LTER Network News

Issue Number 3 Spring 1988

Experimental burn on Konza Prairie Research Natural Area.

KONZA PRAIRIE LTER

Donald W. Kaufman

Konza Prairie Research Natural Area, owned by the Nature Conservancy and managed by the Division of Biology at Kansas State University, is the largest research natural area in tallgrass prairie. Tallgrass prairie, a major ecosystem type in North America, once covered 6-7% of the conterminous United States. The Konza Prairie site is representative of the Flint Hills upland, which extends from Oklahoma to Nebraska, averaging about 70 km wide. This region is dissected upland with hard chert- and flint-bearing limestone layers, resulting in steep-sided hills on which are exposed Permian limestone and shale layers. The ridges are characteristically flat, with shallow, rocky soils, whereas the larger valleys have deep, permeable soils. Although undisturbed examples of tallgrass prairie are rare because of extensive conversion to agricultural crop production, most of the Flint Hills region could not be cultivated and large areas of tallgrass prairie, grazed by cattle, remain today.

Large grazing herbivores, lightning and anthropogenic fire, and periodic droughts were important influences on the plant and animal components of presettlement prairie. We have, therefore, focused our LTER research on the influence of fire, grazing, and climatic variation on populations and processes in tallgrass prairie. Effects of fire on tallgrass prairie has been studied since the establishment of Konza Prairie in 1971, with the initiation of the LTER effort work of the effects of fire was intensified and the collection of detailed climatic data began. In October 1987, 33 bison were introduced to approximately 470 hectares of the site. Preliminary studies of bison have been initiated in preparation for the introduction of bison to an additional 520 hectares of prairie in 2-3 years. With a larger herd of bison, approximately 150 individuals, in a less restricted area including watersheds with monitored streams, we will be able to more fully examine interactions between native grazers and prairie fires.

To investigate the effects of fire on tallgrass prairie, watershed scale burning treatments with fire frequencies of 1, 2, 4, 10, and 20 years were established beginning in the 1970's. Although the effects of annual burning versus no burning on ungrazed tallgrass prairie has been studied at Kansas State University for 60 years, studies on Konza Prairie will provide the first test of the effects of other frequencies of fire. Burning every few years, for example, produces a pattern of plant production related to fire frequency. Also, plant species composition is influenced by fire and time since fire including greater similarity of the vegetation in upland and lowland sites burned annually than similar sites several to many years post-fire. Fire and recovery of vegetation following a fire impact consumer populations, e.g., grasshoppers and small mammals, with assemblage recovery dependent on species-specific patterns of fire-positive and fire-negative responses. In 1988, large portions of Konza, not burned since the mid to late 1960's, will be burned providing an excellent opportunity to test a number of concepts and predictions about the effects of fire that LTER researchers have developed over the last few years.

Since the start of the growing season of 1986, we have expanded LTER research to include experimental analyses of the belowground components to better understand pattern and processes in the total prairie system. A major part of these efforts has involved the establishment of an intensive factorially designed study involving burning, mowing (to simulate grazing), and fertilization (N, P and N + P) of experimental plots. Research on these plots includes analyses of soil properties, root biomass, types and associations of mycorrhizal fungi, and abundance and types of soil nematodes coupled with measurement of aboveground biomass and seed production. Results are beginning to provide insight into the effects of soil microbial activities on the processing of organic matter and the long-term effects of annual burning and nitrogen and phosphorus additions on the chemistry of tallgrass prairie soils. Additionally, data on root growth and production are being collected using root windows to measure growth and senescence of individual roots and soil cores to estimate standing crops of roots. The vertical and horizontal movement of soil water and any possible effects of annual burning on these movements is also included in the belowground component of KONZA LTER.

As part of its National Hydrological Benchmark Network, the U.S. Geological Survey have maintained hydrological records for Kings Creek, the major stream on Konza Prairie, since spring 1979. In addition, four triangular-throated flumes draining catchments of the upper portions of Kings Creek are being used to collect long-term discharge measurements. Work is now progressing on a hydrological model for flows in different watersheds. In addition to flow data, measurements of water quality are routinely taken from the four flumed watersheds. Data on water flow and quality are regionally important since this is the only stream monitored by the U.S. Geological Survey that drains into a major river that does not have its headwater in agricultural areas and, therefore, the Kings Creek serves as benchmark stream for the rest of the Great Plains agricultural area.

Detailed satellite imagery of Konza Prairie for the 1987 growing season was collected as a result of NASA's FIFE program, and will eventually be available to investigators not originally involved in the FIFE project. To facilitate the use of these and other types of digital data, an ERDAS Image Processor is now available as part of the LTER data management effort. Our initial use of this system coupled with a GIS is focused on the prediction of primary production of the tallgrass prairie and spatial analysis of the distribution of woody plant species on Konza Prairie.

For information on the Konza LTER program contact Dr. Donald W. Kaufman, Division of Biology, Kansas State University, Manhattan, KS 66506. **For information** on research opportunities on Konza Prairie Research Natural Area contact Dr. Ted M. Barkley, Division of Biology, Kansas State University, Manhattan, KS 66506.

