Coweeta LTER Program 1997 Annual Report

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Long-term Studies of Disturbances as they Affect Ecological Processes in Landscapes of the Southern Appalachians

PRINCIPAL INVESTIGATORS

David C. Coleman
Institute of Ecology
University of Georgia
Athens, GA

James M. Vose
Coweeta Hydrologic Laboratory
USDA Forest Service
Otto, NC

CO-PRINCIPAL INVESTIGATORS

University of Georgia - Athens, GA
David C. Coleman, Institute of Ecology
D.A. Crossley, Jr., Institute of Ecology
John W. Fitzgerald, Department of Micro-biology
Theodore L. Gragson, Department of Anthropology
Gary D. Grossman, School of Forest Resources
Bruce L. Haines, Department of Botany
Gene S. Helfman, Institute of Ecology
Ronald L. Hendrick, Jr., School of Forest Resources
Mark D. Hunter, Institute of Ecology
Brian D. Kloeppel, Institute of Ecology (Coweeta LTER Site Manager)
Joshua Laerm, Institute of Ecology
Judy L. Meyer, Institute of Ecology
David H. Newman, School of Forest Resources
Catherine M. Pringle, Institute of Ecology
J. Bruce Wallace, Institute of Ecology
USDA Forest Service, Coweeta Hydrologic Laboratory - Otto, NC
Barton D. Clinton
Katherine J. Elliott
Jennifer D. Knoepp
Wayne T. Swank
Lloyd W. Swift, Jr.
James M. Vose

Virginia Polytechnic and State University - Blacksburg, VA
E. Fred Benfield, Department of Biology
Jackson R. Webster, Department of Biology
Duke University - Durham, NC
James S. Clark, Department of Botany
University of Minnesota - St. Paul, MN
Paul V. Bolstad, School of Forestry
USDA Forest Service - Research Triangle Park, NC
Steven G. McNulty
David N. Wear
Mars Hill College - Mars Hill, NC
Scott L. Pearson, Department of Biological Sciences, with sub-contract to
Monica G. Turner, University of Wisconsin-Madison, Department of Zoology
Portland State University - Portland, OR
J. Alan Yeakley, School of Environmental Studies

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Introduction
LTER research at Coweeta 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 have added a large scale (56,000 km^2) approach to our research to better understand the regional interactions of our ecosystems.

This report contains a brief update of these major research projects and the direction in which they are heading along with updates on data management. In addition, as was described in the annual report format distributed by Scott Collins at NSF, we also include information on cross-site and network activities in one to two additional pages. We conclude with listings of site publications and research grants related to our LTER project.

Research Accomplishments

Land-Use Change Project Our land-use change project, initiated with augmentation funding three years ago, has been a steady source of excitement for our site. Both a mid-year meeting of land-use change Co-PIs at Coweeta in February 1997 and our Annual Meeting for all personnel in Athens, GA in June 1997 displayed the large amount of research underway along with several products (publications and map products) from our work. One of the more striking maps showed that the largest movement of land between cover classes (agricultural, forested, and open/cleared) in Macon County, NC from the 1950Æs to the 1990Æs was from agricultural back to forested (see attached map).

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 1950Æs and the 1990Æs. 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 distribution and land cover for the year 2030.

In addition to quantifying the land-use change and population demographics of the region, Theodore Gragson (Co-PI and Anthropologist at the University of Georgia), has been brought on board to study and understand the motivations for and values of peopleÆs land use for populations of both people native to the Southern Appalachians as well as those that constitute the large influx of new permanent as well as seasonal residents of the Southern Appalachians. We are excited about TedÆs work and he has also been awarded with funding for an REU student for the summer of 1997, his first field data collection season. Gregory Arthaud, former Co-PI with the socio-economic group, has left the University of Georgia to take an academic position at Yale University.

Terrestrial Ecology Highlights The terrestrial ecology research group has made progress on two main activities. First, Paul Bolstad, Co-PI and GIS Expert, has worked closely with all groups in the Land-Use Change project to distribute the wealth of digitized mapping and land cover products which his lab has produced for the project. 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. Two years of intense data collection 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 model.

