiana, Lafayette. Advised by Diggle/Lay.

   Years of schooling completed: Freshman
   Home Institution: Other than Research Site
   Home Institution if Other: Univ. of Louisiana, Lafayette
   Home Institution Highest Degree Granted (in fields supported by NSF): Doctoral Degree
   Fiscal year(s) REU Participant supported: 2005
   REU Funding: REU supplement

Name: Miller, Brian
Worked for more than 160 Hours: Yes
Contribution to Project:
From University of Colorado. Advised by Cruz.

   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: 2005
   REU Funding: REU supplement

Name: Plume, Fronny
Worked for more than 160 Hours: Yes
Contribution to Project:
From University of Colorado. Advised by Bowman.

Years of schooling completed: Sophomore
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: 2005
REU Funding: REU supplement

Name: Rodgers, Althea
Worked for more than 160 Hours: Yes

Contribution to Project:
From Colorado College. Advised by Monson/Hu.

Years of schooling completed: Sophomore
Home Institution: Other than Research Site
Home Institution if Other: Colorado College
Home Institution Highest Degree Granted(in fields supported by NSF): Bachelor's Degree
Fiscal year(s) REU Participant supported: 2005
REU Funding: REU supplement

Name: Smith, Jane
Worked for more than 160 Hours: Yes

Contribution to Project:
From University of Colorado. Advised by Seastedt.

Years of schooling completed: Sophomore
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: 2005
REU Funding: REU supplement

Name: Woltz, Megan
Worked for more than 160 Hours: Yes

Contribution to Project:
From NC State. Advised by McKnight.

Years of schooling completed: Sophomore
Home Institution: Other than Research Site
Home Institution if Other: NC State
Home Institution Highest Degree Granted(in fields supported by NSF): Doctoral Degree
Fiscal year(s) REU Participant supported: 2005
REU Funding: REU supplement

Organizational Partners
State of Colorado
(a) matching equipment funds for the NWT LTER ($25K/yr).
(b) Operating funds for the Mountain Research Station.

University of California, Irvine
Katies's stuff
National Oceanic and Atmospheric Administration (NOAA)

U.S. Climate Reference Network (USCRN) is a network of climate stations developed as part of a National Oceanic and Atmospheric Administration (NOAA) initiative. Its primary goal is to provide future long-term homogeneous observations of temperature and precipitation that can be coupled to long-term historical observations for the detection and attribution of present and future climate change. Data from the USCRN will be used in operational climate monitoring activities and for placing current climate anomalies into an historical perspective. The USCRN will also provide the United States with a reference network that meets the requirements of the Global Climate Observing System (GCOS).

USDA Forest Service

U of Colorado Mountain Research Station

NRCS - Snotel

Mountain Studies Institute

The Mountain Studies Institute (MSI) is a non-profit organization based out of Silverton, CO, dedicated to serving the educational and research needs of mountain communities and environments. NWT LTER provides guidance, facilities, personnel exchanges and other help to MSI.

National Atmospheric Deposition Program

City of Boulder Watershed

Mountain Studies Institute (MSI)

Rocky Mtn Coop. Ecosystems Study Unit

NOAA - CMDL

NOAA Climate Monitoring and Diagnostics Laboratory (CMDL) air monitoring for carbon cycle greenhouse gases, halocarbons, and surface ozone at T van and C1.

NOAA - National Weather Service

NOAA National Weather Service - coop precipitation network gage at C1

Other Collaborators or Contacts

Dr. Iggy Litaor of Tel-Hai University, Israel, rejoined the NWT LTER group through the summer of 2004. Dr. Litaor was one of NWT LTER's most prolific scientists during the late 1980s, with expertise in soils, especially soil phosphorus, and geostatistics. He's recently written several papers using Niwot data (Litaor et al. 2003; Litaor et al., in review). He worked with Drs. Townsend, Bowman, and Seastedt on landscape patterns of phosphorus availability to plants. These data are critically important as our biogeochemical focus moves from one that emphasizes carbon and nitrogen to one that emphasizes carbon, nitrogen and phosphorus amounts, ratios, and interactions.

Dr. Barry Rosenbaum, Univ. of Colorado, conducted small mammal surveys at NWT in 2003-2005. In 2005 he was assisted by Dr. Norman Clippinger and three UROP students supported by a non-LTER source. These are the first quantitative data obtained on small mammals in over a decade, and results will be evaluated with respect to a substantive historical database to evaluate what, if any changes in species composition
or abundances have occurred during this interval.

Jessica Lundquist, NOAA CDC. Distribution of temperature sensors along an elevational transect on Niwot Ridge for the dual purpose of evaluating the equipment (iButtons) and characterising air and soil temperatures in this complex terrain with respect to topography and elevation.

