LTER All-Scientists Meeting 2003: Niwot Ridge Posters

SOURCE WATERS AND FLOWPATHS IN A SEASONALLY SNOW-COVERED CATCHMENT, COLORADO FRONT RANGE, USA

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Abstract: It is urgent to understand flow sources and pathways that contribute to water quantity and quality in streamflows in the high elevations of the Rocky Mountains. In this study, source waters and flowpaths of streamflow were determined using isotopic and geochemical tracers during the snowmelt runoff season in 1996 at two sub-catchments at Green Lakes Valley, Colorado Front Range. A two-component hydrograph separation using delta18O indicates that new water (82%) dominated streamflow at the 8-ha Martinelli catchment, while old water (64%) dominated streamflow at the 220-ha Green Lake 4 (GL4) catchment. A principal component analysis (PCA) was performed for the streamflow data using correlation matrix of 8 conservative tracers. A rank analysis indicates that two U subspaces appear to fit the streamflow data at both Martinelli and GL4 catchments, implying that mixing of three end-members is sufficient to form streamflow chemistry. Without using compositions of measured end-members, variance of streamflow data that could be explained by three ideal end-members under two subspaces was computed using eigenvectors of the PCA for all tracers. The variance ratio is defined as “theoretical determinant”, as opposed to “practical determinant” using measured end-members. By using compositions of three measured end-members in end-member mixing analysis (EMMA), three flowpaths were identified. Using the flowpath results, the streamflow data were reproduced. Practical determinant matches the theoretical determinant reasonably well at both catchments for all tracers except delta18O. The flowpath results indicate that surface flow and subsurface flow accounted on average for about 50% at the Martinelli catchment. Surface flow, riparian subsurface flow, and talus flow contributed nearly equal fractions at the GL4 catchment. Subsurface flow is thus recognized to be a major control on the streamflow chemistry in the high-elevation watersheds of the Rocky Mountains.

LTER Dissolved Organic Nitrogen Intersite Comparsion (DONIC)

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Abstract: Our multidisciplinary research team has begun to address the role of organic nitrogen (N) in the N cycle by conducting intersite comparisons at the watershed scale. Here we present initial results from several LTER sites, including Hubbard Brook, Plum Island, Luquillo, Santa Barbara, Niwot Ridge, Baltimore, HJ Andrews, McMurdo Dry Valley, Toolik Lake, and Bonanza Creek, as well as the alpine Emerald Lake watershed. The purpose of this research is to quantify the importance of DON inputs and outputs at the watershed scale in an effort to: 1) test current and novel hypotheses in ecology; 2) compare DON dynamics in a diverse array of watersheds in order to suggest determinants of observed patterns; 3) explore the relationships between physical and biological characteristics of streams and their watersheds (topography, soil standing stocks of C and N); and 4) reveal deficiencies in the available data on DON dynamics at the watershed scale. Within these overall objectives, we have several additional goals, including
(i) test new research tools for DON, including combustion, fractionation and fluorescence techniques; (ii) provide guidance to the LTER network on methods for DON sample collection and analysis; (iii) stimulate interest on research at the watershed scale within the LTER network;
(iv) act as a steering committee to highlight the importance of DON to the ecological community; and (v) act as a repository for DON information that is available to the scientific community at large.

Modeling the Spatial Distribution of Snow in a Rugged Alpine Valley

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Abstract: One of the most challenging problems in snow hydrology is understanding the spatial distribution of snow properties in montane catchments. Natural snow variability is extreme due to complex controls. Many authors have found relationships between topographic parameters and snow distribution, but conclusions are based on datasets that span one or two years and it is not known whether the results are specific to the particular years of the study.

Research was conducted in the Green Lakes Valley, an east-facing headwater catchment that abuts the Continental Divide and is part of the Niwot Ridge LTER. Snow depth surveys at maximum accumulation were conducted from 1997 to 2003.

Snow distribution was modeled using a combined deterministic and stochastic approach. The deterministic trend component was modeled using three approaches: a constant mean, a linear combination of linear topographic parameters, and a linear combination of non-linear topographic parameters. The topographic parameters considered included elevation, slope, an index of total radiation, an index of wind exposure, and an index of snowdrift formation. Some topographic parameters were found to be significant predictors of snow depth for each of the years. Other topopgraphic parameters were found to be significant predictors for some years, while insignificant for other years.

