

Annual Report for Period: 12/1998 - 11/1999

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Award ID: 9810218

Organization: U of Colorado Boulder

LTERR: The Niwot Ridge LTER Research Program 1998-2004: Controls on the Structure, Function & Interactions of Alpine & Subalpine Ecosystems of the Colorado Front Range

Participant Individuals

Senior Personnel

Name: Seastedt, Timothy
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Townsend, Alan
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Wessman, Carol
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Williams, Mark
Worked for more than 160 Hours: Yes
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Name: Bowman, William
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Name: Caine, Nel
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Name: Diggle, Pamela
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Name: Elias, Scott
Worked for more than 160 Hours: Yes
Contribution to Project:

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Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Sanford, Robert
Worked for more than 160 Hours: Yes
Contribution to Project:

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

Name: McKnight, Diane
Worked for more than 160 Hours: Yes
Contribution to Project:

Post-doc

Graduate Student

Undergraduate Student

Partner Organizations

Other Collaborators

Activities and Findings

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

Research Findings:

Our major findings are included in the PDF file

Research Training:

Education and Outreach:

Our outreach activities are included in our activities PDF file

Journal Publications

Books or Other One-time Publications

Web/Internet Sites

URL(s):

<http://culter.colorado.edu:1030/>

Description:

This is our core LTER website

Other Specific Products

Contributions

Contributions within Discipline:

Contributions to Other Disciplines:

Contributions to Education and Human Resources:

These contributions were included in our activities PDF file

Contributions to Science and Technology Infrastructure:

Please see the outreach section of our activities PDF file.

Beyond Science and Engineering:

our virtual fieldtrip (http://culter.colorado.edu:1030/Field_trip)

provides aesthetic dimensions not normally included in scientific investigations.

Special Requirements

Special reporting requirements:

Change in Objectives or Scope:

Unobligated Funds:

Animal, Human Subjects, Biohazards:

Categories for which nothing is reported:

Partner Organizations

Activities and Findings: Any Research Training

Any Journal

Any Book

Any Product

Contributions: Any within Discipline

Contributions: To Any Other Disciplines

Change in Objectives or Scope: None

Special Requirements for Annual Progress Report: None

Change in Objectives or Scope: None

Unobligated funds: None

Animal, human subjects, biohazards: None

DEB 9810218: The Niwot Ridge Long Term Ecological Research Program 1998-2004: Control on the Structure, Function and Interactions of Alpine and Subalpine Ecosystems of the Colorado Front Range

1998-99 Annual Report

I. Research

During 1998 and 1999, we published or have in press 36 papers in refereed journals and had 6 articles published as book chapters. One book, written by NWT PI Scott Elias, included LTER information. We currently have 16 manuscripts in review. A synthesis volume of LTER findings that has been through external review and submission of this book to the publisher is anticipated before the end of this year. During this period we had five graduate students complete theses and dissertations. Among our publications are several first-authored papers from undergraduates, including both REU and honors thesis efforts. All publications are included at the end of this document. In addition to ongoing LTER measurements and experiments, Scientists at our site have begun the new series of projects associated with an analysis of subalpine-alpine interactions. New collaborative projects and new outreach efforts have also been initiated this year. An online version of this report, as well as summaries of our 1998 and 1999 annual workshops are available at our website,

http://culter.colorado.edu:1030/Niwot/Niwot_Ridge_LTER_reports.html.

Research highlights:

1. Species control of nitrogen flux.

Bowman and Steltzer (1998) presented a general model based on empirical studies (Steltzer and Bowman 1998) demonstrating that positive feedback loops can be generated when N enrichment causes a change in plant species composition in the alpine tundra. This work accompanies a suite of studies by Lipson et al. (1997, 1998, 1999) demonstrating patterns of microbial and plant uptake of N, as well as plant uptake of amino-N from soils. Since our renewal, Steve Schmidt and others have received substantial independent funding from NSF to conduct investigations on microbial processes

The change of lifeform from tundra to woody species also strongly influences community microclimate conditions, which strongly affect patterns of organic matter decomposition and N flux (Seastedt and Adams, in press). Finally, a study of the role of an alpine pocket gopher, *Thomomys talpoides*, demonstrates that this species is capable of modifying soil texture, soil chemistry, and manipulating the vegetation community via non-trophic mechanisms (Sherrod 1999; Sherrod et al. submitted). These works collectively demonstrate that individual species do influence ecosystem-level biogeochemical processes.