Douglas Hardy, Univ of Mass, Amhusrt. Elevational profile of temperature and relative humidity from the base to the summit of Mt Kilimajaro, Tanzania.

Nicholas Pepin, University of Portsmouth, Geography Dept. Comparison of surface and free air temperatures at equivalent elevations in the western US. Micro-site air temperatures in complex terrain on Niwot Ridge. Historical comparison of high and low elevation snowpacks on east and west slopes of selected mountain ranges in the western US.

Britton Stevens, NCAR. Three elevation vertical profile of CO2 at T van.

John Miller, NOAA CMDL Carbon Cycle Group. Automated CO2/13CO2 sampling at T van (T van is a good mid-tropospheric air proxy for all downwind locations in the US (to the east coast).

University of Regensburg (Thomas Raabe, Matthias Leopold, and Jorg Volkel), Williams College (David Dethier). Ground Penetrating Radar (GPR): Measurements of ground ice on Niwot Ridge, Martinelli catchment, and GL5 Rock Glacier.


Tad Pfeffer-Arapahoe Glacier Stuff. Conducted annual mass balance surveys of the Arapahoe glacier.

Bob Anderson and Suzanne Anderson: The interaction of mechanical and chemical processes that produce and transport regolith are explored in a simple landscape: the alpine high surfaces in the Front Range of Colorado. These high surfaces are an ideal laboratory because their parabolic shape implies that they are steady state landforms, the regolith is thin and accessible and is generated from granitoid rock, and easily characterized frost processes are expected to dominate the mechanical processes.

Tim Kittel

Research Affiliate with INSTAAR and Research Scientist at Colorado State University. His research interests are on the interactions between ecosystems and climate at global to landscape scales. He is currently studying multidecadal changes in the tundra plant community on Niwot Ridge.

Snow chemistry crew:
Experiments on atmosphere-snow chemical exchanges focusing on volatile organic carbons were conducted from 12-19 March 2005 at the Soddie treeline site by Barry Lefer (Assistant Professor, University of Houston), Mary Albert (Army Research Office, Cold Regions Research and Engineering Laboratory, Durham, New Hampshire), Aaron Swanson, NCAR, Boulder, CO, and others.

Dale Toetz, University of Oklahoma. Continues to conduct research on aquatic biological processes in the Green Lakes Valley.

Niwot Ridge Ameriflux Program. Continue to work with the Russ Monson, PI, on various components of the carbon balance. The NWT LTER contributes weekly measurements of snow properties, etc.

Edith Allen (University of California, Riverside)

Richard Bardgett (University of Lancaster)

Jill Baron (USGS)

Dan Fagre (USGS)

Katie's Collaborators:
C. DeMazancourt, B. Clark, S. Pennings, L. Gough, K. Gross, S. Collins, D. Milchunas, C. Clark, J. Fargione, A. Miller, J. Grace, E. Cleland
INTERNATIONAL

Bowman: Completion of field work in Western Tatra Mountains. Preliminary indications are that 1) soils have been acidified extensively (pH from 3.5-3.3), with aluminum the primary cation; 2) primary production is limited by P, with slight decreases in production when N is added, and 3) pools of soil inorganic N are higher than at Niwot Ridge.

Lubos Halada (Slovak Academy of Sciences)
Rådiger Kaufmann (University of Innsbruck)

Patrick
Tim Bolivia

For the last 4 years, Tim Kittel has taught a summer field course in ecology & conservation biology in Brazil. The course is geared towards both non-science and science students from the US and Brazil. This outreach effort is run through Columbia University's Center for Environmental Research and Conservation.

Detlev Greenland, Antarctica  
Diane, Antarctica  
Alan Central America

Activities and Findings

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

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

Training and Development:

Outreach Activities:

Journal Publications


Sherrod, S.K., T. R. Seastedt and M.D. Walker, "The northern pocket gopher


Books or Other One-time Publications

Editor(s): U. M. Huber, H. K. M. Bugmann, and M. A. Reasoner
Collection: Global Change and Mountain Regions (A State of Knowledge Overview)
Bibliography: Springer, Dordrecht

Collection: Proceedings of the National Academy of Sciences of the United States of America vol. 102 (12) pp. 4387-4392
Bibliography: National Academy of Sciences of the United States of America


Web/Internet Site

Other Specific Products

Product Type:
Web Server
Product Description:
The Website for the Niwot Ridge LTER Site was updated and redesigned.
Sharing Information:
http://culter.colorado.edu

Contributions

Contributions within Discipline:
Contributions to Other Disciplines:

Contributions to Human Resource Development:

Contributions to Resources for Research and Education:

Contributions Beyond Science and Engineering:

Special Requirements

Special reporting requirements: None
Change in Objectives or Scope: None
Unobligated funds: $ 0.00