The stochastic component is used to characterize the spatial correlation between measurements. The range and variance of spatial correlation were found to be persistant between years. Furthermore the range and variance can be related to the total cumulative precipitation of the winter.

This study was possible due to the availability of a multi-year dataset of snow surveys supported by the LTER network.

Influence of the forest-tundra ecotone and environmental variables on subalpine forest at Niwot Ridge, Colorado.

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Abstract: The forest-tundra ecotone (FTE) is the transition area between alpine tundra and subalpine forest (SAF) ecosystems. A major characteristic of FTEs is that they modify the flow of water and materials between the adjacent ecosystems. Our objective was to examine the influence of the spatial pattern and abundance of tree size/growth-form (S/GF) classes within the treeline and environmental variables (EVs) on the spatial pattern and abundance of trees in the SAF at Niwot Ridge, Colorado. At the landscape scale, we compared treeline vegetation among the three FTE types present at Niwot Ridge, and at the local scale we compared treeline and SAF vegetation. Spatial pattern analyses (Ripley's K function and variance reduction bivariate estimate) were used to examine: (1) the spatial distributions of S/GF classes and (2) the spatial associations among S/GF classes. Direct ordination techniques were used to examine the relationship between EVs and the abundance of S/GF classes. At the landscape scale, the results suggest the following: (1) The spatial distributions of S/GF classes are, in general, significantly ($P<0.05$) different from random (clumped) at all distances. (2) Spatial associations among S/GF classes are generally not significant. (3) EVs explaining the greatest amount of variation in abundance among S/GF classes include elevation, metamorphic rocks, and skyward angle variability. (4) Ruggedness index variability best discriminates among the treeline sections of transects. At the local scale, the results suggest: (1) The spatial distributions of S/GF classes in the SAF are predominantly clumped at all distances. (2) Spatial associations among S/GF classes in the SAF are significantly different from spatial independence and exhibit different patterns of association from treeline vegetation. We conclude that the Niwot Ridge SAF is differentially influenced by treeline vegetation among FTE classes and by EV factors such as elevation, microtopography, and geology.

The effect of trees on soil carbon and nitrogen in the forest-tundra ecotone, Niwot Ridge, Colorado

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Abstract: A unique unidirectional flux of materials characterizes the forest-alpine tundra ecotone (FATE) on Niwot Ridge, Colorado. In the alpine it is known that topography affects the redistribution of resources. Trees at treeline are hypothesized to accumulate water nutrients, and organic matter by functioning as snow fences. These inputs would subsidize the biota in the FATE as they provide moisture, carbon, nitrogen, and base cations to the soil. This transported material likely includes nitrogen of anthropogenic origin. These subsidies were hypothesized to be greatest nearest the alpine tundra, the source of the material, and downwind of trees, because of the tree-wind interaction. The goal of this research was to look for indirect evidence for this redistribution by measuring the total pools of carbon and nitrogen, nitrogen cycling rates and resin bag available nitrogen. Total soil carbon and nitrogen, exchangeable cations, in situ N mineralization, and resin bag available N were measured upwind and downwind of individual trees at three sites within the FATE. Total carbon and nitrogen generally increased with altitude across the ecotone and were higher downwind than upwind of trees. Resin bag available nitrogen was greater downwind of trees than upwind of trees and decreased with elevation. The predominant form of nitrogen was nitrate. Nitrogen mineralization was also lower upwind of trees than downwind of trees, significantly so at the tree island site, and increased with elevation. At the closed forest site, ammonium was the dominant form of nitrogen produced, but nitrate was more abundant at the higher elevation sites. These results indicate the spatial heterogeneity in soil pools and fluxes of nutrients. Future work aims to link these processes directly to the eolian inputs, quantify the inputs and losses of nitrogen to these soils and determine if this ecotone, or select locations within it, is approaching nitrogen saturation.

Biogeochemistry in the hyporheic zone of an alpine stream.

