I. RESEARCH HIGHLIGHTS

TUNDRA CAM ALIVE AND WELL.
The tundracam is now up and running for the first time in several years, at http://instaar.colorado.edu/tundracam/

NEW DIRECTOR HIRE FOR NWT LTER IN PROGRESS.
CU-Boulder approved a new FTE at the associate professor level in alpine ecology to become the new PI for the NWT LTER program. That position was then converted to a directed search. Dr. Katie Suding at U.C. Berkeley interviewed for the position the last week in November. INSTAAR voted to offer her the position on December 16th. We are now in the negotiation phase with Dr. Suding.

PIETER JOHNSON RECEIVES PRESTIGIOUS NATIONAL SCIENCE FOUNDATION EARLY CAREER DEVELOPMENT (CAREER) AWARD.
Johnson was awarded $700,000 over five years to study how ecological diversity in natural communities can affect disease risk for amphibians, which are the most threatened class of vertebrates worldwide. One significant reason for the decline of amphibians is their vulnerability to infections by parasitic flatworms called trematodes, which burrow into tadpoles and larval salamanders and cause limb malformations in adults, increasing mortality rates.

Johnson hopes to identify the factors that control disease in natural ecosystems and better understand the role of parasites in ecosystem processes. The complex life cycle of the parasitic trematodes allows them to move from snails into larval amphibians, which causes malformed legs in adult amphibians. These adult amphibians then are often eaten by predatory birds like herons, which pass eggs of the trematodes back into the aquatic environment where they hatch and enter snails to repeal the cycle.

Johnson will be collaborating with National Geographic to enhance a “Citizen Science” program that involves members of the public reporting on deformed amphibians they encounter. In addition, he will work with several other organizations to develop a documentary to promote awareness of the issue, and will team up with a biology textbook publisher to design an educational module that is expected to reach tens of thousands of students annually in classrooms and through online learning programs.

MARK WILLIAMS ELECTED A FELLOW OF THE AMERICAN GEOPHYSICAL UNION.
“For outstanding research that has made fundamental advances in mountain hydrology and biogeochemistry.” AGU Fellows are restricted to 1/10 of 1% (one in a thousand) of AGU members.

FUNGAL COMMUNITIES AT THE EDGE: ECOLOGICAL LESSONS FROM HIGH ALPINE FUNGI.
Schmidt et al. (2012) report that one of the least studied ecosystems on Earth is the plant-free zone found between the alpine tundra zone and the zone of permanent ice and snow. This unique ecosystem type occurs in all of the major mountain ranges on Earth and is especially widespread
in the Andes and Himalayas. They describe recent molecular-phylogenetic studies of the fungi that inhabit these apparently barren soils. Sites that receive significant amounts of snowfall (in the Himalayas, Rocky Mountain, and Andes ranges) are dominated by unique clades of zoosporic fungi (especially the Spizellomycetales), which likely use the saturated soil conditions during snow melt to complete their life cycles and then remain dormant for most of the year during periods of extreme cold and dryness. In more extreme sites that have very sporadic and shallow snow packs, such as the upper slopes of Llullaillaco Volcano (6,741 m above sea level) on the Chilean-Argentinian border, fungal communities show very little diversity and are dominated by clades of yeasts related to the Antarctic endolithic yeasts in the Filobasidiales group. The other major group found on Llullaillaco form a clade most closely affiliated with the Dothideomycetes. Overall, their phylogenetic approach and spatially explicit sampling scheme allow them to formulate new hypotheses about the ecological functioning of fungi that inhabit critically endangered high elevation ecosystems. Schmidt, S.K.; Naff, C.S.; Lynch, R.C. 2012. Fungal communities at the edge: Ecological lessons from high alpine fungi. Fungal Ecology, doi:10.1016/j.funeco.2011.10.005.

ATMOSPHERIC DEPOSITION AS A SOURCE OF CARBON AND NUTRIENTS. Continuing on the theme of high-elevation microbial processes, Mladenov et al. (2012) report that since barren alpine soils can be severely C limited, atmospheric deposition sources may be an important source of C and nutrients for these environments. They evaluated the magnitude of atmospheric deposition of C and nutrients to an alpine site, the Green Lake 4 catchment in the Colorado Rocky Mountains. Using a long term dataset (2002–2010) of weekly atmospheric wet deposition and snowpack chemistry, they found that volume weighted mean dissolved organic carbon (DOC) concentrations were 1.12 ± 0.19 mg L⁻¹ and weekly concentrations reached peaks as high at 6 – 10 mg L⁻¹ every summer. Relationships between DOC concentration, fluorescence, and nitrate and sulfate concentrations suggest that pollutants from nearby urban and agricultural sources and organic aerosols derived from subalpine vegetation may influence high summer DOC wet deposition concentrations. Interestingly, high DOC concentrations were also recorded during “dust-in-snow” events in the spring, which may reflect an association of DOM with dust. Detailed chemical and spectroscopic analyses conducted for samples collected in 2010 revealed that the DOM in many late spring and summer samples was less aromatic and polydisperse and of lower molecular weight than that of winter and fall samples. Atmospheric deposition of carbon in both wetfall and dryfall are important sources of C for microbial populations in “barren soils”. Mladenov N., M.W. Williams, S.K. Schmidt, K. Cawley. Atmospheric deposition as a source of carbon and nutrients to an alpine catchment of the Colorado Rocky Mountains, Biogeosciences, 9, 3337-3355, doi:10.5194/bg-9-3337-2012, 2012.

INTERANNUAL VARIABILITY OF SNOWMELT OVER 12 YEARS. The distribution of snow and the energy flux components of snowmelt are intrinsic characteristics of the alpine water cycle controlling the location of source waters and the effect of climate on streamflow. Interannual variability of these characteristics is relevant to the effect of climate change on alpine hydrology. The objective of Jepsen et al. (2012) is to characterize the interannual variability in the spatial distribution of snow and energy fluxes of snowmelt in watersheds of a maritime setting, Tokopah Basin (TOK) in California’s southern Sierra Nevada, and a continental setting, Green Lake 4 Valley (GLV4) in Colorado’s Front Range, using a 12 year database (1996-2007) of hydrometeorological observations and satellite-derived snow
cover. Snowpacks observed in GLV4 exhibit substantially greater spatial variability than in TOK (0.75 versus 0.28 spatial coefficient of variation). In addition, modeling results indicate that the net turbulent energy flux contribution to snowmelt in GLV4 is, on average, 3 times greater in magnitude (mean 29% versus 10%) and interannual variability (standard deviation 17% versus 6%) than in TOK. These energy flux values exhibit strong seasonality, increasing as the melt season progresses to times later in the year ($R^2 = 0.54$-$0.77$). This seasonality of energy flux appears to be associated with snowmelt rates that generally increase with onset date of melt (0.02 cm per d$^2$). This seasonality in snowmelt rate, coupled to differences in hydrogeology, may account for the observed differences in correspondence between the timing of snowmelt and timing of streamflow in these watersheds. Jepsen, S.M.; Molotch, N.P.; Williams, M.W.; Rittger, K.E.; Sickman, J.O, 2012. Interannual variability of snowmelt in the Sierra Nevada and Rocky Mountains, United States: Examples from two alpine watersheds. Water Resources Research, vol 48, W02529, doi:10.1029/2011WR011006.