2. A new model for patterns of methane flux.

West and Schmidt (in press) and West et al. (1999) have proposed that observed patterns of methane consumption observed in the alpine tundra and elsewhere are generated by a population of methane-feeding microbes that are subsidized by a heretofore unrecognized population of methane-producing organisms. The latter group

occupies anaerobic microsites that are found in mostly aerobic terrestrial ecosystems. This conclusion is based on observations and experiments demonstrating that consumption rates of atmospheric methane are simply too high to be explained on the basis of atmospheric concentrations of this greenhouse gas.

3. Ecosystem responses to climate and atmospheric changes.

Ongoing studies of the snowpack manipulation site (snowfence) continue to define and expand upon earlier studies by Brooks et al. (1997). Work by Bryant et al. (1998), Hamann (1998), Williams et al. (1998) and Addington and Seastedt (1999) have further substantiated snowpack effects on decomposition and mineralization and decomposer organisms. These results support the contention that increased moisture can enhance the carbon flux from the soil, thus converting alpine regions into a carbon source under a wetting but otherwise unchanged climate. Ongoing vegetation studies will be continued to see if productivity changes in the plant community can compensate for enhanced decomposition losses.

4. Understanding of alpine-subalpine linkages

New studies initiated in summer of 1999 include a) variation in ecosystem sensitivity to N additions, b) analysis of factors controlling treeline, c) comparisons of soil carbon and N characteristics across an altitudinal gradient and among ecosystem types, and d) effects of soil age on nitrogen and phosphorus dynamics. New studies were emphasized at our 1999 annual workshop, and summary reports of these can be found on the web page. A central focus of these studies is the potential mitigation of increased anthropogenic N deposition by different ecosystems found along a short elevational gradient at the alpine-subalpine interface.

1999 was our first year of operation for the subalpine ecotone subnivean laboratory. This effort is for instrumentation in snow hydrology research to support ongoing and new research efforts to understand the physical processes that control snowpack dynamics. Funding for the project is a cooperative endeavor between the Army Research Office and NWT LTER. Instrumentation includes an underground/undersnow laboratory with dimensions of 30'x10'8', 106 snow lysimeters each connected to dedicated tipping buckets housed in the laboratory by over 10,000 feet of 1.5" pvc pipe, a fully equipped meteorological tower to measure snow-energy transfers, zero-tension soil lysimeters to better understand snow-soil interactions, and a host of other equipment. Additionally, we now have AC power to the site. Additional funding was received from ARO for supplemental instrumentation, including high-precision thermister arrays and liquid moisture meters for use in snow.

5. New collaborations.

Alan Townsend has recently been awarded a Mellon Foundation grant to study how variations in nitrogen availability affect decomposition of soil organic matter. The study will use recent advances in ^{14}C accelerator mass spectrometry which allows the investigators to assign turnover rates to organic matter pools. Most importantly, the study looks beyond the 'how' questions and addresses why these effects occur. This study will involve the alpine and arctic tundra, the tallgrass prairie, and at Harvard Forest.

Russell Monson has constructed a 30-meter tower in the subalpine zone of Niwot Ridge to study-atmosphere interactions. Project goals for this multi-investigator effort

include 1) measurement of the patterns and capacity for carbon sequestration, 2) identification of possible influences of ozone and nitrogen oxide deposition from the Denver airshed, 3) study seasonal and interannual variation in the components of the carbon balance, 4) study controls and emission of biogenic hydrocarbons from this ecosystem, and 5) study environmental and physiological controls over ammonia production and consumption. The last goal is an LTER-supported effort and collaboration with Herm Sievering and will be compared with similar estimates obtained from the tundra.

Summer visiting scientists included Patricia Weigant, Peace College, Raleigh NC and Iggy Litaor from Israel. Dr. Weigant was studying the relationship between local plant diversity and elevational gradients. Dr. Litaor was attempting a new soil analysis technique that may allow for rapid determination of soil organic matter and phosphorus content. The new procedure was also used in a geostatistical analysis of these variables.