EXPERIMENTAL LAKE ACIDIFICATION AT NORTH TEMPERATE LAKES LTER SITE

Thomas M. Frost and Annamarie Beckel

One of the primary values of long-term ecological data sets is the crucial background information they can provide for experimental research, especially whole ecosystem manipulation. The North Temperate Lakes (NTL)-LTER project of the University of Wisconsin-Madison's Center for Limnology not only supplies background data for the Rock Lake Acidification Project, but also provides reference data for the development of new statistical techniques for analyzing the often complex results of ecosystem manipulations.

In 1983 the Center's Trout Lake Station in the Northern Highlands Lake District of Wisconsin was chosen by the US Environmental Protection Agency as a major national site for research on the biological effects of lake acidification. This site was chosen partly because of the existence of the NTL LTER program and the long tradition of limnological research and ecosystem manipulation at Wisconsin. Little Rock researchers have been able to use the sampling and data management schemes developed by the NTL LTER project. In turn, LTER researchers have gained two additional lake basins in their set of lakes. They can also use the insights gained from research on a stressed ecosystem located near the primary LTER lakes.

The Little Rock Lake Project involves the gradual acidification of one half of an hour-glass shaped lake whose two lobes are separated by a chemically resistant, neoprene barrier. The treatment basin is being acidified in steps of 0.5 pH units/2 yr period from a starting pH of 6.1 to a final pH of 4.6, which is roughly the average pH of rain in this region. One half of the lake will be left untouched as a reference lake until 1991. The goals are to document the biological and chemical changes that occur in response to acidification, to identify the direct and indirect mechanisms that regulate responses, and to expand insights to a class of lakes for which responses to acidification were understudied.

The project, which is the only one of its kind in the United States, is a cooperative study involving not only researchers Tom Frost, Tim Kratz, and John Magnuson from the University of Wisconsin-Madison, but also Carl Watras, project site manager, Kathy Webster and Paul Garrison from the Wisconsin Department of Natural Resources, Pat Brezonik and Jim Perry from the University of Minnesota, Bill Swenson from the University of Wisconsin-Superior, Bill Rose from the US Geological Survey, and John Eaton, project officer, from the US Environmental Protection Agency.

The experimental manipulation of whole ecosystems is a powerful analytical approach and, perhaps, the only way to quantify responses in natural systems. A tradition of using natural lakes for experimental studies was started in northern Wisconsin by Chancey Juday in the 1930s to quantify the relationship between inorganic nutrients, plankton production and fish yield. Arthur D. Hasler greatly refined experimental ecosystem manipulations by splitting and then liming one half of Peter-Paul Lake on the Wisconsin-Michigan boundary.

The advantages of large-scale manipulations are tied to their capacity to (1) incorporate a full range of ecosystem processes, (2) encompass all of the life stages of aquatic organisms, and (3) allow for the proliferation of indirect as well as direct environmental effects. At the same time, however, replication in large-scale manipulations typically is limited by logistic considerations. This lack of replication confounds the interpretation of whole-lake experiments by traditional statistical techniques. Thus, whole-lake experiments require varied and comprehensive analytical approaches for their interpretation. Attention must be paid to (1) developing a baseline against which to measure the effects of acid treatment, (2) discerning whether a non-random change has occurred in a treated system, and, finally, (3) determining whether observed changes can actually be attributed to the direct or indirect effects of pH change.

In the Little Rock project, all three approaches have been combined. Although the primary focus is on comparisons between a treatment and a reference basin, pretreatment data were collected for 1.5 years and the seven LTER lakes nearby serve as secondary references.

To test the applicability of nearby lakes as reference systems, we have developed an analytical approach to evaluate limnological variability patterns (Kratz et al. 1987). We have applied it to a variety of parameters from the North Temperate Lakes LTER site and from other lakes in the region.

Variability patterns for long-term data from a set of lakes within a common region can be expected to fall into three categories: (1) lake-specific parameters, consistent in each lake through several years of sampling but different among lakes, (2) year-specific parameters, consistent across lakes in each year but different among years, and (3) stochastic or complex parameters, consistent neither with lake nor year. A two-way analysis of variance can be applied to long-term, multi-lake data matrix to provide a measure of the total parameter variance that is associated with year or site. Potentially, four variance types may be revealed by this analysis: Type I - with both lake and year effects, Type II - with a lake effect but no year effect, Type III - with a year effect but no lake effect, and Type IV - with neither a lake effect nor a year effect.

Data from the seven LTER lakes will permit an analysis of lake and year variability patterns for limnological parameters in the Little Rock Lake region. This analysis, combined with data from the treatment and reference basins of Little Rock Lake, will provide a more general basis for evaluating early responses to experimental

Diver inspects the curtain separating the two basins of Little Rock Lake.

acidification. For example, abundance patterns for Daphnia galeata mendotae in the LTER lakes indicate a Type II parameter, consistent year after year in each lake (Thomas Frost, unpublished data). In Little Rock's treatment basin, substantial increases were observed for Daphnia spp. during the second year at pH 5.6 (Frost and Montz, in press). Although caution must be used in extrapolating from data on one species to the lumped behavior of the genus, the increase in Daphnia would appear to be an unlikely event except in response to a major change in lake conditions, in this case Little Rock's acidification.

Regardless of the data used to establish baseline conditions, analytical methods are also necessary to test whether observed differences between treatment and reference systems are greater than those that would be expected to occur by chance alone. Once again the limited replication in whole-system experiments confounds the use of standard statistical procedures. We are pursuing several methods to establish the significance of change in the acidified basin of Little Rock Lake.

