Coweeta LTER Program 2000 Annual Report
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Introduction

Coweeta LTER research focuses on studies along complex environmental gradients to examine the response to disturbance in a landscape perspective. We are examining the causes and consequences of land cover change in the southern Appalachians and are examining three linked components of the landscape: upland forests, riparian zones, and streams. In addition, the regional and socio-economic components of our research include a large scale (56,000 km^2) research approach to better understand the regional interactions of our ecosystems.

This report contains a brief update of these major research projects along with updates on data management and other LTER related research. In addition, we also include information on outreach, cross-site, and LTER/ILTER Network activities. We conclude with listings of publications and research grants related to our Coweeta LTER project.

Research Activities and Findings

Land-Use Change Regionalization Project

Our regionalization land-use change project, initiated with augmentation funding in 1994, has been a steady source of excitement for our site.

Aquatic Ecology Highlights

The aquatic research group has focused on a series of twenty-four sampling sites representing six replicated primarily forested and pasture sites in two different river drainage systems (Little Tennessee and French Broad). Fish and invertebrate quantity and diversity, along with water quality variables, have been sampled at each site over the past three field seasons and have yielded numerous interesting results. As more detailed data of the land cover history of the area upstream of sample points has become available from GIS projects, additional analyses of the

stream data have been possible. Results show that though significant differences exist in the species assemblages between primarily forested and agricultural drainage types, the history of the landscape may account for much of the difference between sites within each type of drainage. For example, terrestrial recovery from agricultural use may be relatively rapid, however recovery of stream fauna to their pre-disturbance species and population dynamics may take considerably longer (i.e. decades).

In 2000, we have initiated a long-term (30 year) study on the predicted land-use change in stream ecosystems in the southern Appalachians. This study contains a set of stream study sites where half are predicted to undergo land cover change and the other half are predicted to have no significant change in land cover. Sampling of stream indices (e.g. water quality, fish populations, benthic invertebrates, stream morphology, riparian size and condition, etc.) were conducted in 2000 and will be conducted every five years until 2030. This research project is integrating social and economic predictive modeling with aquatic and riparian ecology.

Terrestrial Ecology Highlights

The terrestrial ecology research group has made progress on two main activities. First, Paul Bolstad, Co-PI on the project, has worked closely with all groups in the Regionalization project to distribute the wealth of digitized mapping and land cover products which his lab has produced. Paul is also a member of the three-person carbon cycling team, along with James Vose and Brian Kloeppel, who are quantifying the pools and fluxes of the carbon cycle across the complex southern Appalachian landscape. Three years of intense data collection and one year of summary and analysis have yielded relationships for the effect of slope position, aspect, temperature, and seasonal morphology on foliage, woody, soil, and litter carbon fluxes. These functional relationships, coupled with the more straightforward measurement of carbon pools for each of the above components now allow the development of a first generation carbon cycling model.

In addition to the carbon-cycling work, efforts by Scott Pearson and Monica Turner have focused on the diversity of species, both plant and bird populations, across the landscape in relation to land-use history. Jim Clark's lab has made a significant contribution to understanding the role of fire in land-use change by reconstructing the charcoal and pollen records from cores taken from 12 small bogs and ponds in North Carolina and Virginia. They were analyzed to determine the importance of fire and human disturbance in shaping presettlement and 20th century forests in the southern Appalachians. Prior to European settlement, low charcoal accumulations occurred, indicating low amounts of burning during the past 2000 years. However, charcoal peaks after European settlement suggest the presence of natural fires in forests. Furthermore, high charcoal concentrations occur at the transition between coniferous and deciduous forests of the Holocene and Pleistocene indicating a greater role of fire in these transitional forests.

Socio-Economic Highlights

Our socio-economic group has made significant progress on two fronts. First, an intense mapping and modeling project has digitized select areas from a five state southern Appalachian area. The database contains typical GIS layers such as slope, elevation, aspect, and land cover along with more socio-economic layers such as building density, population distribution, and road systems. These data have been summarized from sets of aerial photos and satellite imagery from both the 1950's and the 1990's. This forty year time period change has then been used as a

baseline, along with other socio-economic factors, to predicting future land use change with predictions of population and building distribution and land cover for the year 2030.

Ted Gragson has also been performing an extensive census and population history of our regionalization study area and has found numerous interesting patterns. Rather than population growth and seasonal migration being strictly recent phenomena (from retiree and vacation home construction), they may be a repetition of a pattern set early in the population history of the Blue Ridge Mountains. A settlement history from 1790 to the present for the 42 counties in northern Georgia, western North Carolina, and southwestern Virginia comprising the cultural Blue Ridge has been developed from archival census records and other information.