II. Information Management

Niwot Ridge LTER site continues to be a leader on data availability and data transfer. Hydrological data from the Niwot Ridge LTER site is now in press with Water Resources Research, and will be one of the first papers published in that journal to feature important data sets that are available to all scientists through the internet (Williams et al. in press).

In addition to the hydrological data, the NWT LTER WWW server provides unrestricted access to 97 other data sets, and metadata for an additional 28 data sets that are available with permission from the investigator. The WWW server also now provides current meteorological data from the climate stations at 10,000 and 11,600 feet.

In the summer of 1998 the LTER program purchased a high resolution GPS unit (+/- 70cm accuracy in x,y geo-space), which is being used to accurately map all known plots both past and present.

Drs. Mark Williams and Barbara Buttenfield have been awarded a CU Boulder Advanced Technology Learning grant to use LTER data in a project designed to provide a "Vertical integration of technology into the Geography curriculum".

Finally, the NWT LTER program has requested all investigators and students to test all their electronic equipment for Y2K compliance, and has taken the appropriate steps to ensure that all Data Management computers and field recording equipment will make the transition to the year 2000 with no anticipated problems.

III Outreach Activities

1. Completion of Virtual Fieldtrip.

The Niwot Ridge virtual fieldtrip was put online in 1998. The present material located at http://culter.colorado.edu:1030/Field_trip/ focuses on two general topic areas. First,

information on the natural history (flora and fauna) of the alpine is presented. Second, the trip emphasizes information about nitrogen and nitrogen saturation issues and biodiversity issues. Our former REU Environmental Journalist students have developed the second group of topics. Also, additional links to real-time weather on the tundra and another virtual field trip to the site created by a former geography graduate student are included. A videocamera has been purchased so that real-time pictures of the alpine will be available. The virtual field trip will be enhanced by linking this to real-time data acquisition activities at the alpine weather station (D1 microwave relay) for comparison with the tundra weather data currently available from the Tundra Laboratory.

This web site has, to date, not received extensive attention, with only about 1300 visits since its creation about 9 months ago. Recently, however, we've formed a collaboration with the Boulder Areas Sustainability Information Network (BASIN), a group interested about environmental issues of the Boulder watershed (which includes much of Niwot Ridge and all of the Green Lakes Valley areas of our LTER). This group is funded by the Environmental Monitoring for Public Access and Community Tracking (EMPACT) program of EPA. BASIN will now add our information to their system, which should enhance our visibility to the public. Similar efforts to connect our outreach activities with Colorado and national mountain clubs are underway.

2. K-12 Outreach

Our outreach program is a continuation of the involvement of teachers from the Boulder/Denver area achieved through our LTER Schoolyard LTER program. This program has four aspects: 1) teaching in-service and pre-service teachers alpine ecology in a summer course at the MRS, 2) bringing elementary and middle school students to the MRS for field trips in the summer 3) development of a schoolyard monitoring program for streams on the lowlands to follow the spring flush of colored organic material (DOC) from the alpine and sub-alpine and 3) development of instructional materials about the Colorado alpine to be used by educators that complement the summer field programs. We take advantage of the fact that children in elementary and middle school years are most receptive to environmental education that emphasizes discovery, exploration and empathy of their local environment. As discussed by D. Sobel in his text "Beyond Ecophobia", a locally based approach to environmental education is more effective in both conveying ecological concepts and developing empathy than are approaches emphasizing more distant and abstract environmental crises, such as destruction of rain forests.

We are in the process of improving the connectivity at the MRS by installing a T1 line to Kiowa Laboratory and to the new Hostel that is currently under construction. The new Hostel will be used by the teachers when they take the course in alpine ecology as a classroom and computer laboratory facility. We will further improve the access to computers for the teachers at the MRS by having 6 workstations available at MRS. We are providing the teachers participating in this program PC's and high speed modems for their use in the classroom. In this manner, the teachers and their students will be able to access the NWTLTER database from their class in a straightforward manner. During the spring snowmelt and the rise of the color in the streams, the students and teacher will be

able to enter their data and also follow the changes in color at the other streams being monitored by other classes. This real time aspect and easy accessibility should make the monitoring activity more immediate and interactive, and increase its value as an educational activity.