In addition to the carbon-cycling work, an effort by both Scott Pearson and Monica Turner has focused on the diversity of species, both plant and bird populations, across the landscape. The impact of fragmentation on species diversity was quantified in the field as well as with a simulation model that incorporates both the landscape pattern and the life history of the organism. Model results suggested that species able to tolerate a high degree of habitat fragmentation had the highest survivorship probabilities.

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 two field seasons and have yielded some interesting preliminary results. As more detailed data of the land cover history of the area upstream of sample points has become available, additional analysis of the current stream conditions have been possible. Results show that though significant difference exist in the species assemblages between primarily

forested and agricultural landscapes drainages, the history of the landscape may account for much of the differences between sites within each type of drainage. For example, findings suggest that forest regeneration within a catchment may alleviate some detrimental physical effects of long-term agriculture, however recovery of the fauna to its pre-disturbance structure may take decades.

Stream Ecology Projects Our Coweeta Basin stream ecology research is highlighted by two major publications this year. The first is a publication in *Science* by Wallace et al. 1997 regarding a litter exclusion project. The leaf litter was excluded from the first 200 m of a headwater stream which led to a reduction in standing stock of benthic organic matter, a shift in the resource base of the food web, less secondary production of benthic invertebrates, and increased periphyton biomass. The periphyton increase was probably a result of decreased nutrient competition with heterotrophic microbes (to be tested in experiments during summer 1997) and less shading by leaf litter on the stream bottom.

The second major publication this year is in Ecological Monographs by Grossman et al. (in press). They examined a variety of assemblage-level characteristics in Coweeta Creek between 1984-1992. This period encompassed both a major drought (1985-1988) as well as three years with extremely high flows (1989, 1990, 1992). Species richness (total = 16) was significantly higher in drought periods. Assemblage structure samples clustered on the basis of hydrologic period rather than season or year. Variations in the abundance of potential competitors or predators did not produce strong shifts in microhabitat use by assemblage member. In conclusion, results indicate that variability in flow had a much stronger effect on the structure, stability and use of spatial resources than either interspecific competition for space or predation.

Riparian Project Our research in the riparian zones is investigating the role of riparian zones as regulators of terrestrial-aquatic linkages. All variables in the rhododendron removal project have had two years of post-treatment measurement since removal of the rhododendron understory in August 1995. In October 1995 Hurricane Opal destroyed the overstory of one of our monitoring slopes. Though our initial reaction was of frustration, project scientists were soon relieved to know that areas upslope from both the treatment and hurricane impacted slope were intact and functioning as control locations. Soil lysimeter, microclimate, decomposition, sulfur dynamics, and other variable collections were continued and provided a rare situation of both a hurricane and treatment comparison complete with two years of pre-disturbance data. In reaction to the disturbances, biomass felled by hurricane Opal is scheduled to be quantified and seedling monitoring studies were initiated in April 1997. Initial results suggest that the uprooting of vegetation by hurricane Opal in comparison to the chain saw removal of the rhododendron understory resulted in differing seed bed conditions favoring tulip poplar (*Liriodendron tulipifera*) seedlings in the rhododendron removal and sweet birch (*Betula lenta*) in the hurricane impacted site.

Gradient Project The study of forested ecosystems over a complex environmental gradient which was initiated in 1991 has continued to generate many interesting resulting as well as several new studies which are currently underway. The gradient has five plots established from a relatively dry oak ecosystem to a mesic high elevation northern hardwoods ecosystem. Strong seasonal trends in mineralization and nitrification were observed: highest rates occur in spring and summer with

negligible activity in winter. Mineralization rates are lowest in the oak-pine and mixed oak sites averaging less than 1.5 mg N^{-1} kg $soil^{-1}$ 28 $days^{-1}$. The northern hardwood site rates were greatest with an annual average N mineralization rate of 19 mg N^{-1} kg $soil^{-1}$ 28 $days^{-1}$. Nitrification rates are typically low with rates of 0.5 mg N^{-1} kg $soil^{-1}$ 28 $days^{-1}$, or less. The exception is the northern hardwood site where nitrification averages 9.5 mg N^{-1} kg $soil^{-1}$ 28 $days^{-1}$. These data show that most forest types in the southern Appalachians have an NH_4 based nitrogen economy. However, in the northern hardwood forest type, NO_3 plays an important role in the nitrogen cycle.