Animal, Human Subjects, Biohazards: None

Categories for which nothing is reported:
Activities and Findings: Any Training and Development
Activities and Findings: Any Outreach Activities
Any Web/Internet Site
Contributions: To Any within Discipline
Contributions: To Any Other Disciplines
Contributions: To Any Human Resource Development
Contributions: To Any Resources for Research and Education
Contributions: To Any Beyond Science and Engineering
RESEARCH AND EDUCATION ACTIVITIES

Long-term climate monitoring. We continued our long-term climate monitoring at Niwot Ridge, which began in the 1950s with the installation of meteorological stations along an elevational gradient. The NWT LTER operates the longest-duration, high-elevation meteorological program in the United States. Temporal analysis of four decades (1951-1996) of instrumented climate records show (1) decreasing autumn temperatures (-0.043 °C/yr) but no significant annual cooling; (2) a decrease in incident summer solar radiation (-1.04 W/m²/yr) between 1965 and 1996; and (3) an annual precipitation increase of 11.0 mm/yr (Greenland and Losleben, 2001) (Figure 2.1a). Additional research has found: (1) an extreme cold temperature event from 1981-86 (Kittel et al., 2002); (2) different lapse rate changes at different elevations between 2,200 and 3,749 m (Pepin, 2000); (3) elevationally dependent differences in precipitation chemistry (Losleben and Pepin, 2000); and (4) decoupled climate conditions between upper and lower troposphere (Kittel et al., 2002; Williams et al., 1996a). The increase in annual precipitation and decrease in summer shortwave radiation are consistent with most model scenarios using doubled atmospheric CO₂ of increased annual precipitation and increased water vapor, but the lack of an annual temperature increase on Niwot Ridge is inconsistent with model predictions of increasing air temperature.

Climate-ecosystem experiment. We have continued our long-term experimental program on climate interactions with ecosystem processes. A snowfence 60 m long and 2.8 m high was erected in 1993 to study long-term effects of changing winter snow conditions on the integrated physical-biological processes of alpine tundra. The anoxic conditions produced by enhanced snow increased denitrification rates by an order of magnitude (Brooks and Williams, 1999). Initial findings suggested that decomposition rates increased because of enhanced snow (Williams et al., 1998), and this effort was subsequently expanded with litterbag studies (Bryant et al., 1998). At least one species, Kobresia myosuroides, had almost completely died out, but other species are increasing (Walker et al., 1999). Re-inventories of plant species richness and species composition have been obtained (e.g., Seastedt and Vaccaro, 2001) with the most recent collection in 2003. Those data are now being analyzed to estimate vegetation change that has occurred over the first 10 years of the experiment.

National Atmospheric Deposition Program. The NWT LTER program continues its participation in the National Atmospheric Deposition Program (NADP), which began in the early 1980s, maintaining the highest-elevation site in the US at 3,520 m on Niwot Ridge, and also the subalpine Sugarloaf site at 2,524 m. Annual deposition of inorganic N in wetfall at the Niwot Ridge site showed a significant increase of 0.3 kg/ha/yr for the 1984-1996 interval (Figure 2.2) (Williams and Tonnessen, 2000). A sophisticated analysis of atmospheric deposition of pollutants throughout the entire Rocky Mountain Region from Canada to Mexico shows that nitrate and sulfate deposition increase from north to south, with hot spots of deposition in the Colorado Front Range (Nanus et al., 2003). Burns (2003a) shows that the increase of inorganic N in wetfall in the Front Range is partly driven by increases in the metropolitan population east of the Front Range. We
added a third NADP site at C1 (elevation 3,000 meters) that complements our two existing sites at Sugarloaf and also the Niwot Saddle. The new NADP site provides three sites along an elevational transect, the only such elevational transect of NADP sites in the US. We are also working directly with NADP to test precipitation collectors that might improve measurements in snow-dominated regions. As part of this program, we installed an NADP Ott Pluvio precipitation collector at the new site at C1 in November 2005.

**Factorial fertilization experiments.** We have continued our long-term experimental additions of nitrogen and phosphorus in terrestrial environments. Experimental additions of N have caused changes in species composition from *Acomastylys* to *Dechampsia* in wet meadow communities (Bowman et al., 1995; Theodose and Bowman, 1997), and reductions in species richness (Seastedt and Vaccaro, 2001). Such shifts in species composition may lead to increased leaching of nitrate from soils to aquatic systems because the favored species often has greater rates of net nitrification (Bowman and Steltzer, 1998; Steltzer and Bowman, 1998). Additions of labeled N in the form of ammonium nitrate to snow showed that N uptake during snowmelt constituted over 12% of season-long uptake for a graminoid species, and averaged 7.4% for perennial forbs (Bilbrough et al., 2000). Nutrient addition studies generally support the hypothesis that long-term increases in atmospheric N deposition will likely shift terrestrial plant productivity in tundra ecosystems from N-limitation to P-limitation (Burns, 2003b). However, it remains unclear how changes in snow amount, duration, and timing interact with increases in N deposition to structure plant communities.