NITRATE EXPORT RESPONSE TO SPATIALLY DISTRIBUTED SNOWMELT IN ALPINE CATCHMENTS. Danielle Perrot’s master’s thesis.
Danielle’s master’s thesis built on Jepsen et al. (2012) to explore the stream nitrate response to spatially distributed snowmelt in alpine environments. Green Lake 4 Valley, CO (GLV4) and Tokapah Basin, CA (TOK) are two geologically and climatologically different alpine watersheds that served as our study sites for hydrochemistry comparisons (focused on nitrate, NO$3^-$) over a 12 year period (1996-2007). A snow water equivalent reconstruction model was used to estimate daily grids of snowmelt and nitrate flushing for each basin. From a nitrate mass balance, we found that GLV4 exhibited high levels of nitrate-export (i.e., greater stream nitrate-export than snowpack nitrate-loading) for all 12 years. In TOK, years with deeper snowpacks exhibited net nitrate-export from the basin, and years with shallower snowpacks exhibited nitrate-retention. Contributing areas of nitrate (i.e., snowpack and soil flushing) were better correlated with the stream nitrate concentration in TOK than in GLV4. In TOK, as much as 76% of the variability in the stream nitrate pulse could be explained by a spatially distributed snowmelt model. In GLV4, on average only 44% of the variability in the stream nitrate pulse could be explained by this spatially distributed snowmelt model. These results suggest that GLV4 may be potentially less sensitive to snowpack N-loading and snowmelt than TOK. As the snowpack regimes of these alpine catchments are altered by climate change and nitrogen-loading to these areas increases over the next century, it will become increasingly important to understand how these fragile ecosystems may react chemically, hydrologically, and ecologically.

SUBALPINE SNOWPACK-CLIMATE MANIPULATION AND MODELING EXPERIMENT AT NIWOT RIDGE, CO AND VALLES CALDERA NATIONAL PRESERVE, NM. Leah Meromey’s master’s thesis
Leah’s master’s thesis builds on the theme of ecosystem responses to climate warming by evaluating snowpack and soil moisture responses to a climate warming experiment, in cooperation with UC Merced. At Niwot Ridge, CO, a global warming experiment using near-infrared (IR) heaters is being conducted by UC Merced (Lara Kueppers PI, DOE funding). Investigation of snow accumulation, snowmelt, and soil microclimate found the heaters to influence these variables at the subalpine experimental site. These changes were compared to an environmentally similar yet naturally warmer subalpine snowpack in the Valles Caldera National Preserve, NM. Over the 2010 and 2011 snow seasons, snow accumulated 42% lower on average
and melted out 1-37 days earlier in the warmer plots (CO heated and NM) compared to the CO controls. Soil temperature was 2.6 °C greater on average in warmer plots compared to controls. Peak soil moisture was 0-12% lower in warmer plots versus controls. In order to estimate differences in energy and mass balance exchange at the snow surface in control versus warmer plots, the one-dimensional, physically based snowmelt model, SNOWPACK, was used. Energy and mass fluxes in control cases were compared to heated, NM, and synthetically warmer cases. Model results found that the heaters alter radiative, turbulent, and mass fluxes by amounts comparable to differences between CO and NM fluxes. The sign and magnitude of energy and mass exchanges were similar between the control and synthetic models. The proportion of the energy flux associated with latent heat was 11-30% of the total energy flux in heated and NM models compared to 2-9% in control and synthetic models during snowmelt, and subsequently the associated evaporative loss to the atmosphere was much lower in control cases relative to NM cases. These results indicate that warmer conditions (i.e., increased average air temperatures) as projected in the coming decades will change snow surface energy fluxes, timing and magnitude of snow accumulation and melt, and soil temperature and moisture. Results of this study aid in the interpretation of climate manipulation experiments and modeling as they pertain to snowpack, and contribute to a better understanding of the interactions between climate, hydrology, and ecological processes.

SNOW, NITROGEN DEPOSITION, AND PLANTS.
Following up on snow and climate change, the Suding lab investigated how modified environmental conditions are driving phenological changes in ecosystems and around the world. Many plants have already responded to warmer temperatures by flowering earlier and sustaining longer periods of growth. Changes in other environmental factors, like precipitation and atmospheric nitrogen (N) deposition, may also influence phenology but have been less studied. Alpine plants may be good predictors of phenological response patterns because environmental changes are amplified in mountain ecosystems and extreme conditions may make alpine plants particularly sensitive to changes in limiting factors like precipitation, temperature, and N. We tested the effects of increased snowpack, temperature, and N on alpine tundra plant phenology, using snow fence, open-top warming chamber, and N fertilization treatments at the Niwot Ridge Long Term Ecological Research (LTER) site. Flowering phenology of three abundant species was recorded during two growing seasons. Treatment responses varied among species and functional types. Forbs responded to warming by flowering earlier and responded to snowpack and N by flowering later; however, when both snow and N were increased simultaneously, phenology was unchanged. Graminoids flowered earlier in response to N addition. Our results demonstrate that changing environmental conditions influence plant phenology, and specifically highlight that N and multiple factor interactions can yield stronger responses than warming alone. Smith, J.G.; Sconiers, W.; Spasojevic, M.J.; Ashton, I.W.; Suding, K.N. 2012. Phenological changes in alpine plants in response to increased snowpack, temperature, and nitrogen. Arctic, Antarctic, and Alpine Research, vol 44 pp. 135-142.

INFERRING COMMUNITY ASSEMBLY MECHANISMS FROM FUNCTIONAL DIVERSITY PATTERNS.
Spasojevic and Suding (2012) addressed the fact that many studies of community assembly focus on two mechanisms: environmental filtering and competitive interactions. This focus ignores the importance of other assembly processes such as equalizing fitness processes and facilitation. The
contribution of different processes to community assembly can be elucidated by examining functional diversity patterns of traits that differ in their contribution to different assembly processes. In alpine tundra, we explored trait patterns along a stress-resource gradient that varied in productivity, nitrogen availability, and soil moisture. We explore whether functional diversity is low in abiotic stressful environments and increases in more benign environments as competition becomes more important, and if equalizing fitness processes and facilitation affect functional diversity. We calculated community-weighted mean trait values and functional diversity for specific leaf area (SLA), leaf area, stomatal conductance, plant height, and chlorophyll content as well as multivariate functional diversity and phylogenetic diversity. At the community level, functional diversity increased at both ends of the gradient: high resource availability was associated with greater functional diversity in height and leaf area, and lower resource availability was associated with greater functional diversity in SLA, stomatal conductance, and chlorophyll content. As a result of this trade-off in functional diversity among traits, multivariate functional diversity did not change across the gradient. Phylogenetic diversity increased with increasing resource availability. We find evidence for at least three assembly processes along the gradient. Abiotic filtering by wind and cold exposure may reduce functional diversity in height and leaf area at the low resource end of the gradient. Also at low resource availability, increasing functional diversity in the other three traits suggests competition for belowground resources. At the resource-rich end of the gradient, increased functional diversity in height and leaf area suggests increased competition for light or facilitation. Synthesis: Our results suggest that multiple assembly processes (abiotic filtering, above-ground competition, and below-ground competition) operate simultaneously to structure plant communities along a stress-resource gradient. These processes would be obscured by a single multivariate trait index or phylogenetic diversity and are only evident by analyzing functional diversity patterns of individual traits. Spasojevic, M.J.; Suding, K.N. 2012. Inferring community assembly mechanisms from functional diversity patterns: the importance of multiple assembly processes. Journal of Ecology, vol 100 pp. 652-661.

GRADUATE STUDENT WORKING GROUP TO CONDUCT CROSS-SITE SYNTHESIS.
Graduate student Katya Hafich co-wrote a successful proposal for a 2013 Working Group entitled “Sensitivity of ecosystem properties to winter climate anomalies” with PI Laura Ladwig (Sevilleta LTER), Zak Ratajczak (Konza LTER) and Troy Ocheltree (Cedar Creek LTER). The grant funds a cross-site synthesis analysis of sensitivity of ecosystem properties (annual primary production, phenology, stream chemistry) to changes in winter temperature and precipitation. Participants from 9 sites will participate in the working group, including 3 students representing Niwot Ridge (Katya Hafich, Amy Churchill, and Jane Smith). Katya will serve as the hydrology/water quality expert on the team, contributing expertise on the relationship between climate and stream nitrate concentrations, a central research theme at Niwot Ridge. The group will meet twice in 2013, and aim to present results at the next ASM and write a manuscript to be submitted in late summer 2013.

