

Annual Report for Period:12/2000 - 12/2001**Submitted on:** 08/27/2001**Principal Investigator:** Seastedt, Timothy R.**Award ID:** 9810218**Organization:** U of Colorado Boulder**Title:**

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

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Organizational Partners

Other Collaborators or Contacts

Recent Synthesis, Cross-site, and LTER Network Activities

The completion of the Niwot Ridge ecosystem volume as part of the Oxford University LTER publications series represents a major accomplishment by the site PIs. To our knowledge, this is the first comprehensive summary of terrestrial alpine ecology in North America. While the focus is on Niwot Ridge, most chapter authors attempted a strong comparative approach whenever possible, which allows us to make statements regarding the generality of findings. We emphasize that most of the research used to form the basis of our conclusions in that effort came from earlier LTER activities. Our perspectives on a few of the issues have already changed, but the summaries presented in this volume remain valid for focusing current and future efforts. In addition, former NWT graduate student David Bryant has written a synthesis effort comparing arctic and alpine decomposition patterns using the extensive LTER LIDET data set (Bryant et al. in press).

Mark Williams et al. have obtained a cross-site LTER NSF grant to expand upon activities to quantify the relationships between organic N and organic carbon in soils and streams of diverse ecosystem types. This effort follows up on the creation of an organic N and organic C analytical facility at CU-INSTAAR. The combined laboratories of LTER PIs McKnight, Townsend, and Williams are developing a suite of analytical procedures to evaluate the fate of organic N and C generated in soils, sediments, and surface waters, that have been transformed into a variety

of recalcitrant organic fractions. This activity is particularly timely and appropriate at our site where enhanced N deposition and enhanced precipitation are directly modifying N inputs and indirectly modifying transformations by affecting species composition and productivity of the site.

The NWT LTER will host the 2002 fall LTER network Coordination Committee meeting and be in charge of developing its science program. The proposed subject will emphasize LTER contributions to the analysis of species change as both a causal mechanism and consequence of various aspects of global change. Seastedt is also chair of the LTER network invasive species working group.

William Bowman participated in three European activities in 2000 and one in 2001. These included: 1) Bowman and Suding. Biotic Influences on the Response of the Rocky Mountain Alpine to Environmental Change. Third Annual ILTER workshop, Central and Eastern Europe, Nitra, Slovak Republic. 2) Bowman, On the role of biotic interactions in structuring alpine plant communities- keynote address in Community Ecology, Third Annual Conference on the Physiology, Ecology and Evolution of Alpine Plants, Lautaret Alpine Field Station, France, 3) Bowman and Damm. Causes and consequences of vascular plant diversity in the Rocky Mountain alpine, workshop on Global Mountain Biodiversity Assessment, Rigi, Switzerland. 4) Bowman, Plant control of ecosystem processes in the alpine: implications for response to environmental change. The 4th Central and East European Regional Meeting of the ILTER. Bowman is on the Global Mountain Biodiversity Assessment Steering Committee, and has remained active in collaborative efforts with European scientists.

Patrick Bourgeron was host for a group of potential ILTER scientists from France in summer, 2000. He reciprocated by organizing an ILTER workshop activity in France in January, 2001. Seastedt also participated in the workshop, and several projects involving Bourgeron and French scientists have been proposed from this effort.

Activities and Findings

Research and Education Activities:

The Niwot Ridge LTER prepared for its midterm, formal NSF site review by developing a 'new' model that describes the biogeochemistry of high elevation systems. This model will be the subject of a BioScience article to be submitted in the coming year.

THE LANDSCAPE CONTINUUM MODEL: A BIOGEOCHEMICAL PARADIGM FOR HIGH ELEVATION ECOSYSTEMS

Interactions between a cold, wet, and windy environment and steep elevation gradients generate unique source and sink areas for water and nutrients as a result of water, energy and resource redistribution.

These redistribution patterns structure nival, (highest elevation areas generally lacking rooted vegetation) alpine, and subalpine communities as a result of the coupled response of these three systems to the climatic and atmospheric inputs.

1. Nival systems largely lack biotic mechanisms of water or nutrient retention. This material becomes redistributed to downslope communities. The general absence of primary producers means that heterotrophic processes dominate this system generated from organic material accumulated from atmospheric deposition in protected sites. Hence, in this system, the ratio of NPP/heterotrophic respiration, like a headwater stream, is hypothesized to be <1 .
2. The alpine, while receiving subsidies from the nival zone, is suggested to be a 'source ecosystem' of organic matter and nutrients to the subalpine. This means that, overall, $NPP/Heterotrophic\ respiration >1$. The dry meadow community in particular is suggested to strongly exhibit this property, contributing both a high fraction of aboveground NPP and the largest amounts of organic matter to lower elevation systems. This pattern also generates a nutrient limitation, particularly in the dry meadow areas.
3. Zones within the alpine are potential recipients of nival redeposition in addition to redeposition from alpine sources. Snowfield and wet meadow sites are subsidized with water and nutrients from other sites. Selection for rapid growth and development due to the short growing season should select for species with high nutrient requirements. Dry meadows should represent the most intensively nutrient limited sites, both because of the lack of subsidies, but also because these are hypothesized as source communities for organics and therefore lose nutrients via a fairly unique mechanism (aerial transport!).
4. There exists an inverse relationship between solar energy inputs and water and nutrient inputs in the alpine system. Following the Chapin (1990) model, species should attempt to minimize the extent to which any single resource is limiting and allocate resources

accordingly. This pattern should be evident in the composition of the various alpine communities in terms of root/shoot ratios and nutrient composition.

5. Redeposition of water, nutrients and particulates is maximized at the alpine-subalpine interface. The trees themselves provide the mechanism to scavenge these materials by functioning as windbreaks and collectors. In the absence of a developed treeline, these materials are transported further downslope. Overall, the subalpine is hypothesized to be a 'sink' ecosystem for both nutrients and organic matter. If organic subsidies are large, then the potential for the relationship $NPP/heterotrophic\ respiration < 1$ exists, and the site should exhibit characteristics of high nutrient availability.