IV. Cross-site, Synthesis and LTER Network Activities

A. Alpine-Arctic comparisons

Work continues on collaborations with research involving a) snow depth manipulations and b) greenhouse warming studies with the arctic LTER site, and in conjunction with ITEX (International Tundra Experiment). Former NWT LTER PIs, Marilyn and Skip Walker, are now formally associated with the Taiga LTER and the University of Alaska, respectively. We anticipate these collaborations to continue.

Another collaboration between graduate student Heidi Steltzer and Guis Shaver involves setting up a cross-site comparison of plant species feedbacks on N dynamics at Toolik Lake and Niwot Ridge. This effort should establish the generality regarding the positive feedback loops associated with species shifts induced by enhance N deposition.

B. Soil carbon

In addition to the Townsend collaboration described above, other LTER researchers continue to evaluate climate-vegetation-soil interactions on soil carbon storage and flux (e.g., Seastedt, in press). A suite of studies initiated this year will document elevational and vegetation effects on soil carbon and C:N ratios on Niwot Ridge. These data are essential for participation in cross-site comparisons and modeling efforts.

C. Regionalization and Regional Networking

Perhaps the most significant new activity is the establishment of a research facility within Rocky Mountain National Park, the McGraw Ranch Research Center that will have formal ties to the University of Colorado. The park's interest in this activity is to address "emerging threats to park resources." Niwot LTER's history of climate and vegetation studies in the alpine, in addition with the commitment to archive and maintain a 40-yr. study of plant species composition within RMNP, has made our group visible to park personnel. Moreover, the use of procedures developed for our information management system (Ingersoll et al. 1997), should also facilitate the development of this center.

Our interests are in combining LTER efforts with other formal, long-term research programs to develop a Front Range environmental monitoring and research center. We anticipate a formal proposal to the NSF NEON program.

D. National and international activities.

William Bowman participated in a Diversity workshop, sponsored by the Swiss Academy of Sciences and DIVERSITAS. The purpose of this workshop was to plan a global network of sites monitoring biotic diversity and experimentally addressing the relationship between diversity and ecosystem function and resilience.

Mark Williams received the US Environmental Protection Agency (EPA) Region VIII Outstanding Environmental Achievement Award, for community based work on ecosystem protection in the San Miguel river basin. The applied research in the San Miguel river basin evolved from process-based research conducted at the NWT LTER site. Mark Williams was also a member of the White House Office of Standards,

Technology, and Policy committee on national index sites, chaired by Jim Gosz and Peter Murdoch. The draft report from the committee featured research results from the NWT LTER program.

A graduate student working with Pam Diggle, Tara Forbis, has been awarded the Karling Award from the Botanical Society, and she used the award money to attend the International Botanical Congress and present an poster on her LTER-supported research. Dr. Diggle is also been charged to prepare a special feature for Ecology on phenotypic plasticity that will feature the LTER alpine work.

V. Publications

1999

Addington, R.N. and T.R. Seastedt. 1999. Activity of soil microarthropods beneath snowpack in alpine tundra and subalpine forest. *Pedobiologia* 43:47-53.

Lipson, D.A., T.K. Raab, S.K. Schmidt, and R.K. Monson. 1999. Variation in competitive abilities of plants and microbes for specific amino acids. *Biology and Fertility of Soils* 29:257-261.

Lipson, D.A., S.K. Schmidt, and R.K. Monson. 1999. Links between microbial population dynamics and nitrogen availability in an alpine ecosystem. *Ecology* 80:1632-1647.

Lipson, D.A., C.W. Schadt, S.K. Schmidt, and R.K. Monson. 1999. Ectomycorrhizal transfer of amino acid-nitrogen to the alpine sedge *Kobresia myosuroides*. *New Phytologist* 142:163-167.

Parker, E.R., and R.L. Sanford. 1999. The effects of mobile tree islands on soil phosphorus concentrations and distribution in an alpine tundra ecosystem. *Arctic, Antarctic, and Alpine Research* 31:16-20.