AGU SPECIAL SESSION.
Heidi Steltzer (former Ph.D student at NWT LTER and now an assistant professor at Fort Lewis College in Colorado), Mark Williams (NWT LTER), and two others convened a special session at the 2012 annual meeting of the American Geophysical Union (AGU) in San Francisco in
December, entitled “When winter changes: hydrological, ecological and biogeochemical responses”. This session focused on how winter is changing and the impacts of these changes on natural systems and human well-being. This session was proposed because many new studies have been underway in recent years to characterize the effects of changing winter conditions on specific species, ecosystems, and people. The session was quite successful, with two full oral sessions (very unusual at AGU where about 85% of the presentations are posters) and a large poster presentation. NSF did a press release on the session:

II. RESEARCH ACTIVITIES
Here we focus on new activities for 2012.

HIGHLIGHTING PIETER JOHNSON LAB ACTIVITIES.
Project title: Long-term biotic community patterns in Niwot Ridge high elevation lentic habitats.

Field Sampling: During the 2012 season, our team conducted aquatic surveys in the Green Lakes Valley from June-August. Sampling was mainly conducted by a CU undergraduate, Abigail Branson, and a Niwot Ridge REU student, Courtney Currier, while under the supervision of a graduate student. This provided a fantastic opportunity for undergraduate research experience in the field.

Green Lake 4 was sampled weekly throughout July, as well as one week in August, for a total of 6 site visits. During each visit to Green Lake 4, vertical tows were conducted from a boat to collect zooplankton samples. Of the tows conducted, half of all samples were preserved in ethanol and half were kept alive for examination of patterns of pigmentation and/or infection. Samples were analyzed in the lab by a postdoctoral research associate, Esra Kellermans, and information was collected on species richness, total biomass, average body size, and breeding prevalence.

Courtney and Abigail conducted a new project in 2012 that involved comprehensive sampling of the Kettle Moraine Ponds at Niwot Ridge. The main goal of the project was to determine the pond characteristics that influence pigmentation patterns in copepods. Throughout the summer, the team conducted 3-4 repeated visits to 12 separate Kettle Ponds, for a total of 44 site assessments. Abiotic data (elevation, pond area, water temperature, pH, DO, conductivity, total dissolved solids, turbidity, salinity, total nitrogen, total phosphorus, and dissolved organic carbon) and biotic data (zooplankton tows and invertebrate sweeps) were collected at each site. Zooplankton samples were analyzed in the lab for species richness, total
biomass, average body size, as well as pigmentation intensity across copepod species. Preliminary results indicate that pigmentation significantly varied across ponds, and patterns seem to be driven mainly by biotic factors as opposed to abiotic.

**Reporting and Outreach:** Courtney Currier presented a poster “Understanding variation in zooplankton communities among alpine kettle ponds within the Niwot Ridge LTER” at the 2012 All Scientists Meeting held on September 10-13 in Estes Park, CO. Courtney also presented her LTER research experience at an information session for Notre Dame’s Undergraduate Research Internship Program. During the summer, Abigail and Courtney both participated as mentors to a group of high school students from the Science Research Seminar program through Boulder Valley School District. The one-day seminar involved guiding students to the alpine kettle pond field sites and providing a hands-on learning experience in the scientific method and aquatic sampling.

**Future plans:** We are currently recruiting a graduate student to work on understanding changes in organismal food webs of high elevation lakes in relation to nitrogen deposition, invasive species, and climate change. This research, centrally focused on LTER sites, will expand upon our current work towards the project, and will greatly benefit our understanding of long-term patterns in these ecosystems.

**HIGHLIGHTING KATIE SUDING LAB ACTIVITIES.**

1. **Long-term N fertilization experiment.** We are maintaining an ongoing N fertilization experiment initiated in 2002. N fertilization treatments are crossed with species removals to tease apart competitive vs. non-competitive mechanisms of diversity decline. We have continued collecting basic response measurements from these manipulations, which include species composition (mid-July), production (end of July), and N cycling with resin bags (late June). One result of note is that both co-dominant species populations, *Geum rossii* and *Deschampsia cespitosa*, remain fairly constant over time in the control plots, and both species increase in abundance in plots where their competitor is removed (Fig. 1 A, C). However *Geum*’s population declines sharply in the N fertilized plots, both with and without its competitor present (Fig. 1 B), suggesting that non-competitive mechanism such as plant-microbe interactions are contributing to its decline.

2. **Plant-microbe interactions and response to N deposition.** In order to investigate the role that plant-microbe interactions play in driving species response to N deposition, we performed a 13C labeling experiment to test how plants are allocating resources to microbial symbionts. Specifically we tested whether fungal communities are becoming parasitic on *Geum* plants in N fertilized plots, and thus causing carbon limitation and contributing to decline in *Geum*. In 2010, we 13C labeled *Geum* and *Deschampsia* plants in control and N fertilized plots in the long-term N fertilization experiment. Throughout 2011 and 2012, we analyzed shoot, rhizome, and roots samples for 13C content and we extracted PLFA from the soil and measured 13C content of the PLFA to assess C transfer to soil microbes.

We have found that, contrary to our hypothesis, *Geum* plants in N fertilized plots did not allocate more carbon to fungal symbionts (Fig. 2a). Rather, gram-negative bacteria received a lot of carbon from *Geum* in fertilized plots (Fig. 2b). The identity of the gram-negative bacteria is
unclear, since PLFA only allows coarse identification of the microbial community. They may be pathogenic on *Geum* or they may be interacting with soil fungi and disrupting *Geum*’s relationship with its fungal symbionts. We are currently pursuing molecular work to identify how N affects fungal and bacterial root communities in the two co-dominant species, and preliminary analysis has detected a few pathogenic microbes that increase in *Geum*’s roots with N fertilization.

We also found that *Geum* is allocating less carbon to its belowground storage organs (rhizomes, roots) in nitrogen plots. Thus, carbon limitation may be occurring if *Geum* is not storing enough carbon to maintain itself through the long winter and emerge in the spring. Altered plant-microbe interactions may be contributing to this carbon limitation.

3. Elevation vegetation survey. In 2012 we initiated a survey of plant communities along an elevational gradient at Niwot Ridge. The goal is to continue monitoring these plots annually to document changes in plant community composition due to warming temperatures and earlier snowmelt, which may cause transitions from primarily snowmelt-fed communities to rain-fed communities. We chose six sites across Niwot Ridge (Fig. 3), ranging from 3370-3910 m in elevation, all of which had historic vegetation census data. The sampling locations within each
site spanned the historical sampling locations, but methods were standardized across all six sites so that robust comparisons can be made among them. We set up 4 horizontal transects centered on a snowbed at each site, encompassing locations within the snowbed and the wet, moist, and dry meadow communities on the peripheries of the snowbed. 15 1m² plots were located along each transect and were censused for vegetation composition using the point intercept method.

Fig. 2. Carbon allocation to soil fungi (a) and gram-negative bacteria (b) in *Geum* and *Deschampsia* in control and N fertilized plots.