Overall, the above concepts link Billing's (1973) mesotopographic alpine model with ideas developed in the Vannote et al.(1980) river continuum hypothesis. The two models collectively provide both the landscape and elevational components required to understand high elevation systems from a biogeochemical perspective. The model explains overall patterns of biogeochemical cycles, carbon fluxes, NPP, and makes predictions about growth strategies of plants. The model easily integrates with similar concepts and principles required to understand high-elevation catchments and watersheds, and provides a mechanistic interpretation for how components of the high-elevation landscape can be experiencing both excesses and deficiencies of the same nutrient.

What is particularly exciting and compelling about this model is that, for the first time, we are able to integrate both terrestrial and aquatic processes across diverse ecosystem types. The relevance of this model can be discerned from research findings cited below.

While our educational mission remains secondary to our research mission, we're very proud of our outreach and have documented recent activities in that section of this report.

Findings:

Niwot Ridge LTER investigators produced 50 research articles that have been published or in press since 2000. The synthesis volume, 'Structure and function of an alpine ecosystem', (Bowman and Seastedt, eds., Oxford Univ. Press 2001) has provided a summary of our science through about 1998. Unresolved science questions identified in that work, in addition to the model described above, provides the basis for our current and future science initiatives.

I. Research highlights:

1. Nitrogen (N) deposition. Efforts to understand sources and fates of nitrogen inputs have remained an active area of research. Continued monitoring of N inputs from NADP sources indicates an increase of about $0.05\ g\ N\ \cdot\ m^{-2}\ \cdot\ y^{-1}$. Previous and ongoing studies document vegetation responses to changes in N availability.
2. Climate change. Work by Nel Caine (submitted) has independently documented enhanced precipitation in the highest regions of Niwot Ridge. (Previously, this observation was based solely on time-series data from a single climate station.) This work provides justification for the ongoing snowfence manipulation, and suggests that increased precipitation in the southern Rockies may be more significant to high elevation ecosystems than increased warming.
3. Phosphorus - Nitrogen interactions. Concurrently with the N deposition work, preliminary sampling for plant-available phosphorus in alpine and subalpine soils suggests that the age of these soils influences the strength of P limitation (Townsend et al., unpublished results). We see this line of research as one that's critically important to predict species composition shifts associated with the reduction of N limitation in these ecosystems.
4. Ecosystem responses to climate and atmospheric changes. Ongoing studies of the snowpack manipulation site (snowfence) continue to define and expand upon earlier studies. 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.
5. Understanding of alpine-subalpine linkages. 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 in snow. These studies have been continued, with two Ph.D. students continuing work on consequences of treeline establishment in terms of both vegetation composition and ecosystem processes.

Training and Development:

At our recent site review, we reported 26 graduate students (currently involved or 2001 graduates) participating with the Niwot LTER program. Our LTER invests only about 80k per year in graduate student stipends, but the 26 students represent a minimum investment of 468k per year

in graduate education. The majority of graduate student training is accomplished by using LTER graduate student summer stipends to leverage additional support from Colorado resources, or the students are funded through programs that are linked to LTER efforts but have been funded from sources outside the core LTER grant.

In addition to training several undergraduates annually as part of the LTER-REU supplement, the LTER researchers also form a large portion of the faculty involved in a CU Dept. of EPO Biology REU summer research program. These students are housed at the field station and work on their own projects, alongside graduate students and faculty. This program has been remarkably productive, with many of these students senior-authoring or co-authoring research efforts published in national and international journals.

Outreach Activities:

The NWTLTER has carried out a K-12 outreach program from 1998 through the present time by collaborating with existing programs for children in the Denver/Boulder area and by working specifically with the Boulder Valley School District. The conceptual theme of the outreach is the connection between the alpine systems in the mountains and the communities of the Rocky Mountain Front Range. These communities are located at the intersection of the Great Plains and the Rocky Mountains, and have been expanding in population and development. We have found that in elementary and middle school years, children are particularly receptive to environmental education that emphasizes discovery, exploration and empathy with their local environment.

Current K-12 Outreach Program

The NWTLTER has an outreach program to elementary and middle school students in the Boulder/Denver area through a collaborative effort with Science Discovery (1998-2001) a local program based at the University of Colorado, Bixby School (1999-2001) in Boulder, and Wild Bear Science School (1999-2000) in Nederland, a mountain town located near the Mountain Research Station (MRS). The age range of the children is 5-12 years and the group size for summer field trips is 12-18 children, with 4-6 scientists and student teachers as leaders. Each of these programs and schools serves children with different backgrounds and interests. Science Discovery offers a wide range of summer science programs for children, including one-day programs, one-week classes based in Boulder and one-week field trips within the Rocky Mountains. The program with Science Discovery offered two Saturday field classes in conjunction with our NWTLTER program, one for elementary and one for middle school children. Bixby School is a private elementary school that uses an experiential theme for all their classes during the academic year and the students attending Bixby School in the summer have been in an informal experiential learning environment. Bixby teachers integrate the students' experiences from the field trips to the MRS into subsequent activities during the school year. The Wild Bear Science School has a two-week session for elementary students on an ecological theme, and a one-week session for middle school students. These students are primarily from the mountain communities. The field trip to the MRS is integrated into the middle of the program for each week of these classes, as a component that emphasizes observations and recording by sketches and note taking.