Schmidt, S.K. and R.L. Ley. 1999. Microbial competition and bioavailability limit the expression of allelochemicals in natural soils. In Inderjit, S., K.M.M. Dakshini and C.L. Foy (eds.). *Principles and Practices in Plant Ecology: Allelochemical Interactions*. CRC Press, Boca Raton.

Welker, J.M., Brown, K.A., and Fahnestock, J.T. 1999. CO₂ flux in arctic and alpine dry tundra: comparative field responses under ambient and experimentally warmed conditions. *Arctic, Antarctic and Alpine Research* 31: 308-313.

West, A.E., P.D. Brooks, M.C. Fisk, L.K. Smith, E.A. Holland, C.H. Jaeger III, S. Babcock, R. Lai, and S.K. Schmidt. 1999. Landscape patterns of CH₄ fluxes in an alpine tundra ecosystem. *Biogeochemistry* 45:243-264.

Wickland, K.P., R.G. Striegl, S.K. Schmidt and M.A. Mast. 1999. Methane flux in subalpine wetland and unsaturated soils in the southern Rocky Mountains. *Global Biogeochemical Cycles* 13:101-113.

1998

Bieber, A.J., M.W. Williams, M.J. Johnsson, and T.C. Davinroy. 1998. Nitrogen transformations in alpine talus fields, Green Lakes Valley, Front Range, Colorado, U.S.A.. *Arctic and Alpine Research* 30:226-271.

Bowman, W.D. and H. Steltzer. 1998. Positive feedbacks to anthropogenic nitrogen deposition in Rocky Mountain alpine tundra. *Ambio* 27:514-517.

Briggs, J.M, B.J. Benson, M.A. Hartman, and R.C. Ingersoll. 1998. Data Entry. Pp. 29-32 In Michener, W.K., J.H. Porter, and S.G. Stafford (eds.). *Data and information management in the ecological sciences: a resource guide*. LTER Network Office, University of New Mexico, Albuquerque, NM.

Brooks, P. D., M. W. Williams, and S. K. Schmidt. 1998. Inorganic nitrogen and microbial biomass dynamics before and during spring snowmelt. *Biogeochemistry* 43:1-15.

Bryant, D.M., E.A. Holland, T.A. Seastedt and M.D. Walker. 1998. Analysis of litter decomposition in an alpine tundra. *Canadian Journal of Botany* 76:1295-1304.

Diggle, P.K., S.S. Lower, and T.A. Ranker. 1998. Clonal diversity in alpine populations of *Polygonum viviparum*. *International Journal of Plant Sciences* 159:606-615.

Fisk, M.C., S.K. Schmidt and T.R. Seastedt. 1998. Topographic patterns of above- and belowground production and nitrogen cycling in alpine tundra. *Ecology* 79:2253-2266.

Inyan, B., M. W. Williams, K. A. Tonnessen, D. Campbell, and J. Turk. 1998. Nitrogen leaching from high-elevation lakes on the west slope of the Colorado Front Range. *Physical Geography* vol.19, no.4.

Lipson, D.A. and R.K. Monson. 1998. Plant-microbe competition for soil amino acids in the alpine tundra: effects of freeze-thaw and dry-rewet events. *Oecologia* 113:406-414.

Mullen, R.B., S.K. Schmidt., and C.H. Jaeger III. 1998. Nitrogen uptake during snowmelt by the snow buttercup, *Ranunculus adoneus*. *Arctic and Alpine Research* 30:121-125.

Reich, P.B., M. B. Walters, D.S. Ellsworth, J. Vose, J. Volin, C. Gresham, and W. Bowman. 1998. Relationships of leaf dark respiration to leaf nitrogen, specific leaf area and leaf life-span: a test across biomes and functional groups. *Oecologia* 114:471-482.

Steltzer, H. and W.D. Bowman. 1998. Differential influence of plant species on soil nitrogen transformations within moist meadow alpine tundra. *Ecosystems* 1:464-474.

Thomas, B.D. and W.D. Bowman. 1998. Influence of a N₂-Fixing Trifolium on Plant Species Composition and Biomass Production in Alpine Tundra. *Oecologia* 115:26-31.