In a direct attempt to address the limited replication in environmental assessment work, Stewart-Oaten et al. (1986) suggested an approach involving a comparison before and after a treatment for a reference site and a site in which a change might be expected (termed BACI for a before: after, control:impact comparison). Carpenter et al. (unpublished) have developed a modification of the BACI approach that incorporates randomized intervention analysis (RIA) to provide an estimate of the probability that an observed shift in conditions might have occurred by chance.

We are testing the utility of the randomized intervention approach by comparing not only the reference and treatment basins of Little Rock Lake but all of the possible pairwise comparisons between the two Little Rock basins, the seven LTER study lakes, and three lakes now being used for whole-lake experiments involving shifts of top piscivores at the University of Notre Dame Environmental Research Center located less than 50 km north of Little Rock Lake.

Having detected changes in the acidified basin, it is critical to ascertain whether observed changes can be attributed, either directly or indirectly, to acid treatment. Consideration must be given to alternative explanations for observed changes. We are relying on at least two validation techniques: comparison with the results of previous studies and experimentation on a smaller scale. Before initiating the acidification, a set of predictions was compiled for each target pH, based on reports in the literature and on deterministic models. These predicted responses will provide one benchmark for gauging effects. In addition, smaller experiments are nested within the ecosystem manipulation. These experiments include limnocorrals, in situ bottle incubations, laboratory assays and paleolimnological investigations. Many of the limitations of the whole-system approach can be circumvented by coupling it, hierarchically, with these other experimental scales.

Ecosystem-level experiments are essential in assessing the effects of environmental perturbations like acidification. By coupling the Little Rock Lake acidification to the Northern Lakes LTER project, we can overcome constraints imposed by limited replication and develop powerful analytical tools for the interpretation of complex ecological data.

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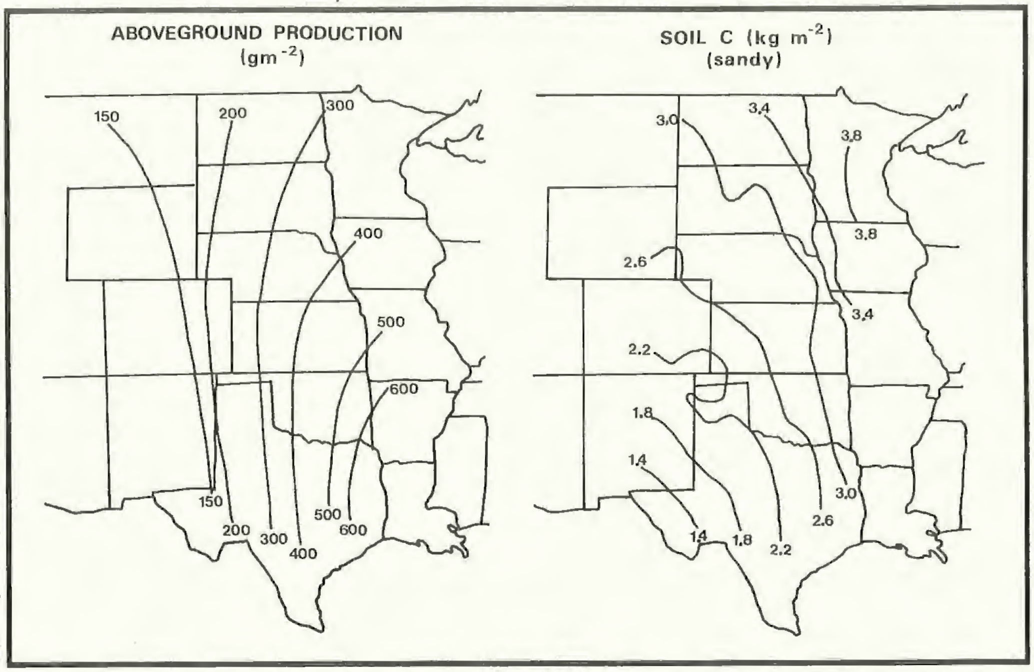
For more information, contact Tom Frost or Carl Watras, University of Wisconsin, Trout Lake Station, 10810 County N, Boulder Junction, WI 54512, (715)356-9494.