All of these field trips are coordinated with a MRS summer course- 'Alpine Ecology and Experiential Learning'. Five-fifteen students have taken this course each year, with about half of the students being in-service teachers. The course is taught by NWTLTER scientists (e.g. Diane McKnight, Susan Sherrod and Hector Galbraith) and by Dr. Jane Larson, an expert in science education from the College of Education at the University of Colorado. Hector Galbraith, Diane McKnight and Jane Larson will teach the class this summer. As the service learning aspect of the summer course, the undergraduate and graduate students, along with the course instructors, lead the field trips described above. In some cases, the instructors from the school programs participate as well. Prior to leading the field trips, the undergraduate students lead 'practice' field trips with children of friends and colleagues at the University of Colorado.

Virtual Field Trip to Niwot Ridge- The NWTLTER has developed a virtual field trip to Niwot Ridge with support from the University of Colorado. The prototype of this field trip is now posted on the web site at http://culter.colorado.edu/Field_trip. The virtual field trip provides background information, and then 3 field trips that emphasize the mammals, plants and the effect of nitrogen on biodiversity. Essays written by environmental journalists funded through the REU program have provided text. The trip is structured with pictures of the animals and plants that can be enlarged. The virtual field trip complements the experiential field trips in many ways: providing a back-up should inclement weather limit the trip, providing access for children in a group who may have a handicap limiting the possibility for a hike, providing follow-up and refresher material for students after the trip which they can access at school or at home; providing material that the students could use in later classroom activities and projects in later grades. We hope to upgrade and revise this effort in the coming year.

Children's book: 'My Water Comes from Silver Lake'- Another accomplishment of the NWTLTER K-12 program has been the completion of a text and pictures for a children's book describing the ecology of the Green Lakes valley and the hydrologic cycle which supplies water from the valley to the City of Boulder. A former student from the MRS summer course prepared the text and the pictures are brilliant water colors painted by students in her third grade class. This material has been submitted to several potential publishers. We believe that support from several sources can be found to support the publication

of the initial edition. A web version is also being considered.

Science Library Video- Last fall, Diane McKnight and INSTAAR scientists provided technical support and coordinated local arrangements for a video production company preparing a series on biomes of the world for Schlessinger Science Library. NWT LTER scientists and elementary and middle school students participating in our outreach effort last year were filmed. This footage was used extensively in three tapes: Biomes of the World in Action: Tundra, Biomes of the World in Action, Coniferous Forest, and Forest Ecosystems for Children. These videos are sold to middle school and k-4 educators and audiences worldwide.

A major use of outreach funds has been and will continue to be for stipends to support the participation of current elementary school teachers in this program. We use funds to enroll teachers for the summer program in the subsequent year (July 2002). We support the teachers for a month while they take the MRS class, and stipends are provided to seven teachers. We have found that providing stipends greatly encourages participation. We expect that the interest in the outreach program in future years will also be sustained by word of mouth based on the experience of the teachers who have participated in the course.

With funds provided by an additional previous supplement we are also providing computers to the teachers who have participated in the class. This allows the teachers to access the NWTLTER database and use other materials with which they became familiar during their classes during the school year. For example, the teachers can access the images from the Tundracam, a camera located at the top of the Tundra lab that provides continuous images of the surrounding alpine area and can be steered by remote access over the web.

We have conducted an additional outreach activity that more directly reaches middle school students. For the past two years INSTAAR has held an event in which 200-500 middle school students come to INSTAAR for a half-day of lab tours and a science lecture. As part of the INSTAAR event in the fall 1999, 2000, and 2001. NWTLTER scientists conducted 5 sessions of an activity for the students at Boulder Creek (located two blocks from INSTAAR) in which we demonstrated methods for stream flow measurement, water quality sampling and measurement, and collection of aquatic biota, and discussed the connections between Boulder Creek as it travels through the city and its origins in Green Lakes Valley. The activity is completed in about 45 minutes, with stops at 3 stations along the creek. The activity at the creek is followed by a tour of the limnology laboratory at INSTAAR, including looking at algae in a microscope. Some of the students who took the middle school Science Discovery class had participated in the field activity at INSTAAR. From this activity, one middle school student conducted a science fair project with a NWTLTER graduate student, and she won an award at the state competition.

During the summer and fall of 2000, the involvement of elementary and middle school students in NWTLTER outreach activities was as follows (the 2001 program has just finished and statistics have not been summarized):

Summer field trips to the MRS: 12 groups, about 180 children

Field trips by teachers with their classes: 4 classes, about 120 children Field sampling exercise in Boulder Creek at INSTAAR for middle school students: about 300 students

Because we provide teacher training and computer resources, all of these activities involve some continuing opportunities for in-class involvement by the teachers and the students. This approach has applications to other communities in the Rocky Mountain Region.

Journal Publications

Gross, K.L., M.R. Willig, L. Gough, R. Inouye, and S.B. Cox., "Patterns of species density and productivity at different spatial scales in herbaceous plant communities.", *Oikos*, p. 417, vol. 98, (2000). Published

Baron, J.S. and N. Caine., "Temporal coherence of two alpine lake basins of the Colorado Front Range, U.S.A.", *Freshwater Biology*, p. 463, vol. 43, (2000). Published

Conley, A.H., E.A. Holland, T.R. Seastedt and W.J. Parton, "Simulation of carbon and nitrogen cycling in an alpine tundra", *Arctic, Antarctic, and Alpine Research*, p. 147, vol. 32, (2000). Published

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*, p. 441, vol. 32, (2000). Published

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*, p. 1723, vol. 34, (2000). Published