Fig. 3. Map of Niwot Ridge showing the six snowbed sites in black boxes.
4. Interactive effects of global change experiment. We are continuing a global change experiment testing indirect and interactive effects of global change on alpine tundra. Nitrogen, warming (passive warming chambers), and snowpack (snow fences) have been manipulated since 2006 in all factorial combinations in the moist meadow community. Annual measurements include species composition, production, and summer N cycling (resin bags). In some years, microbial biomass, N mineralization (buried bags), and winter N cycling (resin bags) have been measured. We have found that ecosystem properties (nitrogen availability, microbial biomass, production) and the plant community (richness, evenness, abundance of dominant species) responded primarily to nitrogen and snow manipulations; temperature only affected microbial biomass. Both ecosystem and plant communities showed lags in their response to global change drivers, with effects manifesting after three to four years (Fig. 4). No interactive effects of global change drivers were found. Indirect effects were common: specifically, global change drivers indirectly affected richness, evenness, microbial biomass and N mineralization through their effects on the abundance of dominant species and productivity (Fig. 5).

Fig. 4. Effect of global change drivers on productivity and evenness. Only significant global change drivers are shown, and values are the change in productivity or evenness from pretreatment conditions (2006).


Figure 5. Path analysis diagram illustrating indirect effects of global change drivers on plant community and ecosystem properties in 2012. Effects shown are significant causal relationships (p<0.05) and the width of the arrow is proportional to the strength of the relationship (correlation coefficient).

HIGHLIGHTING PATRICK BOURGERON LAB ACTIVITIES.

Ecosystem Dynamics and Ecosystem Services.

The analysis of ecosystem services at NWT and the region was refined to include the impact of disturbances (fire and mountain pine beetles) and the consequences of trade-offs for the services. A conceptual model of mountain social-ecological system resilience was developed during a synthesis workshop (Building Resilience in Mountain Social-Ecological Systems to Global Change). NWT work provided a basis for the model. NWT data were also included in a study of impacts and adaptation options in response to climate change. A manuscript is currently in press in Current Opinion in Environmental Sustainability (Elsevier). The main conclusions of this review are as follows:
• Long-term monitoring of ecosystem processes conducted by the ILTER provides scientific insights into mechanisms that may mitigate the impact of climate change on ecosystem functions and services, particularly regulating and supporting ecosystem services.

• Continuity in space and time and the large amount of data collected at many ILTER network sites, makes these a unique resource of information for climate change and ecosystem service studies.

• Global-scale, problem-driven and site-based research form the basis for detecting global trends and allow ILTER to address international ecological and socio-economic issues.

• The adoption of standard methods is critical to achieving ILTER network.

• New forms of collaboration, coordination, and data synthesis are needed to integrate scientific findings into decision-making processes.

Presentations, posters, and panels:


• Bourgeron, P.S. The International Long Term Ecological Research Ecosystem Services Assessment Initiative: A comparative study of interactions and tradeoffs among services across the globe. EcoSummit 2012 – Ecological Sustainability, Restoring the Earth Services, Columbus, Ohio.


Organized Symposia and Workshops. Bourgeron organized 3 symposia and workshops on the research themes outlined above. A special issue of Ecological Processes is being written from the presentations made at EcoSummit 2012.


International service work:
• President, External Science Council, Zones Ateliers (French sister program of the US-LTER, Centre National de la Recherche Scientifique, CNRS).
• Member, International Committee, U.S. Long Term Ecological Research Network.

PROGRAM IMPROVEMENTS.
We have made a number of improvements, updates, and additions at the NWT LTER site over the past year in data collection and processing, safety, and operations. Many of these improvements are three-fold, as improvements in operations enhance the quality and quantity of our data collection, as well as the safety of our students, field technicians, and researchers.

Data Collection and Processing. We are replacing our last generation Campbell Scientific CR10, CR21x, and CR23x data loggers with Campbell’s new CR1000 data loggers on Niwot Ridge. The new loggers have improved capabilities for data transfer, storage, and programming flexibility that will allow us increase our data storage frequency, and enhance the transition from field data to quality checked and processed data sets available for widespread use. The radios we use for remote data acquisition have also been updated for increased throughput and improved troubleshooting features.

In addition to improvements in data collection efficiency, there have been additions to data collected. In November we installed a new optical sensor precipitation gauge at our C1 site (also a National Atmospheric Deposition Program (NADP) site). The gauge, an ETI NOAH IV, replaces the current Belfort gauge and is expected to improve the efficiency and precision of data collected. Two sites (A1 and B1) that had been discontinued due to vandalism have been refurbished with new Stevenson Screens containing new temperature and relative humidity sensors. Three new soil lysimeter arrays with co-located soil moisture and temperature sensors were installed in late summer on talus slopes in the Green Lakes Valley (adjacent to Niwot Ridge in the City of Boulder Watershed), in collaboration with the Suding lab. The arrays will add to an existing network of soil lysimeters already in use in the valley and on Niwot Ridge.

Holly Hughes, Niwot Ridge LTER Lab Manager, installs a new soil lysimeter in the Green Lakes Valley Watershed at 12,000 feet, working carefully to avoid disturbing soil horizons.
**Operations.** Without continued maintenance and attention to aging operational tools and resources, our research at NWT would not be possible. Recent improvements have focused on transportation and lightning protection, including greatly needed repairs to our 1965 Thiokol Spryte Snowcat. We use the snowcat to transport heavy equipment, researchers, and students on Niwot Ridge during the winter months, and it is vital to the success of our annual snow survey. Last fall we re-welded the cracking steel substructure of the bed, fixed the breaks, exhaust system, lights, heating and cooling system, and most importantly, replaced the cracking belts that had been worn down by UV and age. The snowcat is important to both the success of the research program and the safety of those working on Niwot Ridge as it provides a reliable means for evacuation and rescue in difficult winter conditions. In addition to snow cat repairs, a new snowmobile and ATV (All-Terrain Vehicle) were purchased to replace their aging (and beyond repair) predecessors.

![The Thiokol Snowcat in three feet of new snow on Niwot Ridge. Looking for some krummholz or other definition to orient in this landscape. Above treeline on Niwot Ridge with the new snow and low light, everything is white.](image)

We are updating our lightning protection of instrument towers and research structures on Niwot Ridge and at CU Mountain Research Station in an effort to better protect our instrumentation from lightning damage. Lightning Eliminators and Consultants Inc. (LEC) designed a lightning protection system for these highly vulnerable research sites and has installed Spline Ball Terminals and Surge Protection Devices. Next summer, LTER staff will dig shallow trenches to install eight-foot copper grounding rods surrounded with a conductive backfill (to make up for the rocky and resistive soils on Niwot Ridge) to complete the grounding system designed by LEC.

As if to confirm our decision to improve grounding – but before work could begin – our instrument tower at the Subnivean Shelter suffered a direct lightning strike at the end of August, and all instrumentation at this site was irreparably damaged. Fortunately, we were able to file a claim with University Risk Management, and the LTER will receive reimbursement at replacement cost for the loss.

**Safety.** In cooperation with the Mountain Research Station’s director and manager, the University of Colorado Director of Emergency Management, and University Risk Management,
as well as the City of Boulder Wildland Fire Management coordinator and the Boulder County Sherriff’s Office of Communications, we have made a number of improvements over the past year for the safety of LTER staff and all who work, study, or do research at Niwot Ridge. We are working to identify events, such as wildfire, lost or missing persons, or personal injury, to create knowledge-based response plans should such events occur. Because NWT LTER is one of the largest projects operating out of MRS, we provide many of the resources needed to implement these response plans. Such resources include: training of LTER staff as Wilderness First Responders, participation in meetings with Boulder County emergency response agencies to create posted plans for all MRS users and visitors, placement and maintenance of comprehensive back country first-aid kits, sleeping bags, and tarps at remote research structures and buildings, installation of a VOIP (Voice Over IP) emergency phone and supplemental oxygen at the Tundra Lab (located at 11,500 ft.), tower climbing safety and rescue classes and equipment, and chainsaw safety class and equipment (for clearing snags over roads or other emergency response routes). Many of the processes for enhancing safety are a work in progress, and we will continue to make improvements as knowledge, time, and funding become available.