REGIONAL MODELLING OF GRASSLAND BIOGEOCHEMISTRY

William Parton

Regional modelling is an essential step in scaling plot measurements of biogeochemical cycling to global scales for use in coupled atmosphere/biosphere studies. We have developed a model for carbon (C), nitrogen (N),phosphorus (P) and sulfur (S) biogeochemistry for the U.S. Central Grassland region based on laboratory, field and modelling studies. Model results showed geographic patterns of cycling rates, plant production, and element storage to be a complex function of the interaction of climatic and soil properties. The driving variables for the model include soil texture (sand, silt and clay content), monthly precipitation, average monthly maximum and minimum air temperature, and plant lignin content. The model was validated by comparing simulated soil C, N, P, and aboveground production to observed values for a large number of sites (16 to 56) in the Great Plains, which span large temperatures (4 to 22 C mean annual temperature) and moisture gradients (30 to120 cm annual precipitation). The model has been adapted for the four grassland LTER sites (Konza, Central Plains Experimental Range (CPER),Jornada, and Cedar Creek) and has been used extensively to simulate the interactive impact of fire and grazing at the Konza Tallgrass prairie and CPER sites.The model (CENTURY) simulates soil organic matter (SOM) dynamics in natural and agroecosystems and represents the dynamics of C, N, P and S in the soil-plant system using a monthly time step. The plant production submodel simulates the dynamics of C, N, P and S in the live and dead aboveground plant material, live and dead roots, and the structural and metabolic surface, and soil residue pools. In the SOM submodel, plant residues are decomposed by microbes and the resulting microbial products become the substrates for SOM formation. We divide SOM into three fractions: (1) an active soil fraction consisting of live microbes and microbial-products (1 to 4-y turnover time); (2) a protected fraction that is more resistant to decomposition (20 to 40-y turnover time) as a result of physical or chemical protection;and (3) a fraction that is physically protected or chemically resistant and has a long turnover time (800-1200 y).The plant residue is divided into structural (2 to 5-y turnover time) and metabolic (.1 to 1 y turnover time) pools as a function of the lignin to N ratio of the residue. Decomposition of each of the state variables is calculated by multiplying the decay rate specified for each variable times the combined effect of soil moisture and temperature. The decay rate of the structural material is also a function of the lignin content of the structural pool, and the active SOM decay rate is a function of the soil content of silt plus clay (low values for high silt plus clay soils). The microbial respiration loss for each carbon flow is fixed for all the flows except the active SOM, which varies with the soil content of silt plus clay (decreasing with high silt plus clay content). A more detailed description of the model is presented by Parton et al. (1987 a,b).Regional patterns of ecosystem properties for grasslands in the Central grasslands region have been simulated (Parton et al., in press) and include: above- and belowground production and decomposition, soil organic C, N, P, and S levels, and N, P, and S mineralization rates. Figure 1 shows the simulated regional patterns for aboveground plant production and soil C levels (0-20cm). Aboveground production increases form west to east following the dominant precipitation trend. Soil organic C reflects the contrasting patterns for production and decomposition, and thus increase from the southwest to northeast. Soil organic C and N levels vary with soil texture and increase by 50% as you decrease the sand content from 75% to 25%.The results of this modelling work suggest a general approach to regional modelling of biogeochemical cycling. First, driving variables need to be identified, using laboratory or comparative field studies. Second, relationships between driving variables and rates of processes must be quantified. Third, the geography of the driving variables must be determined.



Regional pattern for plant production and soil C for the U.S. Central Grassland region.

Finally, the regional simulation can be developed. By identifying environmental gradients in variables that have large effects on processes, much of the spatial variability in rates of processes may be explained. For example, a key driving variable with high spatial variance from our study is soil texture, which has virtually no temporal variance, but controls much landscape- and region-scale variation in productivity and soil organic matter accumulation. This approach provides a mechanism for extrapolating from process measurements typically conducted in the laboratory, or using field experiments to thousands or millions of hectares in area. Models like the CENTURY model are mechanistic enough to simulate effects of changing climate or atmospheric chemistry and will be an essential tool in the study of global change.

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Niwot Ridge/Green Lakes Valley LTER Site

Norman R. French

The research site is in alpine tundra 45 km west of Boulder in the Front Range of Colorado. The investigations are conducted at elevations of 3000 to 3750 meters. Niwot Ridge extends eastward from the Continental Divide approximately 10 km, beginning as a rocky arête at Navajo Peak (4087 m), then changing to a narrow rocky-sided ridge topped by tundra. The ridge then broadens to a maximum width of almost 2 km before changing into krumholz and dwarf tree islands of Subalpine Fir and Engleman Spruce at treeline (3500 m). The Niwot Ridge/Green Lakes Valley LTER project is investigating the effects of disturbance on loss and cycling of elements in alpine tundra, and the response of vegetation (both terrestrial and lacustrine) to short term and long term fluctuations in climate characteristics. Tundra small mammal populations are monitored annually, as are seasonal changes in snowpack and plant phenology. Paleoecological studies focus on pollen, diatoms and insects. There are continuing studies of effects of altered snow cover, nutrients, and pH on the growth and phenology of Kobresia.

View of the Martinelli Slope site on the south-facing slope of Niwot Ridge showing distribution of 2x1.5 meter sample plots (27 in all).

In this mid-latitude continental location, climate is strongly influenced by elevational and topographic conditions. Average annual precipitation is slightly greater than 900 cm, the majority coming as snow and, due to wind redistribution, is spatially non-uniform. Highly variable moisture conditions and topoclimatic characteristics determine vegetation community development and characteristics. Investigations are centered on the top of Niwot Ridge, an interfluve with tundra, in the wetland of Green Lakes Valley adjacent to the Ridge, and on the Martinelli Snowbank slope between. Niwot Ridge is the site of intensive climalotogical and biological investigations initiated more than 35 years ago; Martinelli is the site of disturbance studies, and the Green Lakes wetland adds a distinct and important habitat to our research. Long-term data sets are maintained on climate, snowpack, water and atmospheric chemistry, biological productivity, community composition, phenology, and long-term decomposition rates. Soil profiles have been described in each of the major vegetation types. Experimental studies are under way to determine effects of increased snowpack and of acid rain on alpine tundra.