- Addington, R.N. and T.R. Seastedt, "Activity of soil microarthropods beneath snowpack in alpine tundra and subalpine forest", *Pedobiologia*, p. 47, vol. 43, (1999). Published
- Bowman, W.D., A. Keller, and M. Nelson, "Altitudinal variation in leaf gas exchange, nitrogen and phosphorus concentrations and leaf mass per area in populations of *Frasera speciosa*", *Arctic, Antarctic, and Alpine Research*, p. 191, vol. 31, (1999). Published
- Brooks, P.D., M.W. Williams, "Snowpack controls on nitrogen cycling and export in seasonally snow-covered catchments", *Hydrologic Processes*, p. 2177, vol. 13, (1999). Published
- Chase, T.N., R.A. Pielke, T.G.F. Kittel, J.S. Baron, and T.J. Stohlgren, "Potential impacts on Colorado Rocky Mountain weather and climate due to land use changes on the adjacent Great Plains", *Journal of Geophysical Research*, p. 16673, vol. 104, (1999). Published
- Greenland, D., "ENSO-related phenomena at long-term ecological research sites", *Physical Geography*, p. 491, vol. 20, (1999). Published
- Hood, E., M. W. Williams, and D. Cline, "Sublimation from a seasonal snowpack at a continental, mid-latitude alpine site.", *Hydrologic Processes*, p. 1781, vol. 13, (1999). Published
- Lipson, D.A., T.K. Raab, S.K. Schmidt, and R.K. Monson, "Variation in competitive abilities of plants and microbes for specific amino acids", *Biology and Fertility of Soils*, p. 257, vol. 29, (1999). Published
- Lipson, D.A., C.W. Schadt, S.K. Schmidt, and R.K. Monson, "Ectomycorrhizal transfer of amino acid-nitrogen to the alpine sedge *Kobresia myosuroides*", *New Phytologist*, p. 163, vol. 142, (1999). Published
- Lipson, D.A., S.K. Schmidt, and R.K. Monson, "Links between microbial population dynamics and nitrogen availability in an alpine ecosystem", *Ecology*, p. 1623, vol. 80, (1999). Published
- Parker, E.R., and R.L. Sanford, "The effects of mobile tree islands on soil phosphorus concentrations and distribution in an alpine tundra ecosystem", *Arctic, Antarctic, and Alpine Research*, p. 16, vol. 31, (1999). Published
- Raab, T.K., D.A. Lipson and R.K. Monson, "Soil amino acid utilization among species of the *Cyperaceae*: Plant and soil processes", *Ecology*, p. 2408, vol. 80, (1999). Published
- Reich, P.B., D.S. Ellsworth, M.B. Walters, J.M. Vose, C. Gresham, J.C. Volin, and W.D. Bowman, "Generality of leaf traits: a test across six biomes", *Ecology*, p. 1955, vol. 80, (1999). Published
- Soranno, P.A., K.E. Webster, J.L. Riera, T.K. Kratz, J.S. Baron, P.A. Bukaveckas, G.W. Kling, D.S. White, N. Caine, R.C. Lathrop, and P.R. Leavitt, "Spatial variation among lakes within landscapes: Ecological organization along lake chains", *Ecosystems*, p. 395, vol. 2, (1999). Published
- Toetz, D., "Multiple limiting nutrients in a subalpine stream, Colorado Front Range", *Journal of Freshwater Ecology*, p. 349, vol. 14, (1999). Published
- Welker, J. M., Brown, K. A., and Fahnestock, J. T., "CO₂ flux in arctic and alpine dry tundra: comparative field responses under ambient and experimentally warmed conditions", *Arctic, Antarctic and Alpine Research*, p. 308, vol. 31, (1999). Published
- 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, "Landscape patterns of CH₄ fluxes in an alpine tundra ecosystem", *Biogeochemistry*, p. 243, vol. 45, (1999). Published
- Wickland, K.P., R.G. Striegl, S.K. Schmidt and M.A. Mast, "Methane flux in subalpine wetland and unsaturated soils in the southern Rocky Mountains", *Global Biogeochemical Cycles*, p. 101, vol. 13, (1999). Published

- Williams, M.W., D. Cline, M. Hartman, T. Bardsley, "Data for snowmelt model development, calibration, and verification at an alpine site, Colorado Front Range", *Water Resources Research*, p. 3205, vol. 35, (1999). Published
- Williams, M.W., R. Sommerfeld, S. Massman, and M. Ridders, "Correlation lengths of meltwater flow through ripe snowpacks, Colorado Front Range, USA", *Hydrologic Processes*, p. 1807, vol. 13, (1999). Published
- 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, and P.L. Turner, "Long-term experimental manipulation of winter snow regime and summer temperature in arctic and alpine tundra.", *Hydrological Processes*, p. 2315, vol. 13, (1999). Published
- Arft, A.M., et al., "Responses of tundra plants to experimental warming: Meta-analysis of the international tundra experiment", *Ecological Monographs*, p. 491, vol. 69, (1999). Published
- 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*, p. , vol. , (). Accepted
- Gonzalez, G., R.E. Ley, S.K. Schmidt, X. Zou, and T.R. Seastedt, "Interactions between invertebrates and microbes: comparisons between tropical and subalpine forests", *Oecologia*, p. , vol. , (). Accepted
- Gonzalez, G. and T.R. Seastedt, "Soil fauna and plant litter decomposition in tropical and subalpine forests", *Ecology*, p. , vol. , (). Accepted
- Gonzalez, G. and T.R. Seastedt, "Comparison of the abundance and composition of soil fauna in tropical and subalpine forests", *Pedobiologia*, p. , vol. , (). Accepted
- Gough, L., C.W. Osendberg, K.L. Gross, and S.L. Collins, "Fertilization effects on species density and primary productivity in herbaceous plant communities", *Oikos*, p. , vol. , (). Accepted
- 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*, p. , vol. , (). Accepted
- Korb, J. E. and T. A. Ranker, "Changes in stand composition and structure between 1981 and 1996 in four Front-Range plant communities in Colorado", *Plant Ecology*, p. , vol. , (). Accepted
- Meixner, T. M., R. C. Bales, M. W. Williams, D. H. Campbell, and J. S. Baron, "Stream chemistry modeling of two watersheds in the Front Range, Colorado", *Water Resources Research*, p. 77, vol. 36, (2000). Published
- Seastedt, T.R., and G.A. Adams, "Effects of Mobile Tree Islands on Alpine Soils", *Ecology*, p. , vol. , (). Accepted
- Seastedt, T.R. and Lynn Vaccaro, "Plant species richness, productivity and nitrogen and phosphorus limitations across a snowpack gradient in alpine tundra", *Arctic, Antarctic, and Alpine Research*, p. , vol. , (). Accepted
- Sherrod, S. K. and T.R. Seastedt, "Effects of the northern pocket gopher (*Thomomys talpoides*) on alpine soil characteristics, Niwot Ridge, CO", *Biogeochemistry*, p. , vol. , (). Accepted
- West, A.E. and S.K. Schmidt, "Acetate stimulates atmospheric CH₄ oxidation by an alpine tundra soil", *Soil Biology and Biochemistry*, p. , vol. , (). Accepted
- Sievering, H., "Nitrogen deposition and carbon sequestration", *Nature*, p. 629, vol. 400, (1999). Published
- Gonzalez, G. and T.R. Seastedt, "Soil fauna and plant litter decomposition in tropical and subalpine forests", *Ecology*, p. 955, vol. 82, (2001). Published
- Inyan, B. and M.W. Williams, "Protecting headwater catchments from future degradation, San Miguel River, CO", *Mountain Research and Development*, p. 71, vol. 21(1), (2001). Published