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Abstract: Humic substances are a class of refractory organic biomolecules that are present in most natural waters. These substances are important components of natural waters in that they can form complexes with toxic metals, regulate the color of natural water and therefore the depth to which light can penetrate, buffer pH, provide an energy source for microbes, and as is recently being discovered, act as electron acceptros in reducing conditions. Our objective in this study is to gain insight into the role of humic acids as electron acceptors in the hyporheic zone of an alpine stream. Data was collected over a four week period from the hyporheic zone of a stream in the Green Lakes Valley, a headwater catchment that is part of the Niwot Ridge LTER program. Using fluorescence spectroscopy, we have characterized the oxidation state of quinone moieties in humic substances found at this site. A tracer experiment was conducted using lithium bromide to gain a better understanding of the flow paths into and out of the hyporheic zone. Preliminary data from the tracer experiment and hyporheic sampling is presented here. Tracer data in conjunction with dissolved organic carbon (DOC), conductivity, fluorescence index, iron speciation, and fluorescence spectroscopy has provided a good framework to examine the role of humic acids as electron acceptors.

Decomposition in the forest-alpine tundra ecotone of the Colorado Front Range.

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Abstract: Nitrogen (N) and phosphorus (P) availabilities strongly influence alpine plant productivity, yet much uncertainty exists about nutrient availability in the forest-alpine tundra ecotone. The availability of these elements is believed to vary directly with organic turnover and decomposition. Cotton strip assay was used to measure cellulose decomposition through loss of tensile strength of cotton strips (CTSL). Control, P-enriched, and N-enriched strips were left to degrade in the surface soil of forest, krummholz, and tundra plots for one year. Four transects spanning the forest-tundra ecotone, at two sites (Mt. Evans and Niwot Ridge) along the Colorado Front Range were used for experimentation. From preliminary analysis, the alpine tundra appears to have greater rates of decomposition than the subalpine forest or krummholz zone. In the forest, nitrogen enriched strips seem to be most decomposed while the P-enriched strips appear most decomposed in the krummholz. Our initial results suggest nitrogen limitation in the subalpine forest and phosphorus limitation in the krummholz zone.

Analysis of High Elevation Ecosystems: The Niwot Ridge-Green Lakes Valley LTER Program

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Abstract: Ecological studies of the climate and terrestrial and aquatic landscapes composing the Niwot Ridge - Green Lakes Valleys high-elevation region have been ongoing for over 50 years. Current changes in climate and atmospheric deposition of nitrogen to these systems have been identified, and these are causing rapid changes in some portions of this system but not in others. Interactions between climate and ecosystems with complex topographic gradients generate unique source and sink habitats for water and nutrients as a result of precipitation, energy, and chemical redistribution. High elevation lakes and the alpine tundra-forest ecotone are locations expected to receive the brunt of anthropogenic inputs obtained from the redistribution of exogenous materials from the regional environment, and from endogenous sources originating from other montane areas. Inorganic nitrogen inputs to lakes in the uppermost portions of Niwot Ridge experience inputs well in excess of N deposition from precipitation. At the alpine-forest interface, treeline functions as a particulate collector, resulting in the deposition of materials scoured from the alpine. A conceptual model is presented here that links terrestrial ecosystems to each other and to aquatic ecosystems. We report how atmospheric inputs as well as endogenous resources can be amplified or attenuated by transport processes. While transport processes determine local environmental forcings, biotic responses within and among sites mediate these effects. Ongoing research attempts to identify the extent to which biota, soils, and landscapes are changing due to environmental forcings, and the extent to which biotic processes can mediate change.

Variability of Western United States Snowpack, and Resultant Vulnerability of Water Supplies

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Abstract: The western United States is an arid land, where mountain snowpacks provide much, and in some locals all, of the water for its ever increasing demands.
This poster focuses upon the winter precipitation regimes in the mountainous areas of the western US, regions where snowpacks develop. Snowpack development is heavily dependent upon winter climatic conditions in concert with local topography. Climate and weather determine the quantity, form of precipitation (solid or liquid), and storm track, whereas topography influences where and how much precipitation falls through orographic lifting. Liquid precipitation, unlike the gradually melting winter snowpack, can benefit plant and animal (including human) use for only a very short time after it falls, unlike snow which can supply water well into the summer or even early fall. Therefore, not only quantity but also variability of snowpack is important as a measure of our vulnerability to water shortages or excesses.