CROSS-SITE LTER PROJECT ON MICROBIAL FUNCTIONING.

PIs Mark Bradford (Yale), Noah Fierer (CU Boulder), and Rebecca McCulley (Univ. of Kentucky)

NWT LTER is a participant with an NSF-funded, cross-LTER project on whether trade-offs in enzyme activities manifest at the level of microbial community function. We collected and sent to the PI’s several soil samples using their protocols.

The Tundra Lab at 11,500 feet on Niwot Ridge. The newly installed SBT’s for improved lightning protection are visible on the roof of the tundra lab. The TundraCam (an interactive web cam at http://instaar.colorado.edu/tundracam/view.php) was also recently reinstalled by the LTER this fall.
Project Description: Enzymes are proteins that increase the rates of chemical reactions. There are many different enzymes in the cells of living things, including those involved in the process of respiration. This process takes complex organic compounds, such as sugars and fats, and breaks them into simpler forms to create energy. A by-product of respiration is carbon dioxide. The speed at which respiration occurs, and carbon dioxide is produced, increases as temperatures increase. For this reason there is concern that microorganisms living in soil, where much of the world’s carbon is stored, will consume more soil carbon under global warming. If they do, they may release more carbon dioxide into the atmosphere, potentially accelerating global warming. There is substantial uncertainty as to whether this positive feedback to warming will happen – in part because living things can produce respiratory enzymes that have reduced temperature sensitivity. If soil microorganisms do this, then the planet might warm more slowly than predicted. The project goal is to test whether soil microbes maintain initial increases in respiration when temperatures rise, or whether over time they decrease respiration in a way that is consistent with production of less temperature-sensitive enzymes. To quantify soil microbes, this 3-year project will use DNA-sequencing and fatty-acid profiling methodologies. To determine respiration rates, carbon dioxide production from soils will be measured using gas-analysis techniques. To generate differences in temperatures to which microbes are exposed, soils are being collected across a gradient from the arctic to the tropics, in winter and in summer, and incubated in the laboratory at different temperatures.

BOULDER CREEK CRITICAL ZONE OBSERVATORY.
The alpine area of the NWT LTER is one of three headwater catchments that comprise the NSF (GEO) Boulder Creek Critical Zone Observatory (BC-CZO). Altitudinal gradients are among the most powerful ‘natural experiments’ for testing ecological and evolutionary responses of biota to geophysical influences, such as differences in air temperature. Partnering with the BC-CZO allows us to evaluate the ecology and hydrology of the Colorado Front Range along a large altitudinal gradient: Green Lakes Valley (3,500 m), Como Creek (2,900 m), Gordon Gulch (2,400 m), and Betasso (1,830 m) catchments. Initial results show that headwater catchments along this elevation gradient process nutrients differently. A key component of the NWT LTER/BC-CZO partnership is the development of compatible hardware, software, and data standards to facilitate the integration and synthesis of information across the two programs. Williams, Mark W., Rebecca T. Barnes, Jordan N. Parman, Michele Freppaz, and Eran Hood, Stream Water Chemistry along an Elevational Gradient from the Continental Divide to the Foothills of the Rocky Mountains, Vadose Zone Journal, doi:10.2136/vzj2010.0131, 10:900-914, 2011.

NATIONAL ECOLOGICAL OBSERVATORY NETWORK (NEON).
NWT LTER is partnering with NEON to establish a transect across the mountains from the Great Plains to the Colorado Plateau to address source-receptor relationships among land-use change, climate change, and human activities that affect movement of dust, nutrients, and water, across a region we call the Prairie, Peak, Plateau (P3) region of the U.S. West. NWT LTER is the core site for NEON domain 13 and the SGS LTER is the core site for the adjacent climate domain 10, effectively bounding the Colorado Front Range. The NEON transect is critical to understanding the changes wrought by soil disturbance, dust deposition, and agricultural and urban nitrogen emissions – from eutrophication and acidification of soils and lakes, to impacts on snow and Western water supply.
HIGHEST EDDY COVARIANCE SITE IN THE WORLD.
We continued measurements of net ecosystem exchange of CO2 and the complete surface energy balance using eddy covariance methods, which has changed our understanding of carbon and water cycling in alpine tundra. Knowles et al. (2012) report that despite 955 mm mean annual precipitation, the 24-hour mean evaporative fraction was 0.39, typical of dry grassland or rangeland ecosystems. These low values were attributed to rapid, efficient removal of snow by prevailing windy conditions throughout the winter. During the summer when rainfall provided moisture, evaporation was principally limited by available energy. Overall, an average of 39% of annual precipitation was evaporated or sublimated back to the atmosphere. They conclude that the annual distribution of precipitation is an essential control on evaporation and sublimation from this ecosystem. Knowles, JF, PD Blanken, MW Williams, KM Chowanski. Energy and surface moisture seasonally limit evaporation and sublimation from snow-free alpine tundra, Agricultural and Forest Meteorology, vol 157, 106-115, 2012.

ATMOSPHERIC DUST MONITORING NETWORK-PARTICIPANT.
NWT LTER is supporting a new high volume dust sampler that is part of a larger network of such samplers being deployed across Utah and Colorado. This network is described at http://moab.colorado.edu/TSP.html and is an effort to better understand the regional transport of mineral dust from deserts to mountainous regions. Jason Neff has been leading the effort to develop this network and presented the results to federal and tribal stakeholders in 2012.

PROJECT BASELINE: A SEED BANK TO STUDY PLANT EVOLUTION.
Project Baseline is a multi-university collaboration that aims to create a unique seed bank used to study plant evolution in response to environmental change. Over the anticipated 50-year lifetime of this project, seeds will be made available to researchers on a schedule of 5-10 year intervals to study evolutionary change through direct comparison of plants grown from archived materials with individuals newly sampled from nature. NWT LTER is a participant in this study.

GLOBAL LAKE ECOLOGICAL OBSERVATORY NETWORK (GLEON).
We are participants in the GLEON Climate Sentinels project. The focus of this working group is on exploring the use of lakes as sensors in the landscape in order to interpret and quantify what their sentinel responses are telling us about the biotic consequences of climate change. Dissolved organic carbon (DOC) quality and quantity are of particular interest, and NWT LTER is contributing its long-term DOC and air temperature data to this effort.

GOVERNING COLLABORATIVE SCIENCE.
Chris Ray and Mark Williams participated in a research study titled "Governing Collaborative Science: Cyberinfrastructure, Scale, and Governance in the Networked Ecological Sciences.” The purpose of the study is to understand patterns of collaboration, governance, and information technology use in large-scale ecological science networks.

Hi Dr. Ray -- Thank you so much for spending time yesterday speaking with me about your experience as both a PI and an Education & Outreach Coordinator for the Niwot Ridge LTER. Your 1.5-hour phone interview was incredibly valuable - we covered quite a bit of ground! I'm glad we hit up topics which ranged from what the education and outreach activities have been at NWT, what you have been doing to lay the groundwork for the ScienceLive citizen science platform, to collaboration, to data sharing and data access, to thoughts about physical samples and what to do with them... I really appreciate your taking the time to be interviewed! We will keep you and
all others interviewed in mind when things start to be published from this work. Dr. Jackson has plans to circulate work products back to interviewees to see what has become of this work. Please don't hesitate to call or email if you have any thoughts, questions, comments, etc! Thanks again, Sarah Barbrow - Research Assistant, University of Michigan sbarbrow@umich.edu 617.620.0690.