- Ley, R.E., D.A. Lipson, and S.K. Schmidt, "Microbial biomass levels in barren and vegetated high altitude talus soils", *Soil Science Society of America Journal*, p. 111, vol. 65, (2001). Published
- Lipson, D.A., T.K. Raab, S.K. Schmidt, and R.K. Monson, "An empirical model of amino acid transformation in an alpine soil", *Soil Biology & Biochemistry*, p. 189, vol. 33, (2001). Published
- Rattray, G. and H. Sievering, "Dry deposition of ammonia, nitric acid, and nitrate to alpine tundra at Niwot Ridge, CO", *Atmospheric Environment*, p. 1085, vol. 35, (2001). Published
- Seastedt, T.R. and G.A. Adams, "Effects of mobile tree islands on alpine tundra soils", *Ecology*, p. 8, vol. 82, (2001). Published
- Baron, J.S. and M.W. Williams, "Preface, recent Loch Vale Watershed Research", *Water Resource Research*, p. 11, vol. 36(1), (2000). Published
- Bilbrough, C.J., J.M. Welker, and W.D. Bowman, "Early spring nitrogen uptake by snow-covered plants: a comparison of arctic and alpine plant function under the snowpack", *Arctic, Antarctic, and Alpine Research*, p. 404, vol. 32(4), (2000). Published
- Bowman, W.D., "Biotic controls over ecosystem response to environmental change in alpine tundra of the Rocky Mountains", *Ambio*, p. 396, vol. 29, (2000). Published
- Buttenfield, B.P. and M. Tsou, "Distribution of an internet-based GIS to remote college classrooms", *Proceedings, ESRI user conference, San Diego, California.*, p. 24, vol. , (2000). Published
- Erickson, T.A.; Williams, M.W. ; Sommerfeld, R.A., "Spatial statistics of snowmelt", In: Bentley, L.R., J.F. Sykes, C.A. Gray and G.F. Pinder. *Proceedings of the XIII International Conference on Computational Methods in Water Resources*, Calgary, Canada, June 2000. A.A. Balkema publishers, Rottendam., p. 1147, vol. 2, (2000). Published
- Losleben, M.V, "Snowpack, ENSO, and atmospheric circulation on the Colorado Front Range", In *Proceedings of the 16th annual Pacific Climate Workshop, Technical report 65 of the Interagency Ecological Program for the Sacramento-San Joaquin Delta*, May 2000, p. 136, vol. , (2000). Published
- Schmidt, S.K.; Lipson, D.A.; Raab, T.K., "Effects of willow (*Salix brachycarpa*) on populations of salicylate-mineralizing microorganisms in alpine soils", *J. Chem. Ecol*, p. 2049, vol. 26, (2000). Published
- Toetz, D, "Decomposition in an alpine wetland brook, Colorado Front Range", *Verh. Internat. Verein. Limnol*, p. 748, vol. 27, (2000). Published
- Williams, M.W. and K.A. Tonnessen, "Critical loads for inorganic nitrogen deposition in the Colorado Front Range, USA", *Ecological applications*, p. 1648, vol. 10(6), (2000). Published
- Williams, M.W., M.R. Ridders, and W.T. Pfeffer, "Ice columns and frozen rills in a warm snowpack, Green Lakes Valley, Colorado, USA", *Nordic Hydrology*, p. 169, vol. 31(3), (2000). Published
- Bugmann, H., "A comparative analysis of forest dynamics in the Swiss Alps and the Colorado Front Range", *Forest Ecology and Management*, p. 43, vol. 145, (2001). Published
- Bowman, W.D. and C.J. Bilbrough, "Influence of a pulsed nitrogen supply on growth and nitrogen uptake in alpine graminoids", *Plant and Soil*, p. 283, vol. 233, (2001). Published
- Bechtold, H.A., T.A. Forbis and P.K. Diggle, "Lack of reproductive plasticity in *Saxifraga rhomboidea* Greene (Saxifragaceae)", *Canadian Journal of Botany*, p. , vol. , (). Submitted
- Bryant, D.M., E.B. Rastetter, K.J. Nadelhoffer, M.D. Walker and J.L. Laundre, "Litter decomposition of the Arctic and Alpine LIDET data", *Ecosystems*, p. , vol. , (). Accepted