Stream Ecology Projects

Research on southern Appalachian streams continues to be a diverse and productive aspect of the Coweeta LTER project involving 7 Co-PIs and at least 15 graduate students. Stream researchers focus on land-water interactions and in-stream processes, and how they are impacted by anthropogenic and other disturbances. Stream research has been integrated into most LTER project areas including gradient, regionalization, and riparian projects. In addition, several stream projects have been inspired by LTER, but are funded from other sources (see listing of Related Research Grants). These include fish diversity and sedimentation in the southern Appalachians (funded by USGS), the Lotic Intersite Nitrogen eXperiment {LINX} (NSF and Fulbright), a litter exclusion experiment (NSF), and a nutrient addition experiment (NSF).

In another series of studies, we examined the role of macrobiota in structuring the benthic communities of two low-order southern Appalachian streams, one draining intact forest (Ball Creek) and one draining pasture (Jones Creek). Fishes and crayfishes were excluded from areas of both streams using an electric exclusion technique; chlorophyll *a*, ash free dry mass (AFDM), and invertebrates were sampled over a 40-day period. In both streams, chlorophyll *a* and AFDM were higher in exclusion than control areas, although these trends were not consistently significant across all sampling dates. In Jones Creek, significantly more large (> 4 mm) aquatic insect larvae were found in exclusion than control areas, most likely due to exclusion treatments providing a refuge from macrobiotic predators. This refuge effect was also evident in Ball Creek, where exclusion treatments contained significantly more filterers. Results indicate that macrobiota influence the structure of southern Appalachian benthic communities by decreasing the amount of organic matter (algal and detrital) available for other consumers and by preferentially preying on certain sizes and taxa of invertebrates. Compared to some low-order tropical streams, however, macrobiotic influences are low. Weaker effects may be attributed to decreased abundance of macrobiota and increased influence of benthic insects in southern Appalachian streams.

Hillslope-Riparian Projects

In the four years following the vegetation cut and hurricane impacts, soil moisture decreased on the vegetation cut hillslope relative to the storm impact hillslope. Groundwater levels did not vary on either hillslope. For all seedlings measured, initial analysis showed little regeneration and high mortality in the control sites. *Acer rubrum* and *Liriodendron tulipifera* seedlings were found prevalent in the treatment removal quadrats while *Liriodendron tulipifera* and *Betula lenta* seedlings dominated the hurricane removal quadrats. Total soil respiration rates were similar in the first year post-treatment, but then gradually increased in years two and three to 30% greater in the cut plot transects compared to the storm plot transects.

Monthly measurements of net N-mineralization along three transects in cut and storm plots showed moderate differences at 1 m, and as much as four times greater mineralization rates at 5 and 15 m above the stream on the storm slope. These differences were most pronounced in spring and early summer.

In the five years following hurricane and *Rhododendron* removal treatments, soilwater nutrient concentrations on the vegetation cut hillslope generally did not vary significantly, although a small increase in NO_3-N was seen in one plot on the vegetation cut slope. In contrast, nutrient concentrations on the storm impact hillslope showed marked changes. NO_3-N concentrations showed consistent increases of at least two orders in magnitude in all lysimeters on the storm impact hillslope. Marked and persistent changes were also seen in SO_4 (decrease), Ca (increase) and Mg (increase) in the soilwater. In groundwater, SO_4 showed no differential response following the vegetation removal and hurricane events. For other nutrients (NO_3-N, Ca and Mg), however, responses in groundwater were similar, although of lesser magnitude, to soilwater. Nutrient concentrations varied seasonally, with major changes occurring in summer and early autumn in both soilwater and groundwater.

Terrestrial Gradient and Canopy Gap Projects

The study of forested ecosystems over a complex environmental gradient was initiated in 1991 and has continued to generate many interesting results as well as several new studies that are currently underway. The gradient has five intensive plots, established from a relatively dry oak ecosystem to a mesic high elevation northern hardwoods ecosystem, as well as 20 extensive plots providing greater spatial coverage of these ecosystems across the Coweeta basin.