INFORMATION MANAGEMENT.
Hope Humphries, NWT LTER Information Manager, helped organize and attended a GeoNIS workshop held at INSTAAR from February 28th to March 1st. Workshop topics included best practices for documenting geospatial data; contents of spatial data packages; the process of data submission to the GeoNIS; and producing metadata, including EML 2.1.0, for geospatial data. Humphries also attended the annual meeting of LTER Information Managers and the All Scientists Meeting in Estes Park, September 9th to 13th.

NWT received supplemental funding in 2012 to increase online data accessibility and generate/upgrade EML for both spatial and non-spatial data. Leanne Lestak, a GIS specialist with many years' experience in working with metadata for spatial data, was hired to generate or upgrade EML for NWT’s geospatial data. She is implementing workflows to upgrade existing EML 2.0.1 to EML 2.1.0 for those spatial data sets (15) that have EML. She is also generating EML 2.1.0 de novo for spatial data sets (43) that lack EML.

An integral part of our plans to increase the number of core data sets available online and to upgrade EML for non-spatial data was to hire former NWT Information Manager Mike Hartman. Unfortunately, Mike’s untimely death has deprived us of his programming expertise and his knowledge of NWT’s data, delaying work in this area. We recently hired Dominik Schneider to implement the GCE Data Toolbox software, developed at GCE LTER, to process our sensor-derived climate data, including conducting quality control/quality assurance and providing graphical displays of the data. Both Schneider and Humphries attended a GCE Data Toolbox workshop held in Athens, GA from November 28th to 30th. Hands-on experience in using the toolbox was provided, along with troubleshooting problems as they arose. Schneider has succeeded in bringing sensor data into the toolbox, applying QAQC procedures, and exporting files in a PASTA-ready format.

During the spring semester of 2012, 12 years of Niwot Lakes LTER data were compiled into one data set to be added to the NWT database. These data were collected from previous Limnology Field Team managers from 2000 to 2011 and contain information for Green Lakes 4 and 5. A graduate student worked with Humphries to complete this process. Each summer’s data set was compiled into a uniform format to enable more consistent reporting and analysis for the compiled data. The field sample data included measurements of chlorophyll-a, pH, temperature, specific conductivity, dissolved oxygen (dO), % saturation, secchi depth, light attenuation, and % of surface. Most samples were collected between 0900 and 1100 MST. The first sampling date each summer occurred shortly after the ice had melted. An inflatable raft was used to reach the middle of the lake. The majority of the measurements were taken at the surface, three meters, and nine meters from the raft, in Green Lake 4. However, additional measurements were taken for side projects of the long-term data set during several of the years. Data from Green Lake 5 is also reported for years that sampling was conducted. Water samples were collected using a Van Dorne sampler. Field measurements were conducted using a YSI dissolved oxygen meter and a
Li-Cor datalogger. Chlorophyll was extracted in the lab from filtered samples; absorbance was measured before and after acidification to quantify chlorophyll a concentration.

**USLTER AND ILTER WORKSHOP AT ECOSUMMIT 2012.**
A workshop on ecosystem services ([http://www.ecosummit2012.org/symposia-bourgeron.html](http://www.ecosummit2012.org/symposia-bourgeron.html)) organized by Bourgeron and Roy Chowdhury included scientists from four LTER networks (US, France, China and Mexico). The Chinese LTER (CERN), the USLTER, and the ILTER jointly sponsored the workshop. A synthesis paper is planned and the Chinese delegation will visit selected US sites.

**ALL SCIENTISTS MEETING.**
Williams was on the organizing committee for the All-Scientists Meeting in Estes Park in September. He is also a co-lead on the “Disappearing Cryosphere” working group. NWT LTER presented 25 posters, among the highest site participation. We convened or co-convened several workshops, including “Bourgeron, P.S., J. Gosz, and M. Williams. Resilience and Sustainability of Complex Mountain Landscapes.”

**BIOSCIENCE SPECIAL ISSUE.**
NWT LTER personnel were co-authors on four of the papers in the LTER special issue of BioScience.


**III. OUTREACH AND EDUCATION ACTIVITIES.**

**NWT LTER VIDEOS.**
Short (90 seconds) and long (9 minutes) videos of the NWT LTER program were developed by Earth Initiatives for the NWT LTER program. The intent of the videos is to provide an enhanced viewing experience, especially for the general public and potential graduate students. The videos
can be accessed at: http://culter.colorado.edu/NWT/videos/videos.html. Additionally, we’ve posted a couple of very short videos to highlight the unique alpine challenges of our site.

**MEDIA OUTREACH.**

NWT LTER research results were highlighted in numerous local, regional, and national media outlets. For example, Bill Bowman’s research on determining alpine ecosystem responses to nitrogen deposition was featured in national (e.g. Science Daily) and local (e.g. KUNC, KOA, Daily Camera) media. Williams was interviewed for an extensive article by Greenwire on the hydrology results from the LTER BioScience special issue (http://www.rlch.org/news/human-water-management-masks-effects-rising-temps-stream-flows):

Even though air temperature has increased over the past decade across the United States, the amount of water flowing out of many headwater basins has not changed as expected, according to research published today in BioScience.

"They haven't changed that much -- that was a bit of a surprise," said Mark Williams, a hydrologist at the University of Colorado, Boulder.

Williams is part of a large team that analyzed temperature, precipitation and stream flow data from 35 headwater basins throughout North America. Most of the sites are a part of the Long Term Ecological Research (LTER) network, which was started 1980 and is funded by the National Science Foundation.

As temperatures increase with climate change, more water is generally expected to be lost to the atmosphere through evaporation and transpiration -- "evapotranspiration" for short -- decreasing the amount of water stored in the ground and flowing through rivers and streams.

But that's not happening, according to data collected over the past 30 years at most of these LTER sites and others, Williams said.

"The amount of water coming out of the basin depends on a lot of other factors besides air temperature," Williams said. He added that climate effects are being masked by one of those other factors -- in this case, past and present human disturbances and management of ecosystems.

"Human interaction is the dominant player in water availability," Williams said. "It's a bigger factor than climate change."

**LTER-MENTORED HIGH SCHOOL STUDENTS WIN SCIENCE FAIR PRIZES.**

Michael Reese and Thomas Evans, high school seniors at Monarch High School (Boulder, CO) won several prizes at the regional science fair in spring 2012 based on their research on water quality and the effects of acid mine drainage on James Creek in Jamestown, Colorado. Accompanied by LTER core funded graduate student Katya Hafich, they spent a day in Jamestown taking water samples and monitoring pH, conductivity, and dissolved oxygen levels at several locations on James Creek. Water samples were analyzed at the Kiowa Wet Environmental Chemistry laboratory, funded by NWT LTER. Michael and Thomas won third place in the Environmental Category at the Boulder Valley Science Symposium in April 2012, as well as the Thorne Nature Experience Award and the Stockholm award at the Symposium. They also presented their work at the CU Undergraduate Hydrology Symposium in April 2012. Katya Hafich is currently mentoring another high school student, Leslie Seitz from Fairview High School, on a project analyzing residence time of atmospheric nitrate at NWT.

**SCIENCELIVE OUTREACH PROJECT HIGHLIGHTS LTER RESEARCH.**

LTER-supported master’s student Katya Hafich is being highlighted by a new outreach project, ScienceLIVE. The objective of the website is to connect K-12 students and teachers from across
Colorado with graduate students doing exciting research in the field. Katya’s research on nitrogen cycling in headwater catchments at Niwot Ridge will be featured on the site. She has begun a blog for students to follow her work (http://www.science-live.org/nitrogen/follow/) and the website will soon include videos of Katya working at Niwot Ridge, as well as curriculum that teachers can use in their classrooms on glacier dynamics and the nitrogen cycle.