The following are four key areas of investigation: (1) On the south-facing slope of Niwot Ridge an experimental study of distribution of elements and nutrient cycling in a mesic tundra meadow has been initiated. The study is located near an area of high snow accumulation known as the Martinelli Snowbank. The experimental design consists of latin square where natural disturbance has been imposed by intense pocket gopher activity. In addition to plant, animal and nutrient studies, we are investigating the role of organic acids in acid neutralizing processes within the soil, and aluminum mobility across the landscape, using a geochemical catena approach. (2) We are establishing a Niwot Ridge-Green Lakes Valley Geographic Information System (GIS) as part of the Joint Facility for Regional Ecosystem Analysis. The facility will support ARC/INFO GIS and LAS image analysis software. This facility is being established cooperatively by the University of Colorado and Colorado State University, and will link our site with the LTER site at the Central Plains Experimental Range and with the Center for Study of Earth from Space (CSES). We will develop a data base for our site from existing soil and vegetation maps, detailed field investigations, and from satellite imagery. (3) The wetland study aims to determine current accumulation rates of organic and inorganic nutrients in the system, major pathways of cycling within the system, and developmental history through pollen and diatom analysis. Aquatic biology studies focus on demography and food habits of key organisms, periphyton growth rates and decomposition rates. The site is a fen characterized by willow and sedge communities, with ponds of standing water, and saturated or near-saturated soils. Snow cover is complete for eight winter months, with depths up to three meters. Water comes mainly from a persistent snowbank and from a rock glacier. (4) The paleoecology study is examining pollen and diatom assemblages from cores obtained in several nearby lakes and from ponds in the wetland. These paleoindicators are being used to reconstruct vegetation and climatic changes over the past 12,000 years.

The Niwot Ridge/Green Lakes LTER project encourages visiting scientists and collaborators to utilize these facilities for research that contributes to the LTER goals and objectives. **For further information** contact Dr. Norman R. French, Institute of Arctic and Alpine Research (INSTAAR), Campus Box 450, University of Colorado, Boulder, CO 80309.

Recent Publications (Niwot)

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The Jornada LTER Site

Walter Whitford

The Jornada LTER has experienced a major change in principal investigators and a modification of program objectives. In January 1988, four new P.I.'s joined the Jornada team: Dr. William Schlesinger (Duke University); Dr. Wesley Jarrell (University of California-Riverside); Dr. Ross Virginia (San Diego State University); and Dr. Laura Huenneke (New Mexico State University).

Dr. Schlesinger has been conducting research on nutrient cycling processes at the Jornada for several years and has been an informal participant in the Jornada LTER program since its beginning. Bill will be expanding his studies of denitrification and initiating work on ammonia volatilization in the summer of this year. Drs. Jarrell and Virginia have been conducting research on N-fixation in deep rooted legumes and on rhizosphere processes in deep rooted shrubs. They are expanding their efforts to examine soil organic matter dynamics utilizing natural abundance ratios of stable isotopes in addition to other techniques. Because Dr. Peter Wierenga will be leaving the Jornada LTER program to take a position as head of the soils department at the University of Arizona, Wes and Ross will assume responsibility for the soil water studies. They plan to expand their root studies using mini-rhizotions to obtain data on root growth and root turnover. Our current studies have shown that deep rooting is not limited to mesquite, Prosopis glandulosa. Other shrubs may have viable roots at depths of 5-7 meters which imposes logistic constraints on root studies of such species.

Dr. Huenneke is a recent addition to the biology faculty at NMSU. In addition to continuing some studies in collaboration with Hal Mooney at Stanford where she was a post-doc, Laura is setting up long term demographic studies of several shrubs plus collaborating on primary productivity studies and studies of the effects of soil disturbance by animals.

Dr. James Reynolds, who joined the Jornada LTER in 1985, is modifying his modelling work which has focused on primary production, decomposition, and nitrogen cycling processes to incorporate spatial patterns using a dynamic geographic information system approach. Jim is currently director of Systems Ecology at San Diego State University.

Dr. Tim Ward, collaborating hydrologist, and Sue Boln have been analyzing infiltration and run-off data as part of their hydrological studies. They found that run-off was a function of storm energy not vegetative cover, for virtually all of the storms that we experienced on the Jornada since 1980. Thus one more conventional idea must be modified when applied to desert ecosystems.

The modification of program objectives is a change from focusing on hypotheses built around temporal and spatial variability with work focused on a single watershed to hypotheses built around the concept that desertification has changed a previously uniform distribution of resources to a patchy distribution of resources. We hypothesize that this shift in distribution of resources has disrupted temporal linkages among ecosystems and ecosystem processes. In order to address questions concerning desertification processes, we have set up research at several new locations on the Jornada and are working to increase collaborative efforts with the USDA programs at the Jornada.

Additional information may be obtained by contacting Dr. Walt Whitford, Dept. of Biology, New Mexico State University, Las Cruces, NM 88003.

Aerial photo of Jornada LTER site, with a dry lake in the foreground and the water shed draining into that lake.