**Microbial ecology.** Our finding that microbial communities are active under snow has changed the estimated global rates of biogeochemical processes beneath seasonal snow packs. These results have prompted a re-evaluation of whether some seasonally snow-covered environments are sinks of atmospheric CO$_2$ (Fahnestock et al., 1999). In addition, under-snow microbial metabolism is an important biogeochemical N sink (Lipson et al., 1999). Unexpectedly, our results show that tundra soil microbial biomass reaches its annual peak under snow and not during the warmer summer months, and that fungi account for most of the biomass. Phylogenetic analysis of tundra soil fungi using microbiological and molecular techniques revealed a high diversity of fungi and three novel clades that constitute major new groups of fungi, divergent at the subphylum or class level (Figure 2.3) (Schadt et al., 2003).

NWT representatives Patrick Bourgeron and graduate student Dan Lipson attended a regional meeting on treeline change in the Western US. The meeting was held in West Glacier, Montana. Thirteen scientists representing nine universities, one institute (Woods Hole) and two agencies (USFS and USGS) attended the meeting. The workshop is part of the western mountain initiative (WMI; http://www.cfr.washington.edu/research.fme/wmi/) sponsored by USFS, USGS and NPS.

NWT LTER and the Mountain Research Station (MRS) hosted a National Park Service (NPS) workshop on developing an alpine monitoring network for the western US. Hosted the workshop from 20-22 September 2005 at the MRS. Monitoring of alpine
areas is important, but are often isolated and small areas that provide a critical challenge for several NPS I&M Networks. Monitoring challenges include site accessibility, often-hostile weather conditions, sensitivity to anthropogenic pollutants, sensitivity to climate changes, and potentially complicated interactions between vegetation, fauna, weather and hydrology (just to name a few). 25 NPS representatives attended the meeting from the following Inventory and Monitoring (I&M) Networks: Greater Yellowstone, Southern Colorado Plateau, Kalamath, Sierra, North Coast and Cascades, and Rocky Mountains. NWT LTER (Bill Bowman, Tim Seastedt, Mark Williams) provided insights to the NPS on monitoring alpine areas based on the NWT LTER program.

M. Williams participated in an NPS workshop on "WORKSHOP ON DESIGNING NATURAL RESOURCE SCIENCE/RESEARCH AGENDAS FOR PARKS", 17 October, Mammoth Hot Springs, Yellowstone National Park. M. Williams gave an invited talk on "How does a LTER program develop research strategies/models" and was a panel participate. 30 participants from national parks nationwide.

NCALM. Received a $37,000 grant to develop a high-resolution DEM using LIDAR for the NWT LTER site. The LIDAR mission was flown in September. A preliminary 5-m DEM produced and available on 6 October 2005. Sub 1-m DEM in production.

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LTER NETWORK ACTIVITIES
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LTER CROSS-SITE SYNTHESIS (K. Suding): Nitrogen increases can put rare species and susceptible functional groups at risk. Katie Suding has been leading a synthesis effort across nine LTER sites to investigate functional responses to increases in nitrogen inputs. Based on an analysis of >900 species responses from 34 nitrogen fertilization experiments, we found that both trait-neutral and trait-based mechanisms operate simultaneously to influence diversity loss as production increases. Rare species were often lost due to soil fertilization, randomly with respect to traits. The risk of species loss due to fertilization ranged from >60% for the rarest species to 10% for the most abundant species. Perennials, species with N-fixing symbionts, and those of native origin also experienced increased risk of local extinction following fertilization, regardless of their initial abundance. As nitrogen availability continues to increase globally, management that focuses on locally-susceptible functional groups and generally-susceptible rare species will be essential to maintain biodiversity.

LTER PLANNING GRANT (EXPANSION) ACTIVITIES
Mark Williams chaired the "Climate and Ecosystems working group"
Hosted workshop Jan 31-Feb2, Boulder, CO
Attended 14-17 June meeting, Santa Fe, NM
Attended 17 August meeting, Boston, MA
Attended 7-9 November meeting, Sevilleta, NM
Katie Suding was a member of the Biodiversity working group and participated in the same meetings.

LTER ALL SCIENTISTS MEETING (ASM)
Tim Seastedt is serving on the planning committee and is co-chair for the 2006 ASM, which is being held at Estes Park in Colorado. Tim gave Bob Waide (Executive Director, LTER Network Office), a tour of meeting site on 12 October 2005.