**MOUNTAIN RESEARCH STATION REU PROGRAM.**

2012 was the final year of the current 3-year REU site grant at the Mountain Research Station. This REU program has been in operation since 1990, and supported students such as Jason Neff, currently a tenured faculty member at CU. A 5 year renewal is currently under consideration. The REU students in the program enjoy logistical support provided by the NWT LTER program and the majority of the students conducted research with LTER personnel. This year’s line-up included:

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**NIWOT RIDGE FIELD TRIP: MERCYHURST UNIVERSITY BIOLOGY FIELD CLASS, JUNE 22ND, 2012, 8AM-3PM.**

This field trip was led by Jennifer Morse, climate technician at NWT LTER and Mountain Research Station, tailored to eight biology undergraduates from Mercyhurst University in Erie, Pennsylvania studying environmental physiology. The students participated in a day-long tour with stops at a number of field sites on Niwot Ridge relating to their studies, with guest speakers arranged to talk in the field about their research on the ridge.

Sites and topics included: the C1 met station, sixty year temperature and precipitation record, NOAA’s gas chromatograph and CO2 standards sampling instrumentation with speaker Duane Kitzis, research scientist from NOAA’s Carbon Cycle Greenhouse Gases group; a ribbon forest near the Soddie LTER met site and the dynamics of wind and snow distribution on vegetation patterns; the University of California Merced Warming Experiment Alpine Site, how temperature increases could change tree line and water availability in alpine environments, plant physiology and adaptability, and the challenges of running an infrastructure intense experiment in extreme conditions with speaker Ethan Brown, Research Assistant at Merced; T-van site gas sampling and NOAA’s 40 year CO2 record; the Tundra Lab; long-term snow fence experiment; the West Knoll; and the North American Pika as a possible indicator species in alpine climate change.
This field trip was led by Jennifer Morse, climate technician at NWT and Mountain Research Station, tailored to twelve Porter Scholar undergraduates from Adams State University in Alamosa, Colorado. The students participated in a day-long hiking tour with stops at a number of field sites on Niwot Ridge and guest speakers arranged to talk in the field about their research on the ridge.

The research station road is often closed in May, and students began the tour with a four-mile hike from the Research Station to the Tundra Lab at 11,500 feet. Sites and topics were introduced along the ridge throughout the return hike and included T-van site gas sampling and NOAA’s 40 year CO2 record, T-van eddy covariance towers and questions relating to CO2 fluxes in and out of the tundra; the University of California Merced Warming Experiment Alpine Site, how temperature increases could change tree line and water availability in alpine environments, plant physiology and adaptability, and the challenges of running an infrastructure intense experiment in extreme conditions with speaker Ethan Brown, Research Assistant at Merced; a ribbon forest near the Soddie LTER met site and the dynamics of wind and snow distribution on vegetation patterns; the C1 met station, sixty-year temperature and precipitation record, NOAA’s Global Air Monitoring Division’s gas chromatograph and CO2 standards sampling instrumentation. The tour concluded with a visit to the LTER Ameriflux Tower with speaker Sean Burns, from the Mesoscale and Microscale Meteorology Division of the National Center for Atmospheric Research.

NIWOT RIDGE FIELD TRIP: COLORADO COLLEGE BIOLOGY FIELD CLASS, SEPTEMBER 11TH, 2012, 8AM-3PM.
This field trip was led by Jennifer Morse, climate technician at NWT LTER and Mountain Research Station, tailored to ten biology undergraduates from Colorado College in Colorado Springs, Colorado, studying environmental science and the way research questions are
developed. The students participated in a day long tour with stops at a number of field sites on Niwot Ridge relating to their studies, with guest speakers arranged to talk in the field about their research on the ridge. In addition, since this field trip fell on an LTER field sampling day, students participated in data collection at our National Atmospheric Deposition Program (NADP) sites and NOAA’s gas sampling site on Niwot Ridge.

In addition to participating in field data collection, sites and topics included: the Tundra Lab and patterns of vegetation associated with the long term wind fence experiment; the East Knoll and the North American pika as an indicator species for climate change; the University of California, Merced Warming Experiment Upper Sub Alpine site, what questions led to the initiation of the project, and how have those questions changed or been answered as the project continues, as well as the challenges of running an infrastructure intense experiment in extreme conditions with speaker Ethan Brown, Research Assistant for the University of California, Merced; a ribbon forest near the Soddie LTER met site and the dynamics of wind and snow distribution on vegetation patterns; and the C1 met station, sixty year temperature and precipitation record, NOAA’s gas chromatograph and CO2 standards sampling instrumentation with speaker Duane Kitzis, research scientist from NOAA’s Carbon Cycle Greenhouse Gases group.

**LTER ASM FIELD TRIP, SEPTEMBER 12, 2012.**
NWT LTER Lead PI Mark Williams led a group of 24 ASM attendees on a field trip to the Mountain Research Station and the NWT LTER field site. Jennifer Morse and graduate student John Knowles accompanied him. It was a cold and foggy day at 11,500’, but participants were cheery and engaged.

This field trip was led by Jennifer Morse, climate technician at NWT LTER and Mountain Research Station, William Bowman, Director of the Mountain Research Station, and Laura Kueppers, PI for the University of California Merced’s Warming Experiment. The field trip was open to participants in the 2012 Mountain Climate Research Conference held in Estes Park October 1-4th. From the MTNCLIM home page, “The MTNCLIM research conferences are sponsored by the Consortium for Integrated Climate Research on Western Mountains, and are dedicated to mountain climate sciences and effects of climate variability on ecosystems, natural resources, and conservation in western North American mountains (www.fs.fed.us/psw/mtnclim/). The field trip was tailored with the goals of MTNCLIM in mind.

Approximately fifteen participants from the climate conference joined the field trip, and sites visited included the University of Colorado Merced’s Upper Subalpine and Alpine warming experiment sites, the Tundra Lab, West Knoll, and the C1 met site.

Participants from MTNCLIM 2012 on the west knoll of Niwot Ridge.

NWT LTER OUTREACH ACTIVITIES BY CHRIS RAY, OUTREACH COORDINATOR.

Mar. Chris: Provided a phone interview on LTER education and outreach practices as part of University of Michigan Professor Steve Jackson’s NSF-sponsored research on information technology use, collaboration patterns, and governance within the LTER and NEON. The 1.5-hour interview (Mon, Mar 5, 11:30 am – 1:00 pm) focused on my experiences both as a PI and an Education & Outreach Coordinator for NWT LTER, as well as my hopes to integrate the
varied education and outreach offerings of NWT LTER through a novel, web-based outreach tool called ScienceLIVE. I also offered thoughts on collaboration, data sharing, data access, and how to manage physical samples from long-term research.

Chris: Represented NWT LTER in a presentation of web-based resources for the professional development of middle- and high-school science teachers in the Pikes Peak region (Tue, Mar 6, 4:00 pm – 8:00 pm, Colorado Springs). As part of the “Science Hubs: Peak Area Leadership in Science” program, the presentation included representatives from CU’s Office of University Outreach, CIRES and LMAC and was titled “Learn more about climate: Climate change, Colorado's future and resources for teaching”. Chris presented information on the Schoolyard LTER program as well as the new ScienceLIVE web tool showcasing education and outreach resources associated with NWT LTER. The presentation received a glowing review by participants: “If you wanted abundant resources for teaching standards focused on climate, this was the meeting to attend. Dr. Stephanie Chasteen, Dr. Anne Gold, Cheryl Manning, and Dr. Chris Ray presented multiple classroom, web-based resources and activities for teachers to explore and discuss with students. Every participant received a resource folder with DVD, brochures, information sheets, and resource bookmarks. Dr. Chris Ray fascinated teachers with her presentation of long-range data observations on the American Pika. All of the presentations provided a springboard for teachers to have greater involvement in online communities, list-serves and a seemingly endless amount of classroom material on climate and climate change. We appreciate the time, effort, and expertise of our presenters in giving us the opportunity to explore these valuable resources.”