- Duguay, C.R., "An approach to the estimation of surface net radiation in mountain areas using remotely sensed and digital terrain data", *Theoretical and Applied Climatology*, p. , vol. , (). Accepted
- Forbis, T.A. and P.K. Diggle, "Sub-nivean embryo development in the alpine herb *Caltha leptosepala* (Ranunculaceae)", *Canadian Journal of Botany*, p. , vol. , (). Accepted
- Fox, A., M. W. Williams, and N. Caine, "Equivalent permeability of a continental, alpine snowpack in the Colorado Front Range, USA", *Water Resources Research*, p. , vol. , (). Accepted
- Gonzales, G., R.E. Ley, S.K. Schmidt, X. Zou, and T.R. Seastedt, "Interactions between invertebrates and microbes: comparisons between tropical and subalpine forests", *Oecologia*, p. , vol. , (). Accepted
- Hazen, J.M., M.W. Williams, B. Stover, and M. Wireman, "Acid mine drainage characterization and remediation using a combination of hydrometric, chemical, and isotopic analyses, Mary Murphy Mine, Colorado", *Environmental Geochemistry and Health*, p. , vol. , (). Accepted
- Hood, E., M.W. Williams, and N. Caine, "Outputs of organic nutrients from a high-elevation catchment, Green Lakes Valley, Colorado", *Arctic, Antarctic, and Alpine Research*, p. , vol. , (). Accepted
- Korb, J.E. and T.A. Ranker, "Changes in stand composition and structure between 1981 and 1996 in four Front-Range plant communities in Colorado", *Plant Ecology*, p. , vol. , (). Accepted
- Lipson, D. and Nasholm, "The unexpected versatility of plants: organic nitrogen use and availability in terrestrial ecosystems", *Oecologia*, p. , vol. , (). Accepted
- Litaor, M.I., T.R. Seastedt, and D.A. Walker, "Spatial analysis of selected attributes of soil across topographic/snow gradient", *Landscape Ecology*, p. , vol. , (). Accepted
- McKnight, D.M., B.A. Kimball, and R.L. Runkel, "pH dependence of iron photoreduction in a Rocky Mountain stream affected by acid mine drainage", *Hydrologic Processes*, p. , vol. , (). Accepted
- Meloche, C.G. and P.K. Diggle, "Preformation, architectural complexity and developmental flexibility in *Acomastylis rossii* (Rosaceae)", *American Journal of Botany*, p. , vol. , (). Accepted
- Meloche, C.G. and P.K. Diggle, "Patterns of carbon allocation in *Acomastylis rossii* (Rosaceae) an alpine plant exhibiting extreme preformation", *Ecology*, p. , vol. , (). Submitted
- Peddle, D.R., and C.R. Duguay, "Incorporating topographic and climatic GIS data into satellite image analysis of an alpine tundra ecosystem, Front Range, Colorado Rocky Mountains", *GeoCarto International*, p. , vol. , (). Accepted
- Raab, T.K., and M.C. Martin, "Visualizing rhizosphere chemistry of legumes with mid-IR synchrotron radiation", *Planta*, p. , vol. , (). Accepted
- Schadt, C., R.B. Mullen and S.K. Schmidt, "Isolation and identification of a dark-septate fungus associated with the alpine plant *Ranunculus adoneus*", *New Phytology*, p. , vol. , (). Accepted
- Sherrod, S.K., T.R. Seastedt, and M.D. Walker, "The northern pocket gopher (*Thomomys talpoides*) as an organizer of alpine plant community structure, Niwot Ridge, CO", *Oecologia*, p. , vol. , (). Accepted
- Shiels, A.B. and R.L. Sanford, Jr, "Soil nutrient differences between two krummholz-form tree species and adjacent alpine tundra", *Geoderma*, p. , vol. , (). Accepted
- Sievering, H., T. Kelly, G. McConville, C. Seibold, and A. Turnipseed, "Nitric acid deposition to conifer forests: Niwot Ridge case study", *Atmospheric Environment*, p. , vol. , (). Accepted

Williams, M.W., E. Hood, and N. Caine, "The role of nitrogen cycling in the nitrogen cycle of a high-elevation catchment, Colorado Front Range, USA", *Water Resources Research*, p. , vol. , (). Accepted

Brooks, P.D.; McKnight, D.M.; Bencala, K.E, "The relationship between soil heterotrophic activity, soil dissolved organic carbon (DOC) leachate, and catchment-scale DOC export in headwater catchments", *Water Resources Research*, p. 1895, vol. 35, (1999). Published

Colores, G.M.; Schmidt, S.K, "Colonization of contaminated soil by an introduced bacterium: effects of initial pentachlorophenol levels on the survival of *Sphingomonas chlorophenolica* strain RA2", *Journal of Industrial Microbiology and Biotechnology*, p. 1649, vol. 31, (1999). Published

Yulsman, T, "Twisted trees", *Audubon*, p. 30, vol. nov-dec, (1999). Published

Jaeger, C.H., R.K. Monson, M. Fisk, and S. Schmidt, "Seasonal partitioning of nitrogen by plants and soil microorganisms in an alpine ecosystem", *Ecology*, p. 1883, vol. 80(6), (1999). Published

Books or Other One-time Publications

Seastedt, T.R., "Soil Fauna and controls of carbon dynamics: comparisons of grasslands and forests across latitudinal gradients", (2000). Book, Published

Editor(s): Coleman, D.C., and P. Hendrix

Collection: Invertebrates as webmasters in Ecosystems

Bibliography: Univ. Georgia Press.

Groffman, P.M., E.A. Holland, D.D. Myrold, G.P. Robertson, "Denitrification", (1999). Book, Published

Editor(s): Robertson, G.P., et al.

Collection: Standard Soil Methods for Long-Term Ecological Research

Bibliography: Oxford Press

Holland, E.A., G.P. Robertson, J. Greenberg, P.M. Groffman, R.D. Boone, and J.R. Gosz, "Soil CO₂, N₂O, and CH₄ exchange", (1999). Book, Published

Editor(s): Robertson, G.P., et al.