LTER SCHOOLYARD CHILDREN'S BOOKS SERIES WORKSHOP
Diane McKnight of the NWT LTER hosted a workshop on July 28-29, 2005 at INSTAAR to prepare for the launching of the LTER Schoolyard children's book series. The workshop focused on the many steps involved in writing and publishing a science book for children, and a short course format was used. Experienced authors, educators, an illustrator, an editor, and the publishers of the series gave presentations. A fifth grade teacher who has been developing the teacher’s guide for the NWT LTER book also gave a presentation on using science books in the classroom. 30 people, representing 7 of the LTER sites, attended the meeting. Because a number of other educators in the LTER network expressed interest in the children's book series but were not able to attend, we arranged to have the workshop presentations professionally filmed. A DVD of the workshop has been prepared and is currently being reviewed by members of the LTER community interested in the book series. This DVD will be distributed within the network and will serve as a guide to current and future prospective authors and others participating in the book series. A report on the workshop was given at the CC meeting.

NSF BROCHURE ON "Translating Science for Society".
Participated in putting brochure together, contributing 4 of the published pictures and one of the case studies: "Basic science guides acid mine drainage remediation".

LTER SITE Brochure
Developed a brochure to advertise and inform the public on activities and information collected at the NWT site.

FIRST LTER GRADUATE STUDENT COLLECTIVE RESEARCH SYMPOSIUM
Held on April 13th through the 17th, 2005, at H. J. Andrews LTER, in Blue River, Oregon. Attended by Dan Lipson and Courtney Meier of NWT LTER. They chaired two of the 5 workshops at the meeting.

U.S. CLIMATE CHANGE SCIENCE PROGRAM WORKSHOP: Climate Science in Support of Decision Making, November 14-16, 2005, in Arlington, Virginia. M. Williams was the lead on submitting an abstract and putting together a poster for the meeting that highlighted LTER activities based on the LTER expansion working group he chaired: "ALTERED CLIMATE AND ECOSYSTEM RESPONSE: THE LONG-TERM ECOLOGICAL RESEARCH PROGRAM (LTER)", by Jim Gosz, Mark Williams, Deb Peters, Alan Knapp, and Russ Monson.
NETWORK OFFICE SITE VISIT
NWT hosted Bob Waide, Executive director of the LTER Network office, on 12 October 2005. Bob spoke at our monthly NWT meeting about roles and duties of the network office.

LTER EXTREME CLIMATE COMMUNITY
Mark Losleben is a committee member. Mark co-sponsored a special session on extreme climate events at the Fall 2005 annual meeting of the American Geophysical Union.

LTER ECOINFORMATICS TRAINING WORKSHOP
Sponsored Philip Goldstein to attend the LTER Ecoinformatics workshop; paid for airfare, etc. Philip is a graduate student working on developing a database for the Alpine Microbial Observatory (AMO). By sponsoring and supporting Philip at the LTER Ecoinformatics workshop, we are strengthen the ties between NWT LTER and AMO.

DATA MANAGER ACTIVITIES
The World Wide Web remains as the primary means for dissemination of NWT data. The data is available in a flat file format with attached metadata headers. This same metadata is available as EML, currently at a level 3 in the tiered structure of EML. The EML files are currently uploaded into the NET Metacat upon updating. GIS data is available through an ftp site, or via an ArcIMS mapping server. Development continues on the development of a RDBMS to house NWT data. Currently the data for 6 meteorological sites are automatically imported into the database, this database also houses the metadata for the data files available online in order to generate EML. The website for NWT has been completely redesigned to allow for easier information gathering by parties both within and outside of the NWT site. Our data manager, Todd Ackerman, attended the LTER Information Manager's meeting in Montreal in July. We began participating in Unit Dictionary Workgroup, compiling a repository of units for inclusion into EML reviewed by other LTER sites.

OUTREACH and K-12

OVERVIEW
The theme of the NWTLTER K-12 outreach program is the connection between alpine ecosystems and communities of the Rocky Mountain Front Range. The outreach program involves in-service and pre-service teachers in field trips for children to the alpine tundra. Children are particularly receptive to environmental education that emphasizes discovery, exploration and empathy with their local environment, as discussed by D. Sobel in “Beyond Ecophobia”. We continue to build on the program we have implemented over the past 7 years (1998-2004). The field trips are coordinated with a summer field course (3 credit hr) "Elementary Education in Alpine Ecology", which has been taken by 7-15 students each year, with about half being in-service teachers. The summer 2005 course was taught by alpine ecologists connected to the NWTLTER (e.g. Joyce Gelhorn and
Diane McKnight) and by Dr. Jane Larson, an expert in science education. The course instructors and students lead the field trips.