This poster presents snowpack and winter precipitation conditions over the past three decades in the mountain regions of the western US as a whole, and also in eight specific mountain areas. The trends over time and by elevation vary from region to region. While winter precipitation may be increasing in some locals and at some elevations, snowpack may be decreasing, thus reducing available summer water supply. Further, some areas such as the Oregon Cascades, are highly variable, to the point of low snowpack reaching a virtual zero on its east flank. Other areas, such as the east slope of the Colorado Rockies, historically are much less variable (vulnerable) due to more than one moisture source available for building winter snowpack. Multiple moisture sources also appear to mitigate the variable effect of strong phases of the El Nino Southern Oscillation in a particular area, as well.

Canopy Nitrogen Uptake at a Colorado Subalpine Spruce-Fir-Pine Forest

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Abstract: A study at a Colorado spruce-fir-pine forest was undertaken to obtain canopy nitrogen uptake (CNU), N reallocation, and foliar N requirement. Wet deposition, dry deposition, and throughfall fluxes of ammonium and nitrate were measured during the 2000, 2001 and 2002 growing seasons. Determination of CNU, for both ammonium and nitrate, was obtained by subtracting throughfall (TF) flux from the sum of wet deposition (WD) and dry deposition (DD): CNU = WD+DD-TF. Canopy N uptake efficiency (CNU/[WD+DD]) for ammonium (0.9) was consistent across the 3 seasons. For nitrate, this efficiency was 0.8 (2000), 0.7 (2001) and 0.6 (2002). Foliar N requirement for growth was about 19 (2000), 22 (2001) and 12 (2002) kg N ha^{-1} yr^{-1}. Growing season estimates of CNU were approximately 2 (2000) and 3 (2001 and 2002) kg N ha^{-1}. Thus, CNU may contribute 10-25% of the foliar N requirement for canopy growth. Mountain upslope winds bring substantial amounts of anthropogenic N to this forest during the growing season, thereby contributing to CNU. Given that a sizable fraction of CNU is anthropogenic in origin, the forest's N cycle has likely undergone substantial changes on a decadal time scale.

Wireless Two-Way Communication with Remote Field Sites on Niwot Ridge LTER

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Abstract: This poster illustrates and describes the wireless system that joins the remote field sites scatter ed over Niwot Ridge whose data are ultimately stored in a relational database with a web enabled query and graphing sytem. This wireless network creates an internet accessible vehicle for data down load, datalogging, re-programing, and routine maintenance via the internet. The relational database web interface allows the end user to query the data passed via the wireless network. All these functions are possible from any internetted computer anywhere in the world.

The backbone of this wireless network is the FreeWave frequency hopping, broadband 900 MHz radio. The field dataloggers and software are Campbell Scientific products. The relational database is he ld in a Microsoft SQL Server system. This wireless network has been operational for about one year, and works flawlessly in all seasons despite the complex terrain which prevents line of sight between stations. Nevertheless, connections permit solid two-way communications from any internetted computer.

The fate of nitrogen in alpine tundra

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Abstract: The Colorado Rockies show signs of nitrogen (N) saturation even at comparatively low levels of N deposition. Yet, the mechanisms controlling terrestrial N retention in alpine tundra- or how these processes will change under chronic N input- have not been fully explored. We added a ^{15}N tracer to a series of chronically N amended plots in the dry meadow at the Niwot Ridge LTER to look at how nitrogen moves through, and is stored in the tundra, and to investigate how a range of low to high rates of N fertilization affect this partitioning. Our data suggest that, in the first growing season, ^{15}N was primarily taken up by plants rather than directly sequestered in the soil. There were significant differences between plant species in ^{15}N uptake, with Carex sp. and Hymenoxis grandiflora showing greater enrichment than Kobresia myosuroides, Acomastylis rossii, or Bistorta bistortoides. Enrichment was lower at higher levels of N fertilization. These data, along with previous findings at these study sites, might suggest that changes in plant community in response to N deposition will play a key role in mediating losses of N from alpine tundra.

Alpine Ecology and Experiential Learning at the Niwot Ridge LTER

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Abstract: As part of NWTLTER Schoolyard LTER activities, for the past 6 years we have offered a summer field course for in-service and pre-service teachers. This 3-credit course provides extensive training in alpine ecology through both lecture and field trips. The course also covers topics in environmental and experiential education, such as the importance of helping students to develop "environmetnal empathy" for the natural habitats in their community. The teachers in the field class lead field trips of elementary and middle school students on field trips to the tundra laboratory on Niwot Ridge, and prepare educational materials to enhance these trips as final projects in the class.