Chris: Gave a lesson on pikas to a class of 4-year-olds at a Boulder pre-school, Children’s Creative Learning Center. Read aloud from “A Pika’s Tale”, passed around pika photos and encouraged students to ask questions about pika behavior. When encountered on the street 7 months later, one student immediately exclaimed, “You study pikas!”

Chris: Presented research from the Niwot Ridge Pika Project to the CU Biology Club on Mon, Mar 19.

Apr. Chris: Attended an Outreach Award luncheon hosted by the CU Office of University Outreach on Fri, Apr 27, 12:00 pm -1:30 pm, as PI of the Front Range Pika Project, a citizen-science program that extends the Niwot Ridge Pika Project and received an Outreach Award for 2011-2012.

Jun. Chris: Mentored an REU student (Sara McLaughlin) in research through a 3-month field study course coordinated through NWT LTER and the Mountain Research Station. Sara conducted independent research on pika activity patterns in relation to microclimate, using data she collected from several study areas on Niwot Ridge and within the Indian Peaks Wilderness. She also learned to trap and handle pikas, collected key data on the annual survival of individual pikas tagged in the previous year, learned to identify pika habitat patches and determine fresh signs of pika occupancy, conducted pika habitat occupancy surveys in Great Sand Dunes National Park, and helped to locate, service and position microclimatic sensors for a study of pika-climate relations. To complete her field study course, Sara analyzed her data on pika activity patterns, compared her results to previous studies, and presented her findings at a symposium of REU students at the Mountain Research Station.

Chris and Liesl: Mentored an undergraduate (Jessica Johnson) in field research through a summer internship coordinated through the CU Environmental Studies Department. Jessica
conducted independent research on pika activity patterns in relation to microclimate, using data she collected from several study areas on Niwot Ridge and within the Indian Peaks Wilderness. She also learned to trap and handle pikas. To complete her internship, Jessica graphed her data on pika activity patterns and summarized her research experience in a report for the CU Environmental Studies Department.

Nifer and Chris: Introduced two CU undergraduates (Taylor Stratton and Riley Stuckey) to field research in mammal ecology through an informal 3-month internship program. Students learned to trap, handle and observe pikas on Niwot Ridge and in the Indian Peaks Wilderness, collected key data on the annual survival of individual pikas tagged in the previous year, learned to identify pika habitat patches and search for fresh signs of occupancy by pikas, conducted pika habitat occupancy surveys in Rocky Mountain National Park, and helped to locate, service and position microclimatic sensors for a study of pika-climate relations. Each student participated in at least 15 days of fieldwork, and both have been selected for official projects that follow up on what they learned (Taylor has been offered a 2013 REU position and Riley has received a BURST award to participate in laboratory research on pika stress hormones).

Aug. Chris: Introduced four grade-school students to field research in mammal ecology through a 3-day research experience on Niwot Ridge (July 31-Aug 2). Students learned how to trap and handle the American pika, as well collecting data on the daily activities of pikas, and sampling vegetation for a study of climate-related change in the forage available to pikas. The students involved were participating in CU Science Discovery's week-long research workshop at the Mountain Research Station. Students were Lea Linse, Ethan Putnam, Tai Koester (all high school students), and Evan Savage (an 8th grader).

Chris: Introduced Oregon high school student Anna Thompson to field research in mammal ecology through a 10-day research experience (Aug 20-29). Anna learned how to trap and handle the American pika, as well collecting data on the daily activities of tagged pikas, as part of a long-term comparative study involving pikas from Niwot Ridge, and the Gallatin Range, MT.

Sept. Chris: Attended the LTER All Scientists Meeting in Estes Park, including the full-day Education Representatives meeting (Sun, Sep 9, 8:30 am – 4:30 pm) and three half-day working groups on the Schoolyard book series.

Chris: Gave a lesson on scientific graphs for K-2 grade students at Jamestown Elementary School, using data from the Niwot Ridge Pika Project. Students were shown several different kinds of graphs (scatterplots, time series and pie charts) and were encouraged to name and explain the different parts of each graph as a review of previous lessons. Students had a lot to say!

Chris: Gave a lesson on microclimates for 3-5 grade students at Jamestown Elementary School, using temperature sensors from the Niwot Ridge Pika Project. Students helped download a year’s worth of sensor data, graph downloaded data, and re-program a sensor to take data for another year.

Oct. Chris: Attended the Environmental Studies Internship Fair, Tue Oct 23, 2012, 3:00 pm - 4:30 pm, CU Rec. Center, Conference Rooms 1-4. Created a large tri-fold display and one-page flyer to present undergraduate internship opportunities related to the Pika Project on Niwot Ridge. Spoke at length with 14 undergraduates in ENVS, EBIO and Geology.
Chris, Liesl and Nifer: Presented findings from American pika research in 3 talks at the annual meeting of The Wildlife Society in Portland, Oregon (Oct 14-15), including research associated with the NWT LTER.

NWT LTER EDUCATION AND OUTREACH PHOTO SUMMARY, 2012.
Here, you’ll find several pages of captioned photos of education and outreach activities led by Chris Ray, Liesl Erb and Jennifer Wilkening. Photo credits are not necessary, but are provided in some cases.

Adult *Ochotona princeps* on Niwot Ridge in June. Photo by REU student Sara McLaughlin.

A juvenile American pika gets colored ear tags for a survival study.
CU undergraduate Taylor Stratton releases adult pika in its own territory after tagging. Photos by Sara McLaughlin.

REU student Sara McLaughlin releases a tagged American pika.

High school students Ethan Putnam (left) and Evan Savage (right) search for tagged pikas as part of a Science Discovery Field Course offered through CU’s Mountain Research Station. Photo by Chris Ray.
Eighth-grade student Evan Savage takes data on pika behavior during a Science Discover Field Course offered through CU’s Mountain Research Station. Boulder Valley School District students were mentored by REU and GK12 students.

High school students Ethan Putnam and Lea Linse check the weight of a pika during a Science Discovery Field Course offered through CU’s Mountain Research Station. Photo by Sara McLaughlin.

High school students Tai Koester (above) and Lea Linse (below) trapped, weighed, and released pikas during a Science Discovery Field Course offered through the Mountain Research Station.
CU undergraduate Riley Stuckey (left) releases a tagged pika on Niwot Ridge. Riley recently received a BURST award to study stress hormones in pika fecal samples. Oregon high school student Anna Thompson (right) releases a tagged adult pika in Montana as part of a long-term comparative study involving pikas from Niwot Ridge, CO, and the Gallatin Range, MT. Photos by Chris Ray.

ScienceLIVE

Graduate student Liesl Erb leads a workshop for K-12 teachers. This workshop, run by CU’s Biological Sciences Initiative and ScienceLIVE, provided 20 teachers with resources and curricula about climate change research.
Chris Ray (top) presents long-term data from the NWT LTER Pika Project to an audience of middle- and high-school science teachers in Colorado Springs. Pika Project data can be accessed through ScienceLIVE, which also highlights Schoolyard LTER products associated with NWT LTER (bottom).
GK-12 Program

GK-12 fellow Jennifer Wilkening (middle) attends a summer training program at the CU Mountain Research Station with other fellows and BVSD elementary school teachers.

Pika Project

High school students from Costa Rica learn about pika research at Rocky Mountain National Park during BioBlitz with CU undergraduate Taylor Stratton (in blue) and graduate student Jennifer Wilkening (lower right).