NIWOT RIDGE LTER PROGRAM, ANNUAL REPORT, 1996-1997

1. HIGHLIGHTS OF RESEARCH ACCOMPLISHMENTS:

1.1 Publications.

Over 20 peer-reviewed journal articles, book chapters and one book were published by the Niwot research group in 1996. Journals publishing Niwot LTER studies included Ecology, Oecologia, Oikos, Limnology and Oceanography and Environmental Science and Technology, among others. Scott Elias published a book on the ice-age history of sites within the Rocky Mountain Region. A contract has been signed with Oxford Press regarding the Niwot Ridge LTER synthesis volume, and we anticipate completing a draft of this book by the end of 1997. A total of 14 articles and one book by LTER personnel have been published in 1997 or are currently in press. An additional 18 articles have been submitted for publication. A BioScience article highlighted our data management program and provided guidelines of how to construct multiuser data information systems. This article has already been used by researchers preparing urban LTER proposals.

1.2 New Personnel.

The CU Institute of Arctic and Alpine Research (INSTAAR) is the new home for Dr. Alan Townsend, Assist. Prof. of EPO Biology with expertise in regional biogeochemistry, and Diane McKnight, Prof. of Civil Engineering with expertise in aquatic biogeochemistry. These new faculty are developing research components for the Niwot LTER effort that will expand our analysis of the biogeochemical properties of the tundra and Green Lakes watershed. Townsend has already participated in a synthesis effort with Seastedt that examined the role of current and future enhanced atmospheric nitrogen deposition across regional landscapes (Asner et al. 1997).

Dr. McKnight was also hired as the Associate Director of the University of Colorado Mountain Research Station (MRS). She is expanding the educational mission of MRS and will involve the LTER activities wherever appropriate. She is a co-PI of the McMurdo Dry Valleys (MCM) LTER. The MCM LTER program recently moved their data management program to INSTAAR to take advantage of nesting two LTER data management systems within the same institute. While each program will have their own stand-alone systems, NWT and MCD LTERs should benefit by sharing software and techniques. Both programs have already benefited by using student assistants from the various computer sciences programs on the CU campus.

Dr. Patrick Bourgeron, formerly with The Nature Conservancy, also moved to INSTAAR in January of 1997 as a Research Associate. Dr. Bourgeron 's expertise is in landscape ecology, forest community ecology, and ecosystem management applications. Dr. Bourgeron is currently funded by the USFS and we anticipate exploiting his expertise as we expand to include the subalpine areas (especially the subalpine meadows, ribbon forests, and treeline) in an expanded analysis of the functions of alpine tundra in a regional context.

1.3 Infrastructure.

A Line power and access for a phone and ethernet connections to the Tundra Laboratory were completed in early autumn of 1996. Approximately 21,000 ft of cable were buried beneath a road and trail from the Mountain Research Station (MRS) to the Tundra Lab. The estimated total cost of this effort was approximately $500,000, but was accomplished with NSF and CU funds for about $60,000. This was achieved because both equipment and personnel were provided by the U.S. Army Corps of Engineers. In addition, an estimated $90,000 of fiber optic cable was donated to the project by ATT. The fiber-optic cable will be pulled through the underground piping this year. The fiber-optic cable is currently functional to the subalpine climate station, where it is being used to provide on-line weather information to researchers (see

below).

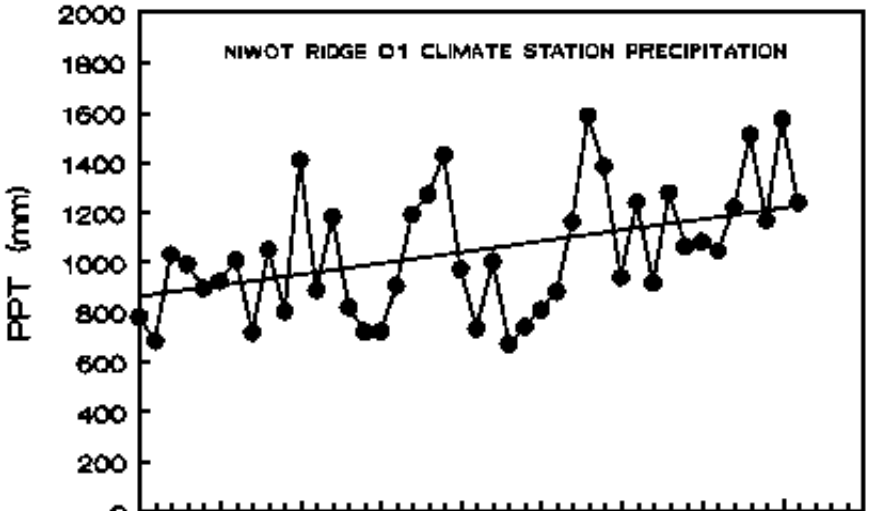
1.4. Data Management and On-Line Data Sets.
The Niwot Ridge LTER WWW server (http://culter.colorado.edu/) was accessed over 34,000 times last year. Both the WWW server and the Niwot Ridge LTER Gopher server (gopher://culter.colorado.edu) now provide unrestricted access to 84 data sets. Metadata for an additional 34 data sets are also readily available, and the data for these are available with PI consent. These data sets are all searchable by keyword and investigator via the WWW server, as is the Niwot Ridge LTER site bibliography. In addition, a digital elevation model, three scales of digital orthophotos, and geographic information system data for Niwot Ridge and the adjoining Green Lakes Valley are now available via the WWW server.