COWEETA LTER SITE

Bruce Wallace

The southeastern drought of 1985-86 is an event expected to have long-term impacts on two LTER sites: Coweeta Hydrologic Laboratory in the Southern Appalachian Mountains of western North Carolina and North Inlet in the coastal marshlands of South Carolina. To assess those impacts, a coordinated research program is now underway at these sites to determine and compare ecosystem responses that follow drought. At Coweeta, objectives of the drought response research include five activities: (1) long-term analyses of the drought as related to long-term climatic data; (2) effects on water budget (soil moisture, evapotranspiration, and short-term stream flow responses) as compared with more normal years; (3) effect of drought upon precipitation and stream chemistry with emphasis on nutrient cycling; (4) effects on forest dynamics with emphasis on reduced vigor or decline symptoms; and, (5) use available simulation models to investigate potential long-term effects of several drought and non-drought scenarios.

Aerial photo of the Coweeta Basin (looking west).

Total flow for mountain headwater streams is only partly due to stormflow. Most of the total annual flow is derived from slow drainage of soil moisture from the large soil mass upslope from the stream. Thus, the 1984-86 pattern of low precipitation during soil moisture recharge periods is reflected by falling streamflow levels. At the beginning of the growing season in May 1986, cumulative streamflow over 18 months was 59 percent of the 52-year mean. Minimum monthly flow records were set for 6 consecutive months, April through September 1986.

This issue focuses on stream studies at the Coweeta LTER site; terrestrial research will be covered in a future issue. Continuous climatic and streamflow studies at Coweeta were initiated in the mid 1930s and continuous baseline precipitation and stream chemistry studies have been conducted since the early 1970s for seven streams draining control watersheds and nine streams draining disturbed catchments. The disturbed catchments include hardwood-to-pine conversions, grass-to-forest succession, clearcut and natural regrowth, selection cutting, and understory cuts. These records have provided a valuable extensive data base for evaluating the integrated biogeochemical function in southern Appalachian forest ecosystems, as well as for evaluating system-level responses to natural epsiodic events, atmospheric deposition, and forest management practices.

Several studies are examining nutrient dynamics in Coweeta streams. Steve Golladay's recently completed Ph.D. research (Jack Webster's and Fred Benfield's laboratory - VPI & SU) examined nutrient retention in disturbed and undisturbed streams, and Donna D'Angelo (VPI & SU) is investigating the influence of disturbance on dissolved nutrient uptake in streams. Nancy Munn's research (Judy Meyer's Laboratory - UGA) is focusing on nutrient uptake and extent of mixing between surface and interstitial waters. Exchange of surface and interstitial waters is rapid, which suggests that ions in transport in water may have great opportunity to interact with sediments. Other research in Meyer's laboratory is focusing on bacterial biomass and organic matter content of sediments, as well as meiofauna in streams at Coweeta. Uptake of DOC and long-term trends in DOC concentration of streams following watershed disturbance are being studied by Judy Meyer. Webster and Benfield have developed a computer model of transport of particulates in streams and are examining effects of long-term hydrologic patterns on particle transport.

Traditionally, studies of macroinvertebrates in Coweeta streams, which were initiated in the 1950s, have examined the influence of disturbance from related forestry practices. The most recent studies have focused more directly upon the role of invertebrates in mediating ecosystem processes such as organic matter processing and nutrient spiraling. Benfield and Webster are examining effects of forest disturbance on food quality available to stream detritivores and Ben Stout (VPI & SU) is measuring detritivorous insect production in disturbed and reference streams. The influence of drought and manipulation of invertebrate populations on ecosystem processes (leaf litter processing, export of dissolved, fine and coarse organic matter, and nutrients) of three headwater streams is being examined in Bruce Wallace's laboratory (UGA). The severe drought of 1986 influenced the amount and form of organic matter exported to downstream reaches; however, the influence of macroinvertebrate reduction (via pesticide treatment) on export of fine particulate organic matter has been much greater than the drought effects. Recently, a study has been completed on the influence of local geomorphology on spatial patterns of macroinvertebrate production and functional structure in a high elevation stream. This study was designed to serve as a point of reference in order to assess any future changes in the biota should acidification occur (Alexander Huryn and B. Wallace, UGA). Huryn, a research associate in Wallace's lab, is currently studying growth patterns and developmental phenology of larval chironomid communities in watersheds of different elevation, aspect, and disturbance history in order to assess these influences on overall patterns of production across the Coweeta Basin.

Studies in Gary Grossman's laboratory (UGA) are concerned primarily with fish studies. At Coweeta, these include the following: (1) Long-term monitoring of fish assemblage structure and environmental variables to ascertain the relationship between these two ecosystem properties; (2) Evaluation of the effects of an experimentally induced resource depression on food and microhabitat use in two benthic fishes; (3) A field removal experiment to test for the presence of competition between mottled sculpin and longnose dace; (4) Construction of an energetic model of microhabitat selection for two water-column species (rainbow trout and rosyside dace); and, (5) Quantification of dietary selectivity in this assemblage.

The Coweeta synthesis volume "Forest Hydrology and Ecology at Coweeta" has been published by Springer-Verlag. The book, edited by W. T. Swank and D. A. Crossley, Jr., is Volume 66 in the Ecological Studies series. The content is divided into eight sections including baseline data on hydrology, geology, climate, and water chemistry; forest dynamics and nutrient cycling; canopy arthropods and herbivory; forest floor processes; stream biota and nutrient dynamics; management of forested watersheds; and long-term research perspectives. Forty-nine co-authors contributed to the 30 chapters.