Several new studies established on the gradient plots include a 15-year small log (bolt) study established by James Vose and D.A. Crossley. During the course of the study, including nine commonly transplanted species on all sites, periodic biomass sampling along with gas flux measurements are being conducted. Two-year results indicate surprisingly high decomposition at the high elevation northern hardwoods site, the site expected to exhibit the lowest decomposition rates. This same site exhibits unexpectedly high soil nitrogen mineralization. In a second set of studies, the area of the gradient plots is being enlarged from 20 x 40 m to 80 x 80 m in an effort to map and model single and multiple tree gap dynamics. Seed rain, seed bank dynamics, seedling dynamics, and overstory survival and growth have already being quantified. This last component will allow a complete analysis of all life stages of the vegetation across the complex gradient. The larger plots have also been used to map and quantify coarse woody debris on the gradient plots.

Our artificially induced forest gap project is nearing completion of the first phase of work. This replicated study conducted on high and low elevation forest sites has monitored the microclimate, seedling dynamics, physiology, and N mineralization of both rhododendron and non-rhododendron study sites. Results show that the impact of rhododendron was highly detrimental to seedling establishment and growth. Several investigators have now established forest gap plots resulting from hurricane Opal that impacted Coweeta on 05 October 95. This progression to more and widespread plots will allow us to investigate the gap dynamics across a larger geographic area and elevational gradient of the Coweeta Basin.

Data and GIS Management

Our Information Manager, Ron Rouhani, and our GIS Manager, Ned Gardiner, have continued to move our Information and GIS management and organization forward as described below.

During the past year, the Coweeta web page (home page URL address: http://coweeta.ecology.uga.edu) has had numerous additions including GIS maps and online data, species lists, schoolyard descriptions, and metadata. The Coweeta LTER bibliography containing 1202 citations including abstracts is available online. The user may search the citations by using a specific or general query string.

A fully interactive web page of our plant tissue and soil sample archive is available online. Jim Deal, our Analytical Lab Manager, maintains the cataloging and management of this archive which contains 82 sample sets with over 21,000 samples. Where possible, online descriptions of the sample sets have also been linked to the online laboratory analyses that have been conducted on the archived samples. Forms for submitting new samples and obtaining subsamples from the archived sets are online and are coordinated by Jim Deal and a committee of two other scientists at Coweeta, Brian Kloeppel and Jennifer Knoepp.

We have fundamentally redesigned our GIS database in the past year. We followed three steps in migrating from an ad-hoc file storage system to a more usable, durable one. First, we archived all GIS data under a simple data directory map. Second, we normalized the database, eliminating redundant information where possible. Third, we standardized the projection, spheroid, and ellipsoid to be used for the entire set of geospatial data. This important planning phase was supported by funding from the University of Georgia (UGA) Office of the Vice President for Research.

Coweeta LTER Outreach Activities

Our research site has participated in a number of outreach activities during the past year.

First, Coweeta personnel have continued to dedicate part of their time to lead tours for a variety of scientists, resource managers, and students to present and discuss research conducted at Coweeta. This past year we provided tours for over 1300 people with topics ranging from climate network operation, to watershed ecology, to terrestrial gradient research, to the impacts of hurricane Opal in October 1995 on our steep mountain terrain.

Second, our site has again been fortunate to receive Research Experience for Undergraduate (REU) positions. This past year, student research focused on rhododendron and laurel biomass and nitrogen distribution and the impact of land use history on small mammals and herbaceous plants.

Third, Sharon Taylor, LTER Technician, currently serves as the Chairperson of the Executive Board of the Little Tennessee Watershed Association which is a multi-agency and public involvement grass roots organization to promote wise land, riparian, and stream management. Coweeta LTER research publications and data sets have frequently been cited to provide scientific-based strategies for various land, riparian, and stream management practices.

Fourth, the Coweeta LTER program has pursued all NSF Schoolyard LTER initiatives to build upon our long term commitment to K-12 education. This past year we have had five teachers, 6 research staff, and over 50 students involved in Schoolyard LTER projects.

Cross-Site Research Projects

There are several cross-site research projects involving the Coweeta LTER site. The first project is a cross-site study by Liam Heneghan, Dave Coleman, Xiaoming Zou, Dac Crossley, and Bruce Haines at the University of Georgia. They are studying microarthropod regulations of microbial populations involved in leaf litter decomposition in sites in Puerto Rico, Costa Rica, and Coweeta. Cross-site litter decomposition is being compared along with a quantification of the abiotic and biotic agents affecting this decomposition. This study has already produced several publications listed at the end of this annual report.