This program is conducted in collaboration with local science education programs: 1) Science Discovery (1998-2004) based at the University of Colorado, 2) Bixby School (1999-2004) in Boulder, and 3) Wild Bear Science School (1999-2004) in Nederland, near the Mountain Research Station (MRS). The age range of the children is 5-12 years and the group size is 12-18 children, with 4-6 scientists and student teachers as leaders. Our Science Discovery program offers two Saturday field classes for elementary and middle school children. Bixby School is an experiential education based elementary school and the students attending Bixby School in the summer participate on the field trips. Bixby teachers then integrate the students’ experiences into activities during the school year. The Wild Bear Science School has two-week sessions for elementary students on an ecological theme, and a one-week session for middle school students. The field trip is integrated into the middle of the weekly program, as a component that emphasizes observations and recording by sketches and note taking. Although all of the school programs involve a field trip with the children to the Tundra Laboratory, including the snow fence experiment at 11,500 ft., each trip is tailored to match with the background and interests of the particular group of children. A common feature of all the field trips are interactions with NWTLTER scientists in the field on the way up and back down. The duration of the field trip is about 6 hours. A major use of the funds from the supplemental grant has been and will continue to be for stipends to support the participation of current elementary school teachers.

Children’s’ Book: MY WATER COMES FROM THE MOUNTAIN was written by Tiffany Fourment and illustrated by Dorothy Emerling, and sponsored by the NWT LTER outreach program. Since publication in 2004, the Mountains and Plains Booksellers Association have nominated the book in 2005 for a regional book award in the children’s category. The book has also been highlighted in NSF Director Arden Bement's first speech on the environment at the March 2005 National Center for Science Education science and policy conference. The narrative of the book takes children of ages 7-10 on an illustrative journey from glacial and snowpack sources high on the Continental Divide to the plains and water in their faucet tap, introducing them to the distinctive wildlife and ecosystems along the way, including the diverse uses and human impact of water in Boulder Creek and St. Vrain watersheds.

2005 CONGRESSIONAL BUDGET REQUEST

EXPANDING ON "MY WATER COMES FROM THE MOUNTAINS"
A successful proposal to expand the Niwot Ridge LTER Schoolyard program by allowed us to: a) enhance the educational effectiveness of the book My Water Comes from the
Mountains; b) increase outreach interactions with teachers and schools through the creation and distribution of a Teacher’s Guide; c) place the Teacher’s Guide on the internet; and d) hold a cross-site prospectus for a network-wide LTER series of similar children’s books.

RET PROGRAM
Ken Nova, a 5th grade teacher at Douglass Elementary School in the Boulder Valley School District, was supported through the RET program in 2005. Ken participated in sampling the Green Lakes for water quality and phytoplankton species distribution. The water quality study focuses on the ability of the natural organic material in the lake water to form complexes with trace metals. Joyce Gelhorn and Colleen Flanagan are working on assembling a teacher's guide for the recently published book "My Water Comes from the Mountains", and Ken helped them on the developing the teacher's guide.

NSF WEBSITE
NWT LTER research on "The Teflon basin hypothesis" was featured on the 27 May 2005 edition of the NSF website.

LTER NETWORK WEBSITE
Two nuggets from NWT LTER were highlighted on the LTER Network News web site: (1) The Teflon basin hypothesis; and (2) Microbial activity in rock glaciers.

8th GRADE SCIENCE FAIR
Mara O'Laughlin conducted an 8th grade science fair project on the chemistry of acid mine drainage in cooperation with NWT LTER staff and using NWT LTER laboratory equipment. She advanced to the Boulder School District Finals in March.

NARST
Jane Larson presented a paper on our alpine ecology at the National Associate for Research in Science Teaching (NARST), in Dallas, TX at the beginning of April.

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GRANTS


Blanken, P., PI, National Park Service (NPS), Design of living snow fences for snow drift control in RMNP, 2005, $15,000

Monson, R., PI, National Science Foundation (NSF), Biocomplexity: Carbonshed Studies of Carbon Sequestration in Complex Terrain, 2003 - 2008, $1,998,000
Schmidt, S., PI, National Science Foundation Molecular and Cellular Biosciences (NSF-MCB), Alpine Microbial Observatory, 2005 - 2009, $1,750,000


Seastedt, T., PI, National Science Foundation (NSF), Dissertation Research: Forest Fire Mitigation and Understory Invasion, 6/2005 - 2007, $11,956


Anderson, R., PI, National Science Foundation (NSF), The Linkage of Chemical and Mechanical Processes in the Evolution of High Surfaces of the Front Range Crest, Colorado, 2005 - 2007, $198,000

Anderson, R., PI, National Center for Airborne Laser Mapping (NCALM), High-resolution DEM of NWT LTER from LIDAR, 2005, $37,000

Williams, M., PI, National Science Foundation (NSF), Schoolyard LTER expansion, 06/01/2005 - 05/30/2006, $42,000

Williams, M., PI, National Science Foundation (NSF), Schoolyard LTER, 06/01/2005 - 05/30/2006, $15,000

Williams, M., PI, National Park Service (NPS), Developing Screening Procedures and Sampling Protocols for Assessment of Deposition-Sensitive Surface Waters in the Rocky Mountains, 8/15/2003 - 5/30/2006, $50,000