Substantial improvements in research facilities at Coweeta are nearing completion. A new building for data processing, office space, library, and other support services will be occupied in April. The building previously used for these functions is being renovated for dormitory, living, and work space to accomodate up to 30 investigators. The renovation is partly supported by a NSF Grant from the Biological Research Resources Program.

For additional information on the book volume and facilities, contact Wayne T. Swank, Coweeta Hydrologic Laboratory, 999 Coweeta Lab Road, Otto, North Carolina 28763, (704) 524-2128.

THE LTER NETWORK

J.T. Callahan and C. Bledsoe

Network (according to Webster's): **any integrated, highly organized system or activity spread over a large area.** The LTER Network certainly qualifies on an area basis, because the sites reach from northern Alaska through the continental U.S. to the Atlantic coast. As for "integrated, highly organized" -- we're working on it!

With over 400 scientists, support staff, postdoctoral researchers, and graduate students, the LTER network is developing into a major scientific entity. In the past 6 months, we have established a new LTER Coordinator position at NSF, developed plans for acquiring and implementing new technologies, published a directory for the network, and begun development of a program to attract more non-LTER scientists to LTER collaborations.

LTER Coordinator. In the past, Tom Callahan has been the primary coordinator for the LTER projects. Now, LTER activities are coordinated/facilitated at NSF by a Senior Staff Associate for Long Term Ecological Research -- a full-time rotator position, currently filled by Dr. Caroline Bledsoe from the University of Washington, Seattle. Caroline is working with the LTER Coordinating Committee on network activities, and is also looking at below-ground activities in the network. Please contact Caroline, who will be at NSF until fall 1988, if you have ideas she can help coordinate within the network.

Candidates interested in the position currently filled by Caroline should contact Tom Callahan (Ecosystem Studies Program, National Science Foundation, 1800 G Street NW, Washington, DC 20550) for a copy of the job description.

New Technologies. An NSF advisory committee, Scientific and Technological Planning for LTER Projects, has been formed. The committee members are H.H. Shugart (Chair; Virginia Coast Reserve), G. Shaver (Arctic Tundra), S. Stafford (H.J. Andrews), and W. Parton (Central Plains). The report the committee submitted to NSF was distributed at the April 1988 LTER Coordinating Committee meeting. Their basic recommendations are: (1) acquire GIS capability with some uniformity across the LTER network; (2) develop network-wide remote sensing analysis capability; (3) augment LTER use of wide-area (WAN) and local-area (LAN) computer networks; (4) maintain data bases, providing convenient, on-line access to users inside and outside the project; and (5) continue evaluation and planning efforts pertinent to the four recommendations above. Further information on these recommendations will be sent to all sites.

Network Directory. Have you wondered just who else in the network is studying nematodes? Or measuring phytoplankton? Or working with GIS? The new LTER Directory (available from Judy Brenneman, Newsletter Editor) has answers as well as phone numbers and electronic mail addresses for LTER scientists, postdocs, graduate students, and staff. The Directory will be updated yearly, in the spring.

Inclusion of Non-LTER Scientists. As the network grows, we want to include non-LTER groups in research activities at the sites. NSF and the LTER Coordinating Committee are exploring ways to increase support and interest. Although most sites are used by non-LTER persons, broader use of the sites is desirable. The next issue of the newsletter should have a progress report on this activity.

Summary. As interactions become more complex, we grapple with such problems as (1) rates of progress and evenness of progress among the sites; (2) increasing interest in LTER by individuals and organizations, national and international; and (3) the continuing goal of realizing the full potential of LTER for comparisons among major ecosystems.

The LTER program is moving forward, becoming more integrated, beginning collaborative projects, and making significant contributions to ecosystem science. The LTER program is an exciting experiment in biology, and its fun to speculate -- "Where will we be in the future?"

Meeting on Global Vegetation Change

A meeting on Concepts and Modeling of Global Vegetation Change was held on April 17-22, 1988 at the International Institute for Applied Systems Analysis (IIASA) in Austria. This meeting was the initial meeting in a project, "toward an ecologically sustainable development of the biosphere" led by Dr. Allen M. Solomon and R.E. Munn. This project is to develop systematic policy analyses for use in examining development implications of potential global environmental concerns and includes 3 activities: (1) creation of a mathematical model of global vegetation response to changing climate, population and land use; (2) assembly of a reference set of scenarios of possible future changes in global climate and land use; and (3) implementation of a series of policy exercises using the model and reference scenarios.

The meeting in April focused on definition of the nature of a dynamic vegetation model at the global scale. Specific subject areas for discussion were: (1) policy analysis and issues, i.e., the kinds of policy questions that the model has to be designed to answer; (2) remote sensing; (3) geographic climatology and pedology, i.e., characterization of the basic environmental constraints on vegetation and land use; (4) agricultural geography and climatology, i.e., definition of the natural geographic range limits of major crop species and their climatic controls; (5) biogeography, i.e., consideration of the differing vegetation classification schemes currently available for ordering global classification schemes currently available for ordering global vegetation; (6) plant ecology; and (7) ecological and geographic models, i.e., identification of the most appropriate approaches.