The second project is NSF funded and concentrates on fine and coarse root growth and dynamics across a series of sites, both LTER and non-LTER, that is coordinated by Ronald Hendrick at the University of Georgia for the Coweeta sampling. The Coweeta site is located on a Terrestrial Gradient project study site and has benefited from the eight years of baseline information already available on the microclimate, soil solution chemistry, throughfall and litter inputs, and large viewing rhizotrons. The minirhizotrons for this study were installed at Coweeta in September 1996 and the first observations were recorded in spring 1997.

Third, the LINX (Lotic Intersite Nitrogen eXperiment) project is a cooperative study among 11 institutions comparing the dynamics of nitrogen in streams at 10 sites ranging from the North Slope of Alaska to Puerto Rico. The central hypothesis of this project is: "the considerable variability among streams in uptake, retention, and cycling of nitrogen is controlled by key hydrologic, chemical, and metabolic characteristics that determine water retention, degree of nitrogen deficiency, and energy flow through food webs in stream ecosystems." We are using simulation modeling, field tracer (N^{15}) additions, and an intersite comparative approach to address this hypothesis. This study is in its second year and in the progress of data collection at the final site.

Fourth, Dave Coleman, Coweeta Co-Lead PI, is a co-author and co-editor on the Standard Soil Methods for Long-Term Ecological Research Volume (in press July 1999), Oxford University Press. Agreement on a common protocol for soil measurements that can be greatly affected by methodology (e.g., soil microbial biomass) is imperative to assist in cross-site synthesis. The present volume addresses those concerns, and draws upon the expertise of over 40 scientists from virtually all of the LTER sites as well as collaborators from federal agencies.

LTER/ILTER Network Activities

We have participated in several LTER and ILTER network activities outside of the regular coordinating committee meetings attended by our site administrators and the annual information management meetings attended by our computer and management staff.

First, Dave Coleman, Coweeta Co-Lead PI, is chairman of the LTER Publications Committee that is advising on all LTER publications, including the LTER synthesis volumes series, to be published by Oxford University Press.

Second, Brian Kloeppel participated in the September 1998 Poland ILTER trip with Jim Gosz. Brian has been awarded a grant for cross-site research in Poland and will be making research excursions to Poland in 2000 and 2001.

Third, Wayne Swank participated in a scientific exchange in 2000 for a cooperative analysis of hydrologic processes on forested watersheds at Coweeta and Turkey.

Publications of the Coweeta LTER Project (1999 - present)

Please link below to the searchable Coweeta LTER Online Bibliography to locate citations and abstracts of publications. As of 11 August 2000, we have 57 publications from 1999 to 2000.

http://coweeta.ecology.uga.edu/webdocs/html/ronbibform.html

Coweeta LTER Related Research Grants (1999 to present)
Excludes 1996-2002 CWT LTER grant from NSF (DEB 96-32854) for $6,030,489
(25 total for $8,097,603 representing 5 funding agencies)

Bolstad, P.V., P.B. Reich, and J.M. Vose. Acclimation/adaptation of leaf respiration in eastern deciduous forests: a biome-wide study. Funded by National Science Foundation - Ecological Studies / Ecosystems for $375,000 from 1999 to 2001.

Coleman, D.C., B.D. Kloeppel, M.D. Hunter, and C.M. Pringle. Equipment and cross-site supplement proposal to the Coweeta LTER program grant number DEB-96-32854. Funded by National Science Foundation for $35,000 from 1999 to 2000.

Geron, C., W.T. Swank, and J.M Vose. Water, soil, and air quality impacts of riparian ecosystem restoration. Funded by Environmental Protection Agency for $150,000 from 1997 through 1999.

Hendrick, R.L., K. Pregitzer, M. Allen and R. Ruess. Factors regulating below ground carbon allocation in terrestrial ecosystems: a cross-site experiment. Funded by National Science Foundation for $1,050,000 from 1997 to 2000.

Hunter, M.D. Top-down and bottom-up effects on herbivores: nutrient availability and the trophic interactions of insects on oak. Funded by National Science Foundation for $70,000 from 1999 to 2001.

Hunter, M.D., M.D. Lowman, and T.D. Schowalter. Canopy herbivory and soil processes in a temperate and tropical forest. Funded by National Science Foundation for $300,000 from 1999 to 2002.

Kloeppel, B.D. and D.C. Coleman. Communications LTER supplement to the LTER program at Coweeta Hydrologic Laboratory (DEB-96-32854). Funded by National Science Foundation for $290,000 from 1999 to 2000.