Williams, M., PI, Environmental Protection Agency (EPA), Isotope Tracing Analysis for Leadville Mine Drainage Tunnel, California Gulch Superfund Site and Affected Areas, 3/2003 - 12/2006, $135,152

Williams, M., Co-I, National Science Foundation (NSF), Complexity across boundaries: Coupled human and natural systems in the Yellowstone Northern Elk Winter Range, 10/2002 - 8/2005, $600,000, (individual budget $49,000)
Suding, K. PI, Andrew K. Mellon Foundation, Young Investigator Award, Feedbacks Between Species and Ecosystem Function: N Form Use & Carbon Compound Inputs, 4/2005 - 03/2008, $230,000
NIWOT RIDGE LTER RESEARCH FINDINGS

Here we present highlights from research and related activities conducted at the Niwot Ridge LTER site.

Tim Seastedt received a 2004 pacesetter award for his contributions to the environment. The pacesetter awards are given annually to people who have made significant contributions to the Front Range community of Colorado, which extends from Pueblo north to the greater Fort Collins area. Tim's citation for the Pacesetter award reads, in part: "Timothy Seastedt, Environment. Tim, a professor of biology at the University of Colorado, solved a multimillion-dollar environmental problem by figuring out how to get the right bugs in the right places to bring the pesky diffuse knapweed under control." The Niwot Ridge LTER program is proud of the recognition that Tim has received.

Katie Suding is leading a synthesis effort across nine LTER sites to investigate functional responses to increases in nitrogen inputs. Based on an analysis of >900 species responses from 34 nitrogen fertilization experiments, they found that both trait-neutral and trait-based mechanisms operate simultaneously to influence diversity loss as production increases. Rare species were often lost due to soil fertilization, randomly with respect to traits. The risk of species loss due to fertilization ranged from >60% for the rarest species to 10% for the most abundant species. Perennials, species with N-fixing symbionts, and those of native origin also experienced increased risk of local extinction following fertilization, regardless of their initial abundance. As nitrogen availability continues to increase globally, management that focuses on locally-susceptible functional groups and generally-susceptible rare species will be essential to maintain biodiversity. This initial report was published in the Proceedings of the National Academy of Science (Suding et al., 2005). This manuscript was selected as editors’ choice, Science, 2005, 308: 326-327.

Katie Suding is also working on feedbacks between plant species and ecosystem processes that may enhance community diversity and stability. At Niwot Ridge, two functionally different plant species are able to coexist due to their impacts on nitrogen cycling: net N mineralization and nitrification rates are four times greater in areas dominated by Deschampsia caespitosa than areas dominated by Acomastylis rossii. She has shown that Deschampsia, directly through rapid N uptake, and Acomastylis, indirectly through microbial N immobilization of its litter, exert strong and often equivalent competitive effects. In collaboration with Ben Clark (Imperial College, UK), they developed a general model of how divergent cycling effects such as these can influence competitive interactions and long-term dynamics. These are major steps in establishing plant-soil feedbacks as a mechanism for coexistence. They also substantiate predictions that further nitrogen deposition, by shifting the balance between recycling and uptake, can dramatically change vegetation composition and nitrogen fluxes. With a Young Investigator award from the Mellon Foundation, she is examining at the NWT LTER how plant utilization of different forms of nitrogen and litter inputs of secondary
carbon compounds influence community and ecosystem dynamics. These two factors have rarely been jointly considered as contributing to strong biotic feedbacks.

Mark Williams reported that geochemical and water isotope studies show that less than half of the annual snowmelt in the Green Lakes Valley region in the high mountains west of Boulder arrives at the watershed treatment facility within a year as "new water." He found that most of the water sampled from North Boulder Creek during the runoff months was "old groundwater" that had been stored in subterranean mountain catchments. Similar studies by Williams and colleagues near Leadville, Colo., show that high-mountain groundwater is dominated by snowmelt that is locked underground for years or decades. The research shows that water from snow pack replenishes high-altitude groundwater reservoirs, pooling underground rather than rushing downstream toward the plains. These results were featured on the 27 May 2005 edition of the NSF website: Unseen Colorado Mountain Aquifers Throw Water on "Teflon Basin" (http://www.nsf.gov/news/news_summ.jsp?cntn_id=104198&org=NSF&from=news). These results were also featured in the new NSF brochure “Translating Science for Society” (NSF, 2005).