Other additions to the WWW server include a password protected area for information exchange among NWT investigators. Among these pages are on-line metadata collection forms that are used daily by field personnel. The WWW server has also been used in conjunction with the newly installed power and phone lines to provide current meteorological data from the climate station at 10,000 feet.

1.5. Outreach Activities.
The LTER program involved six REU students and an honors thesis student in alpine studies in 1996. LTER faculty collectively taught to over 600 students in ecology, biology and geography courses this last year. Results from LTER efforts both locally and nationwide were heavily utilized in course material.

The LTER data system was used as a model this spring to involve classes in Biology (Ecosystem Ecology) and Geography (Snow Hydrology and Introduction to Physical Geography) to use WWW-based data analyses, and information retrievals as classroom homework assignments. Mark Williams received funding from the University for this activity (see grants). While the students appreciated and benefitted from the assignments, the extent to which data can be manipulated and analyzed on-line is severely limited by the availability of web tools. For the most part, we had to create these specifically for the courses.

1.6. Science Issues:
The major thrusts of the Niwot Ridge LTER continue to focus on potential changes in the alpine ecosystem caused by 1) enhanced snowpack and 2) enhanced nitrogen inputs. Monitoring of plant and soil characteristics in response to snowpack augmentation is now in its fourth year since the establishment of the snowfence manipulation. Measurements include plant species composition, plant phenology and growth responses, soil chemistry and soil processes such as decomposition and mineralization. We note that this year continued the trend of the previous years in terms of high snowpack, (Figure 1), and provides substantial justification for using snowpack modification and its associated nitrogen increases as the major experimental thrusts of the LTER program.



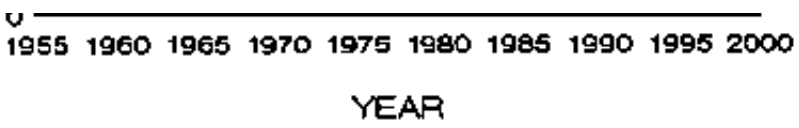


Figure 1. Precipitation at 12,400 ft. Elevation in the Colorado Front Range. Low-elevation records do not exhibit the statistically-significant increases of about 9 mm per year seen in this high elevation record.

A modeling effort completed by Hartz (1997) tested the extent to which the validated CENTURY model could predict the behavior of carbon and nitrogen dynamics under current and future climates of Niwot Ridge, and the extent to which the model suggested that the Ridge was approaching nitrogen saturation. The exercise supported empirical measurements that the biota and soils of the alpine cannot withstand substantial increases in nitrogen without greatly enhancing nitrogen export in streamwater. The study also indicated that decomposition parameters were by far the most sensitive characteristics of the alpine with respect to changes associated with climate variation.

A re-inventory of alpine vegetation plots by Korb (1997) originally surveyed by John Marr in 1954 also provided evidence of nitrogen enrichment on the tundra. The only species to significantly increase in the tundra was a species of Poa, a genus known to respond positively to nitrogen fertilization (e.g., Wedin and Tilman 1996). Changes in the tundra were more conservative than those observed in plots at lower elevations, supporting our contention that both the spatial isolation as well as the climatic restraints on tundra make this system relatively nonresponsive to anthropogenic changes occurring in the Front Range. The conservative growth strategies of many tundra species prevent these species from tracking or quickly responding to climatic (e.g., snowpack) and anthropogenic (e.g. nitrogen) disturbances. Given the absence of replacements for these high-elevation species, one could argue that the entire ecosystem--rather than individual species-- is 'at risk' to rapid environmental changes.

The paleoecology project of the Niwot LTER is studying a 12,000 year record of lake sediments from Sky Pond in Rocky Mountain National Park, approximately 50 km north of Niwot Ridge, analyzing pollen and insect fossils. These preliminary data suggest this site may produce one of the best high altitude paleoenvironmental reconstructions to date. Scott Elias is currently writing a book on the natural history of the Rocky Mountains, aimed at educated lay readers and featuring Niwot LTER research in several ways. Elias has also forged a link with Steve Jackson at U of Wyoming to do inter-site comparisons between Niwot and alpine sites in the Medicine Bow Mountains.