Kloeppel, B.D. and D.C. Coleman. Carbon and water dynamics in mature and old growth forests in Poland and the United States: supplement to Coweeta LTER grant DEB-96-32854. Funded by National Science Foundation for $14,667 from 1999 to 2002.

Kloeppel, B.D. and D.C. Coleman. Dormitory Renovation and Expansion at Coweeta Hydrologic Laboratory. Funded by National Science Foundation - Field Station and Marine Laboratories for $198,000 from 1999 to 2000.

Kloeppel, B.D., D.C. Coleman, and J.M. Vose. Analytical Laboratory Equipment at Coweeta Hydrologic Laboratory. National Science Foundation - Field Station and Marine Laboratories for $60,063 from 2000 to 2001.

Kloeppel, B.D. and D.C. Coleman. REU Supplement to LTER program at Coweeta Hydrologic Laboratory (DEB-96-32854). Funded by National Science Foundation for $10,000 from 1998 to 1999.

Kloeppel, B.D. and D.C. Coleman. REU Supplement to LTER program at Coweeta Hydrologic Laboratory (DEB-96-32854). Funded by National Science Foundation for $10,000 from 1999 to 2000.

Kloeppel, B.D. and D.C. Coleman. Schoolyard Supplement to LTER program at Coweeta Hydrologic Laboratory (DEB-96-32854). Funded by National Science Foundation for $15,000 from 1998 to 1999.

Kloeppel, B.D. and D.C. Coleman. Schoolyard Supplement to LTER program at Coweeta Hydrologic Laboratory (DEB-96-32854). Funded by National Science Foundation for $15,000 from 1999 to 2000.

Nilsen, E.T., O.K. Miller, and B.D. Clinton. Probing the mechanisms by which subcanopy evergreen shrubs inhibit tree seedling recruitment. Funded by USDA-NRI-CSRS for $485,000 from September 1999 to August 2003.

Rosemond, A.D., J.B. Wallace, K. Suberkropp, and P.J. Mulholland. Nutrient effects on a detritus-based ecosystem. Funded by National Science Foundation for $700,000 from January 1999 to December 2002.

Swank, W.T. and J.M. Vose. Estimating effectiveness of groundwater removal in fast-growing cottonwoods planted for phytoremediation of trichloroethylene. Funded by US Department of Defense, Wright-Patterson Air Force Base for $191,000 from 1991-2001.

Valett, H.M., J.R. Webster, P.J. Mulholland, C.N. Dahm, P.V. Unnikrishna, and C.G. Peterson. Nitrate retention in headwater stream: influences of riparian vegetation, metabolism, and subsurface properties. Funded by National Science Foundation for $1,120,000 from April 1999 to March 2002.

Vose, J.M. Distinguishing groundwater vs. surface water uptake in phreatophytes. Funded by US Department of Defense, Wright-Patterson Air Force Base for $75,000 from 2000-2001.

Vose, J.M. and C.D. Geron. Assessing nitrogen cycling mechanisms to evaluate riparian zone restoration effectiveness. Funded by US-EPA Ecosystem Restoration Competitive Grants Program for $486,000 from 2000-2003.

Vose, J.M., C.D. Geron, and W.T. Swank. Water, soil, and air quality impacts of riparian ecosystem restoration. Funded by US-EPA Risk Management for Ecosystem Restoration Competitive Grants Program for $323, 873 from 1997-2000.

Vose, J.M. and W.T. Swank. Phytoremediation of contaminated soil and groundwater: Estimating transpiration in poplar seedlings. Funded by Department of Defense for $134,000 from 1997 through 1999.

Vose, J.M. and W.T. Swank. Determining sensitivity of Class I Wilderness Areas to acidic deposition: case studies of the Joyce Kilmer and Slickrock Wilderness Areas. Funded by National Forest Systems for $90,000 from 1999-2001.

Wallace, J.B., J.L. Meyer, and J.R. Webster. Stream ecosystem response to decoupling terrestrial-aquatic linkages. Funded by National Science Foundation for $800,000 from 1 September 1996 through 31 August 2000.

Webster, J.R., P.J. Mulholland, J.L. Meyer, and B.J. Peterson. Nitrogen uptake, retention and cycling in stream ecosystems: an intersite N^{15} tracer experiment. Funded by National Science Foundation for $1,100,000 from 1 September 1996 through 31 August 1999. One post-doc funded by a Fulbright Scholarship.