Collection: Standard Soil Methods for Long-Term Ecological Research

Bibliography: Oxford Press

Robertson, G.P., D. Wedin, P.M. Groffman, J.M. Blari, E.A. Holland, K.J. Nadelhoffer, D. Harris, "Soil carbon and nitrogen availability: Nitrogen mineralization, nitrification and soil respiration potentials", (1999). Book, Published

Editor(s): Robertson, G.P., et al.

Collection: Standard Soil Methods for Long-Term Ecological Research

Bibliography: Oxford Press

Schmidt, S. K. and R.L. Ley, "Microbial competition and bioavailability limit the expression of allelochemicals in natural soils", (1999). Book, Published

Editor(s): In Inderjit, S., K.M.M. Dakshini and C.L. Foy

Collection: Principles and Practices in Plant Ecology: Allelochemical Interactions

Bibliography: CRC Press, Boca Raton.

Bowman, W.D. and T.R. Seastedt, "Structure and Function of an Alpine Ecosystem: Niwot Ridge, Colorado", (2001). Book, Published

Editor(s): Bowman, W.D. and T.R. Seastedt

Collection: Structure and Function of an Alpine Ecosystem: Niwot Ridge, Colorado

Bibliography: Oxford University Press, New York

Elias, S.A., "Natural History of the Rocky Mountains.", (). Book, Accepted

Walker, D.A., J.G. Molenaar, and W.D. Billings., "Plant processes and patterns in relation to snow in arctic and alpine environments", ().
 Book, Accepted
 Editor(s): Jones, H.G., J. Pomeroy, D.A. Walker, and R. Wharton
 Collection: Snow Ecology
 Bibliography: Cambridge University Press
 Science Series

Jensen, M.E., and P.S. Bourgeron, "An Integrated Ecological Assessment Protocols Guidebook", (2001). Book, Published
 Editor(s): Jensen, M.E., and P.S. Bourgeron
 Bibliography: Springer-Verlag, New York, NY

Jones, H.G., J. Pomeroy, D.A. Walker, and R. Hoham, "Snow Ecology: An interdisciplinary examination of snow-covered ecosystems", (2001). Book, Published
 Editor(s): Jones, H.G., J. Pomeroy, D.A. Walker, and R. Hoham
 Bibliography: Cambridge University Press

Armstrong, D.M., J.C. Halfpenny, and C.H. Southwick, "Vertebrates", (2001). Book, Published
 Editor(s): Bowman, W.D. and T.R. Seastedt
 Collection: Structure and function of an alpine ecosystem: Niwot Ridge, Colorado
 Bibliography: Oxford University Press

Bourgeron, P.S. and M.E. Jensen, "An introduction to integrated regional ecological assessments", (2001). Book, Published
 Editor(s): Bourgeron, P.S. and M.E. Jensen
 Collection: An Integrated Ecological Assessment Protocols Guidebook
 Bibliography: Springer-Verlag, New York, NY

Bourgeron, P.S., H.C. Humphries, M.E. Jensen, and B.A. Brown, "Integrated regional ecological assessments and land use planning", (2001). Book, Accepted
 Editor(s): V. Dale and R. Haeuber
 Collection: Applying Ecological Principles to Land Management
 Bibliography: Springer-Verlag, New York, NY

Bowman, W.D. and M.C. Fisk, "Primary production", (2001). Book, Published
 Editor(s): Bowman, W.D. and T.R. Seastedt
 Collection: Structure and function of an alpine ecosystem: Niwot Ridge, Colorado
 Bibliography: Oxford University Press

Bowman, W.D., "Introduction: Historical perspective and significance of alpine ecosystem studies", (2001). Book, Published
 Editor(s): Bowman, W.D. and T.R. Seastedt
 Collection: Structure and function of an alpine ecosystem
 Bibliography: Oxford University Press

Caine, N, "Geomorphic systems of Green Lakes Valley", (2001). Book, Published
 Editor(s): Bowman, W.D. and T.R. Seastedt
 Collection: Structure and function of an alpine ecosystem: Niwot Ridge, Colorado
 Bibliography: Oxford University Press

Dearing, D, "Plant-herbivore interactions", (2001). Book, Published
 Editor(s): Bowman, W.D. and T.R. Seastedt
 Collection: Structure and

function of an alpine ecosystem: Niwot Ridge, Colorado
Bibliography: Oxford University Press.

Elias, S.A., "Paleoecology and late quaternary environments of the Colorado Rockies", (2001). Book, Published
Editor(s): Bowman, W.D. and T.R. Seastedt
Collection: Structure and function of an alpine ecosystem: Niwot Ridge, Colorado
Bibliography: Oxford University Press

Fisk, M.C., P.D. Brooks, and S.K. Schmidt, "Nitrogen Cycling", (2001). Book, Published
Editor(s): Bowman, W.D. and T.R. Seastedt
Collection: Structure and function of an alpine ecosystem: Niwot Ridge, Colorado
Bibliography: Oxford University Press

Greenland, D. and M.V. Losleben, "Climate", (2001). Book, Published
Editor(s): Bowman, W.D. and T.R. Seastedt
Collection: Structure
and function of an alpine ecosystem: Niwot Ridge, Colorado
Bibliography: Oxford University Press

Monson, R.K., R. Mullen, and W.D. Bowman, "Plant Nutrient Relations", (2001). Book, Published
Editor(s): Bowman, W.D. and T.R.
Seastedt
Collection: Structure and function of an alpine ecosystem: Niwot Ridge, Colorado
Bibliography: Oxford University
Press

Schmidt, S.K., A.E. West, P.D. Brooks, L. Smith, C. Jaeger, M.C. Fisk and E. Holland, "Soil-atmosphere gas exchange across an alpine tundra landscape", (2001). Book, Published
Editor(s): Bowman, W.D. and T.R. Seastedt
Collection: Structure and function of an alpine ecosystem: Niwot Ridge, Colorado
Bibliography: Oxford University Press