West, A.E. and S.K. Schmidt. 1998. Wetting stimulates atmospheric CH₄ oxidation by alpine soils. *FEMS Microbiology Ecology*. 25:349-353.

Williams, M. W., T. Bardsley, and M. Rikkers. 1998. Oversampling of snow and overestimation of inorganic nitrogen wetfall using NADP data, Niwot Ridge, Colorado, *Atmospheric Environment* 32:3827-3833.

Williams, M. W., P. D. Brooks, and T. Seastedt. 1998. Nitrogen and carbon soil dynamics in response to climate change in a high-elevation ecosystem in the Rocky Mountains, *Arctic and Alpine Research* 30:26-30.

Papers in Press

Brooks, P.D., and M.W. Williams. Snowpack controls on nitrogen cycling. *Hydrologic Processes*.

Calanni, J., E. Berg, M. Wood, D. Mangis, R. Boyce, W. Weathers, and H. Sievering. Atmospheric nitrogen deposition at a conifer forest: response of free amino acids in engelmann spruce needles. *Journal of Environmental Pollution*.

Elias, S.A. *Natural History of the Rocky Mountains*. Smithsonian Institution Press.

Holland, E.A., R.Boone, J. Greenberg, P. Groffman, and P. Robertson. Measurement of Soil CO₂, N₂O, and CH₄ Exchange. In Robertson, P., et al. (eds.) *Soils Methods Standardization*, Oxford University Press.

Hood, E., M. W. Williams, and D. Cline. Sublimation from a seasonal snowpack at a continental, mid-latitude alpine site. *Hydrologic Processes*.

Jaeger, C.H., R.K. Monson, M. Fisk, and S. Schmidt. Interaction of plants and microorganisms in the partitioning of soil nitrogen in an alpine ecosystem. *Ecology*.

Lipson, D.A., S.K. Schmidt, and R.K. Monson. Carbon availability and temperature control the post-snowmelt decline in alpine soil microbial biomass. *Soil Biology and Biochemistry*.

Losleben, M.V., N. Pepin, S. Pedrick. Relationships of precipitation chemistry, atmospheric circulation, and elevation at two sites on the Colorado Front Range. *Atmospheric Environment*.

Raab, T.K., D.A. Lipson and R.K. Monson. Soil amino acid utilization among species of the Cyperaceae: Plant and soil aspects. *Ecology*.

Seastedt, T.R. Soil Fauna and controls of carbon dynamics: comparisons of grasslands and forests across latitudinal gradients. In Coleman, D.C., and P. Hendrix (eds). *Invertebrates as webmasters in Ecosystems*. CAB Press.

Seastedt, T.R., and G.A. Adams. Effects of Mobile Tree Islands on Alpine Soils. *Ecology*.

Sievering, H. Forest nitrogen budgets: response to Nadelhoffer et al. *Nature*.

Toetz, D. Multiple limiting nutrients in a subalpine stream, Colorado Front Range. *Journal of Freshwater Ecology*.

Walker, D.A., J.G. Molenaar, and W.D. Billings. Plant processes and patterns in relation to snow in arctic and alpine environments. In: Jones, H.G., J. Pomeroy, D.A. Walker, and R. Wharton (eds.). *Snow Ecology*. Cambridge University Press Science Series.

Walker, M.D., D.A. Walker, J.M. Welker, A.M. Arft, T. Bardsley, P.D. Brooks, J.T. Fahnestock, M.H. Jones, M. Losleben, A.N. Parsons, T.R. Seastedt, P.L. Turner. Long-term experimental manipulation of winter snow regime and summer temperature in arctic and alpine tundra. *Hydrological Processes*.

West, A.E. and S.K. Schmidt. Acetate stimulates atmospheric CH₄ oxidation by an alpine tundra soil. *Soil Biology and Biochemistry*.

Williams, M.W., D. Cline, M. Hartman, and T. Bardsley. Data for snowmelt model development, calibration, and verification at an alpine site, Colorado Front Range. *Water Resources Research*.