Collaborative science activities for this year include a synthesis workshop scheduled for August. This workshop is essential to integrate the specific projects into a unified body of scientific information. Our work continues to span a range of topics from organismic biochemical capabilities and developmental morphology of individual plant species to entire catchment studies and vegetation - atmosphere interactions. Only a Jenny-type model (e.g., Jenny 1980, van Cleve et al. 1991) is capable of synthesizing this work into a unified whole. Ecosystem phenomena cannot be described by emphasizing the significance of a single factor such as biotic diversity while homogenizing other variables (Huston 1997). Thus, while the work of Billings and colleagues several decades earlier described the significance of snowpack as an organizing feature of alpine tundra, this topography variable both controls and is constrained by other biotic and abiotic factors. Our goal is to construct a complex, conceptual model that provides a comprehensive understanding of the biological and physical factors responsible for creating and generating the behaviors exhibited by the alpine ecosystem, both under current conditions as well as those anticipated under modified atmospheric chemical and physical conditions.

Finally, our planned expansion of LTER research in the coming years involves a more explicit coupling of the alpine to the larger regional system, and this work will expand research on 1) watershed phenomena at alpine-subalpine, land-water, and aerobic-anaerobic interfaces, and 2) evaluation of anthropogenic

intrusions, including biotic (e.g., exotic species), chemical (nitrogen and other chemical enrichment) and physical (energy balance) modifications.

One new project is scheduled for the final year of the current grant. We propose to support an inventory of the algae species in the Green Lakes area of Niwot Ridge. The Green Lakes watershed has begun to show signs of nitrogen enrichment. The consequences of this enrichment on lake algae species composition and lake NPP are unknown but potentially important to downstream users. This project will be under the direction of Dr. Diane McKnight and will provide a baseline data set for subsequent comparisons in the Green Lakes region, and a comparison with similar data sets collected by Dr. McKnight and others in the Rockies and elsewhere.

CROSS-SITE AND NETWORK-LEVEL ACTIVITIES

2.1. Cross-site activities:
The International Tundra Experiment (ITEX) study by Dr. Marilyn Walker involves Niwot-Toolik Lake comparisons. The response of ecosystems to altered winter precipitation patterns as predicted by current global change estimates is unclear. An experiment in the Colorado alpine and Alaskan Arctic is examining the short- and long-term effects of altered climate regimes on tundra vegetation. Large snow fences and small portable greenhouses are being used to examine the effects of altered snow regimes and air temperatures. Tundra vegetation communities do not equilibrate quickly because changes to the belowground resources and the substrate require long periods to adjust, and a series of transient plant communities is possible. For this reason, we have designed an experiment with the intent of observing ecosystem change over an extensive time period.

Grizelle Gonzalez, a graduate student working with Seastedt, has initiated a cross-site study of litter decomposition involving the Luquillo site. That project is testing the litter quality-climate interaction hypothesis of Meentemeyer.

Dr. Carol Wessman is active with LTER-NASA collaborations and was funded to get the NWT and SGS LTERs included with the initial set of sites involved in MODLERS (the NASA - LTER link based on validation of MODIS land algorithms).

Drs. Schmidt, Bowman and Williams have a number of projects are also underway that relate Niwot findings to other studies ongoing in the Rockies. A number of efforts have paralleled research at Loch Vale, a NPS/USGS long-term study site, and elsewhere (see grant list).

2.2 Network-level activities:
A. International: Mark Williams remains active with the Chinese Environmental Research Network (CERN) and recently returned from a collaboration at an alpine site in that country. Bowman remains active with several collaborations with Central Europe and represented NWT LTER at an IGBP workshop in Kathmandu, Nepal. He was on the editorial board of the report from that workshop entitled, "Predicting Global Change Impacts on Mountain Hydrology and Ecology: Integrated Catchment Hydrology/Attitudinal Gradient Studies."

B. National: Dr. Elisabeth Holland participated in the LTER soils methods workshop and is senior author of a chapter in that volume (Holland et al., in press). Seastedt remains active with the LIDET group and is currently President of the Association of Ecosystem Research Centers, a group that includes most LTER sites. We are participating in a number of workshops in the National Center for Ecological Analysis and Synthesis that were organized by LTER personnel or organizations (e.g., ITEX, AERC) containing large LTER components or memberships. Dr. Scott Elias will participate in a paleoecological workshop and modeling activity at NCEAS this summer. Michael Hartman functioned as an NSF reviewer of the data

management program of another LTER site. He continues to be active with the Data Manager's network, and maintains the LTER online datasets table (Ingersoll R., Hartman M. LTER site online datasets & methodology. [Online]. Available: http://lternet.edu/about/dmgmt/online.htm)

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