Seastedt, T.R., "Soils", (2001). Book, Published
Editor(s): Bowman, W.D. and T.R. Seastedt
Collection: Structure and function of an alpine
ecosystem: Niwot Ridge, Colorado
Bibliography: Oxford University Press

Seastedt, T.R., M.D. Walker, and D.M. Bryant, "Controls on Decomposition Processes in Alpine
Tundra", (2001). Book, Published
Editor(s): Bowman, W.D. and T.R. Seastedt
Collection: Structure and function of an alpine ecosystem: Niwot
Ridge, Colorado
Bibliography: Oxford University Press

Sievering, H., "Atmospheric Chemistry and Deposition", (2001). Book, Published
Editor(s): Bowman, W.D. and T.R. Seastedt
Collection: Structure and function of an alpine ecosystem: Niwot Ridge, Colorado
Bibliography: Oxford University Press

Walker, M.D., D.A. Walker, T.A. Theodose, and P.J. Webber, "The vegetation: Hierarchical
species-environment relationships", (2001). Book, Published
Editor(s): Bowman, W.D. and T.R. Seastedt
Collection: Structure and function of
an alpine ecosystem: Niwot Ridge, Colorado
Bibliography: Oxford University Press

Walker, D.A., J.G. Molenaar, W.D. Billings, "Snow-vegetation interactions in tundra environments", (2001). Book, Published
 Editor(s): Jones, H.G., J. Pomeroy, D.A. Walker, and R. Wharton
 Collection: Snow Ecology: An interdisciplinary examination of snow-covered ecosystems
 Bibliography: Cambridge University Press

Welker, J.M. W.D. Bowman, and T.R. Seastedt, "Environmental change and future directions in alpine research", (2001). Book, Published
 Editor(s): Bowman, W.D. and T.R. Seastedt
 Collection: Structure and function of an alpine ecosystem:
 Niwot Ridge, Colorado
 Bibliography: Oxford University Press

Williams, W.M. and N. Caine, "Hydrology and hydrochemistry", (2001). Book, Published
 Editor(s): Bowman, W.D. and T.R. Seastedt
 Collection: Structure and function of an alpine ecosystem: Niwot Ridge, Colorado
 Bibliography: Oxford University Press

Meloche, C.G., "Preformation and carbon allocation in Alpine Avens (*Acomastylis rossii*)", (2001). Thesis, Published
 Bibliography: Ph.D.
 Dissertation. University of Colorado, Boulder

Turner, L., "Influence of snow augmentation on alpine plant composition", (2001). Thesis, Published
 Bibliography: Ph.D.
 Dissertation. University of Colorado, Boulder

Davinroy, T, "Hydrological and biogeochemical characteristics of alpine talus, Colorado Front Range", (2000). Thesis, Published
 Bibliography: Ph.D. Dissertation University of Colorado, Boulder

Hazen, J.M., "An evaluation of the importance of dissolved organic nitrogen in snowmelt runoff and its qualitative characteristics, Como Creek, Front Range, Colorado", (2000). Thesis, Published
 Bibliography: M.A. thesis. University of Colorado,
 Boulder

Sherriff, R.L., "Fire history at high elevation in the Colorado Front Range", (2000). Thesis, Published
 Bibliography: M.A. Thesis. University of
 Colorado, Boulder

Wahlquist, A., "The abundance and diversity of autohydrogenotrophic denitrifying bacteria in four aquifers", (2000). Thesis, Published
 Bibliography: M.A. Thesis. University of Colorado, Boulder

Buttenfield, B.P, "Mapping ecological uncertainty", (). Book, Accepted
 Editor(s): Hunsaker, C., Goodchild, M.F.,
 Friedl, M. and Case, T
 Collection: Uncertainty in spatial data for ecological analyses
 Bibliography: New York:
 Springer-Verlag

Web/Internet Site

URL(s):

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

Description:

This is our core LTER website

Other Specific Products

Contributions

Contributions within Discipline:

The recent Science article (293: 624, July 27 2001) summed up our contribution nicely:

'Mountain of data. Research at the Niwot Ridge LTER in Colorado has yielded decades' worth of insights into an alpine ecosystem.'

We are the benchmark high elevation ecology and biogeochemistry site in North America. We hope that at least some of this message was captured in the recent Niwot volume edited by Bowman and Seastedt.

Contributions to Other Disciplines:

We are learning that the alpine, similar to the tropical rain forest, holds a special value to the public. Our tundra-cam (<http://tundracam.colorado.edu>) is currently experiencing 2000 hits per day. This interest strongly suggests that we can greatly increase the use of the alpine as a model system for general educational purposes. We will have to recruit new personnel with new expertise to exploit this potential. Nonetheless, we believe that the beginnings of this have been achieved by our outreach efforts.

Contributions to Human Resource Development:

Our program currently involves 23 ongoing graduate students and 12 undergraduates (either directly or indirectly associated with the LTER REU effort). Previous students that have come through our system have had or currently have positions at Berkeley, Stanford, UCSD, and a number of smaller universities and colleges.

Contributions to Resources for Research and Education:

Please see the outreach section of our activities.

Contributions Beyond Science and Engineering:

Our virtual fieldtrip (http://culter.colorado.edu:1030/Field_trip) and tundra-cam (<http://tundracam.colorado.edu>) provides aesthetic dimensions not normally included in scientific investigations.

Recently we were contacted by a local sculptor who proposed to make us some snow markers for our tree island studies. The prototypes of these sculptures can be viewed at <http://culter.colorado.edu/~tims/sculpture.jpg>

These markers would allow us to measure both snowdepth and tree movement. While final decisions regarding placement of these have not been made, we hope to place at least one of these in view of the tundra-cam, so that the public can view this mix of art and science.

Special Requirements

Special reporting requirements: None

Change in Objectives or Scope: None

Unobligated funds: less than 20 percent of current funds

Animal, Human Subjects, Biohazards: None

Categories for which nothing is reported:

Organizational Partners

Any Product