Williams, M.W., R. Sommerfeld, S. Massman, and M. Rikkers. Correlation lengths of vertical flowpaths in melting snowpacks, Colorado Front Range, USA. *Hydrologic Processes*.

Theses and Dissertations

1999

Estey, T.B. 1999. Krummholz vegetation and nutrient content are spatially distributed: results from two alpine sites in Colorado. Senior Honor's Thesis. Department of Biological Sciences, University of Denver. Denver, CO.

Fox, A.M. 1999. Equivalent permeability of continental, alpine snowpack. M.S. thesis, University of Colorado, Boulder. 116 pp.

Sherrod, S.K. 1999. A multiscale analysis of the Northern Pocket Gopher (*Thomomys talpoides*) in the Alpine, Niwot Ridge, CO. Ph.D. dissertation, University of Colorado, 141 pp.

1998

Hamann, H.B. 1998. Snowcover controls on alpine soil surface temperature patterns, Niwot Ridge, Colorado, U.S.A. M.S. thesis, University of Colorado, Boulder. 129 pp.

Lipson, D.L. 1998. Plant-microbe interactions and organic nitrogen availability in an alpine dry meadow. PhD dissertation, University of Colorado, Boulder. 170 pp.

West, A.E. 1998. Microbial ecology of methane metabolism in alpine tundra soils. PhD dissertation, University of Colorado, Boulder. 149 pp.

Submitted Manuscripts

Brown, K., and J.M. Welker. Growth responses of *Dryas octopetala* to simulated and natural variation in climate. Arctic, Antarctic and Alpine Research.

Chase, T.N., R.A. Pielke, T.G.F. Kittel, J.S. Baron, and T.J. Stohlgren. Impacts on Colorado Rocky Mountain weather and climate due to land use changes on the adjacent Great Plains.

Ebersole, J.J. Succession of alpine vegetation, Colorado Front Range, U.S.A., Arctic, Antarctic and Alpine Research

Inyan, B., and M.W. Williams. Protecting headwater catchments from future degradation, San Miguel River, CO. Ecological Applications.

Jaeger, C.H., R.K. Monson, M.C. Fisk, and S.K. Schmidt. Competition is minimized by temporal displacement of plant and microbial nitrogen uptake in an alpine ecosystem. *Oecologia*.

Jaeger, C.H., M.C. Fisk, L.K. Smith, E.A. Holland, and S.K. Schmidt. A mechanistic approach to understanding N₂O fluxes from alpine soils: Biotic and abiotic factors. *Biogeochemistry*.

Lipson, D.A., T.K. Raab, S.K. Schmidt, and R.K. Monson. Amino acid turnover in an alpine soil: cross-validation of flux and concentration data using a simple model. *Ecology*.

Liu, F., M.W. Williams, J. Sun, S. Zho, E. Hoode, and G. Cheng. Hydrochemical processes and hydrological separation in headwater basins of the Urumqui River, Tien Shan, China. *Hydrologic Processes*.

Losleben, M.V. Behavior of climatically important trace gases at a continental site. *Atmospheric Environment*.

Rusch, D. and H. Sievering. Ambient air nitrogen concentrations and atmospheric deposition at a sub-alpine forest at Niwot Ridge, Colorado. *Atmospheric Environment*.

Sherrod, S.K., T.R. Seastedt and M.D. Walker. submitted. The northern pocket gopher as an organizer of ecosystem and plant community structure. *Science*.

Schmidt, S.K., D.L. Lipson and T.K. Raab. Effects of tree islands on the abundance and distribution of microbial functional groups in alpine soils. *Microbial Ecology*.

Steltzer, H. and W.D. Bowman. Differential influence of plant species on soil N transformations within the alpine tundra. *Ecosystem Science*.

Thomas, BD and WD Bowman. Influence of a N₂-fixing trifolium on plant species composition and biomass production in alpine tundra. *Oecologia*.

Williams, M. W. and K. A. Tonnessen, Critical loads for nitrogen deposition in the Colorado Rocky Mountains, USA, *Ecological Applications*.

Williams, M. W., M. Ridders, and W. T. Pfeffer, Ice columns and frozen rills in a warm snowpack, Colorado Front Range, USA, *Nordic Hydrology*.