Mark Williams’ research team has discovered evidence of microbial activity in a rock glacier high above tree line in the Rocky Mountains, a barren environment previously thought to be devoid of life. Found in an intermittent stream draining from the glacier, the evidence includes traces of dissolved organic material and high levels of nitrates. The high nitrate levels are believed to be a result of microbes metabolizing nitrogen within the glacier, according to graduate student Meredith Knauf. Rock glaciers are large masses of rock debris interspersed with ice in the high mountains of temperate areas. Moving at speeds of just inches or a few feet a year, they require an extremely cold environment, large amounts of rock debris and enough of a slope to allow them to slide. The upshot is that the researchers have shown that rock glaciers are not biological deserts as had been previously thought by scientists. This is one more example that microbes can live in the most extreme of environments. This research was featured in an NSF press release, Science Daily, Astrobiology, and a host of other news outlets, including the Hindu Times.

Steve Schmidt received an NSF grant for an alpine microbial observatory (AMO), funded for $175,000,000 over 5 years which will focus on identifying never-before cultured microbes and discovering ways to grow them in the laboratory so that they can be studied using modern physiological and genomic methods. Such studies will help the researchers at the AMO discover new forms of life and to understand how they perform important biological functions (e.g. nutrient cycling and gas production) under extremely cold conditions. For example, this approach will help researchers to understand how colder regions of the earth function as part of the biosphere and how they will respond to future climate change, e.g. see note above on microbial life in rock glaciers. Such work can only be accomplished via an interdisciplinary approach, involving researchers with expertise in microbiology, biogeochemistry, evolutionary biology, and bioinformatics. In addition, research at the AMO could lead to the discovery of useful products such as antibiotics and industrial enzymes that function at cold temperatures.
**Diane McKnight** hosted a workshop on July 28-29, 2005 at INSTAAR to prepare for the launching of the LTER Schoolyard children's book series. The workshop focused on the many steps involved in writing and publishing a science book for children, and a short course format was used. Experienced authors, educators, an illustrator, an editor, and the publishers of the series gave presentations. A fifth grade teacher who has been developing the teacher’s guide for the NWT-LTER book also gave a presentation on using science books in the classroom. 30 people, representing 7 of the LTER sites, attended the meeting. Because a number of other educators in the LTER network expressed interest in the children's book series but were not able to attend, we arranged to have the workshop presentations professionally filmed. A DVD of the workshop has been prepared and is currently being reviewed by members of the LTER community interested in the book series. This DVD will be distributed within the network and will serve as a guide to current and future prospective authors and others participating in the book series. A report on the workshop was given at the CC meeting. Funding for the workshop was provided in part by NSF-LTER sLTER expansion funding.

**Detlev Helmig** investigated the transfer and uptake of atmospheric ozone in seasonal, mid-latitude snowpack at a subalpine forest site at Niwot Ridge, Colorado during January - June 2004 by vertical gradient measurements of ozone and temperature at four different depths. Most ozone was lost within the first 10-20 cm below the snow surface. This ozone destruction appeared to be independent of solar radiation cycles. These findings are in contrast to similar studies in the polar snowpack, where a much deeper penetration of ozone into the snowpack and strong dependencies of the ozone destruction rate on incoming solar radiation levels have been reported. These observations imply that ozone uptake and ozone deposition rates to seasonal mid-latitude snowpack are much different and likely higher than to the year-round polar snowpack. Furthermore, ozone deposition to the seasonal snowpack probably depends on additional parameters, such as the snowpack temperature and the substrate below the snowpack, and are linked to soil-snowpack-atmosphere gas exchange processes.

**Herm Sievering's** group is investigating the influence of canopy N uptake on chlorophyll fluorescence and gas exchange. The study site is a subalpine conifer forest within the Niwot Ridge LTER area. N-treated branches received NH4+NO3- in ion-matrix solution that is representative of mean precipitation ion concentrations. Branches were sprayed throughout the 2004-growing season with NH4+NO3- to increase the wet deposition N-load to experimental branches and, thus, canopy N uptake by a factor of 1.5- to 2-times above ambient. Control branches received only the ion-matrix solution (no N), while background branches received only natural precipitation. Treatment with N enhanced photochemical efficiency (predawn Fv/Fm and daytime Fv’/Fm’) of old growth spruce shoots (>= 1 year); e.g., N-treated shoots’ daytime photochemical efficiency was 11% greater than control and background shoots (p < 0.05). Enhanced Rubisco activity accompanied this increased photochemical efficiency with the N-treated old growth shoots’ Vcmax being 14% greater than control/background shoots’ Vcmax (p<0.05). Gas exchange and fluorescence measurements on new growth spruce shoots revealed similar
trends (although \( p > 0.05 \)). Two arguments are being evaluated regarding these results. First, the availability of added N may have enhanced the photosynthetic apparatus, thereby increasing photochemical efficiency and \( V_{c,max} \). Second, NH4+ assimilation may have increased photochemical efficiency and \( V_{c,max} \). Both arguments support enhanced photosynthesis and aboveground carbon sequestration. Longer-term effects of N treatment (> 1 growing season) have yet to be considered. These effects and arguments are being considered in the context of broader Niwot-LTER N studies.