The meeting was chaired by Allen Solomon and supported by the Alfred P. Sloan Foundation and IIASA. It is planned to publish results of the meeting in the form of a book. Additional information on the meeting and on the project can be obtained by writing Dr. Solomon at IIASA (A-2361 Laxenburg, Austria).

This work is part of a larger 1988 environment research program planned by IIASA for 1988. Projects on acid rain (under the direction of Roderick Shaw of Canada) and decision support systems for large international rivers (under the direction of Gyoergy Kovacs of Hungary) are also underway. These are supported by an environmental monitoring program led by Michael Antonovsky of USSR). Recently completed activities include projects on integrated assessments of climate impacts and on dendrochronology and applications.

Variability in North American Ecosystems

Caroline Bledsoe

Snow flurries and windy weather in Northern Wisconsin didn't dampen the enthusiasm of those of us attending the "Variability in North American Ecosystems" workshop on April 18-22 at the Trout Lake Station, Wisconsin. I joined representatives from 12 LTER sites for 4 days of working on computers, exploring an intersite LTER data base (code name "VANIE"), and developing intersite hypotheses, which were tested at the workshop. John Magnuson and the group from North Temperate Lakes LTER did a superb job of planning, organizing, and setting up the workshop.

The LTER representatives were: Art McKee, AND (Andrews); Peter Bayley, ILN (Illinois Rivers); John Yarie, BNZ (Bonanza Creek); Gary Cunningham, JRN (Jornada); Richard Inoye, CDR (Cedar Creek); Don Kaufman, KNZ (Konza); Jon Hanson, CPR (Central Plains); Jim Halfpenny, NWT (Niwot Ridge); Cory Berish, CWT (Coweeta); Liz Blood, NIN (North Inlet); Randy Dahlgren, HBR (Hubbard Brook); and John Magnuson and Tim Kratz, NLK (North Temperate Lakes), and the gang from North Temperate Lakes.

The purpose of the workshop was to analyze variability in North American ecosystems, using data on spatial and temporal variability from LTER sites. The requirements were that the data represent at least 5 years of collection from at least 5 locations at the LTER site. Subsequent statistical analyses, done by Tim Kratz from NLK, produced variances attributed to "year," "location," and "other" (a combination of error and interaction terms).

The workshop was well organized, with 8-10 microcomputers (Mac's and IBM's) and 4-5 knowledgeable computer users available to assist workshop attendees. The success of the workshop clearly reflected thorough preworkshop preparation, including visits by Magnuson to 10-12 LTER sites in the fall of 1987 and the extensive preworkshop data manipulations/statistical analyses done by Kratz. With this preparation and the excellent facilities, the workshop group was able to generate hypotheses, divide into smaller groups, and begin analyzing the data base -- we were using the summary data base within about 5 hours after the workshop began!

Data were analyzed in a number of ways. Some workshop persons lumped data, whereas others split data, each with the intent of testing hypotheses about variance. Examples of hypotheses investigated were: Do ecosystems differ in variability? What is the importance of landscape position? Does variability pass up the food web? Are early successional stages more variable than late successional stages? Are predators less variable than their prey? How does variability change with degree of aggregation of functional groups?

It is too early to list conclusions and major hypotheses from the workshop. Several manuscripts were outlined and individuals were identified to complete them. If possible, the workshop attendees will meet a second time in the fall of 1988 for further discussion and review of these manuscripts.

In summary, the workshop was very successful, resulting in a LTER Intersite Data Base, as well as the beginnings of intersite comparisons on a multitude of scales. Although additional work is required to complete what was begun at the workshop, I believe we are beginning to generate payoffs from the LTER Network.

CALENDAR OF EVENTS

Executive Committee of the LTER Coordinating Committee will meet in Washington, D.C. June 9-10, 1988.

The Ecological Society of America will hold its annual meeting in Davis, California August 14-18, 1988 (includes LTER Symposium, August 16).

The LTER Data Managers will meet in Davis, California August 13-14, 1988.

LTER Climate Committee will meet at the Niwot Ridge LTER site August 21-23, 1988.

LTER Coordinating Committee will meet in October (the location and date have not been selected at this time).

LTER DIRECTORY

In an effort to make it easier for our readers to obtain information on any of the LTER sites or research projects described in this newsletter, we are providing a directory that includes general information. The directory that follows contains the name, mailing address, telephone number, and electronic mail address of the principal investigator and data manager from each site. We have also included the name and address of new personnel.

If this directory proves to be useful, it will become a regular feature of the newsletter and an update will be published once a year.

Coordinating Committee Chairman

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H.J. Andrews

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Cedar Creek

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Hubbard Brook

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Data Manager: Louise Flynn, USDA Forest Service, Northeastern Forest Experiment Station, Durham, NH 03824, (603)868-5576

New Personnel: Steve DeGloria, Dept. of Agronomy, Cornell University, Ithaca, NY 14853, (607)255-4330 or 8148 (Research Specialty: Geographic Information Systems)

Illinois & Mississippi Rivers

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Jornada

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Kellogg Biological Station

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New Personnel: Dennis Heisey, Center for Limnology, University of Wisconsin, Madison, WI 53706, (608)262-3088 (Research Specialty: Biostatistics)

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Data Manager: John H. Porter, Department of Environmental Sciences, University of Virginia, Charlottesville, VA 22903, (804)924-7761 [JHP7E@VIRGINIA.EDU]

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