Several new studies established on the gradient 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 will be measured in the winter of 1997-98 when impact to the sites will be minimal. In a second study, the area of the gradient plots is being enlarged from 20 x 40 m to 100 x 100 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.

Forest Gap Project 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 which 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.

In addition, a study by Barton Clinton and Erik Nilsen is looking at the mechanisms for rhododendron impact besides shade. Preliminary results show that the effect of litter decomposition and mychorhizal associations favor rhododendron rather than hardwood tree seedlings. An array of seedlings have been established in rhododendron thickets and physiological measurements are being conducted in the summer of 1997. Results will be available at the end of this year along with mychorrizal density and species distributions.

Data Management

Hightlights During the past year we have entered into an agreement with the University of Georgia School of Forest Resources, Department of Geography, and Information Office to cooperatively operate and maintain our Geographic Information System (GIS). This agreement has helped to provide our students with five rather than two GIS work stations and has also significantly reduced the financial overhead and software agreements that our LTER project was solely responsible for in the past. This arrangement should enable us to more easily and cost effectively keep our hardware and software up to date.

In an effort to more easily keep our online data sets up to date, our Data Manager, Gildo Calabria, has developed a series of online automatic QAQC protocols and "on the fly" SAS code generating programs which enables our technicians to upload, plot, review, and append (if data pass the QAQC procedures) regularly collected data sets within 24 hours of collection from the field. This has been especially helpful for large regularly-collected data sets such as microclimate and thermocouple array stations which generate a tremendous amount of similarly-formatted data.

For all scientists and students working in the field at Coweeta, data lines have been extended to the Coweeta Dorm enabling users to download and transfer data files back to their home institutions, access online reservation systems for housing and vehicles, view online museum archives for sample identification and cataloging, and general communication to other project personnel via email. This has allowed more efficient communication and has also reduced the costs associated with telephone and modem usage since the dataline costs are for a flat fee, regardless of usage.

New Data Sets Online The following list indicates the continuing as well as highlights new data sets online. These are in addition to 64 other archived data sets that have been previously online.

Forest Gap Project: a) microclimate, b) dendrometer bands

Forest Gradient Project: a) microclimate, b) N transformation, c) litterfall, d) dendrometer bands, e) soil moisture

Riparian Project: a) microclimate, b) dissolved organic carbon, c) soil moisture, d) litter decomposition, e) microbial biomass

Stream Organic Matter Budgets

Stream Studies: a) geomorphology, b) dissolved organic carbon, c) fish collections, d) fish habitat availability, e) leaf decomposition, f) benthic organic matter

Tree Stem Temperature Network (from four watersheds)

Annual Meeting Summary
Our Coweeta LTER Annual Meeting was held on 16-17 June 97 at the State of Georgia Botanical Gardens in Athens, GA. All personnel (Co-PIs, graduate students, and staff) participated and combined to present 30 oral papers and 16 posters. Abstracts from all presentations were compiled and distributed to meeting participants to promote further interaction and familiarity between this large group of scientists and staff. In addition, abstracts were placed online as a more permanent record for those on our project as well as for others to access at our Coweeta LTER web site (http://sparc.ecology.uga.edu).

We also invited our four external scientific advisors (see list below) to attend our annual meeting. Two of four (Thomas Heberlein and Pat Mulholland) were able to attend and provided us with some excellent feedback and suggestions in our concluding session. Boyd Strain agreed to attend our Contributed Paper session to be held at the Ecological Society of America Annual Meeting in Albuquerque, NM in

August 1997. Schedules did not allow Keith Van Cleve to attend either event, but he reviewed the abstracts and will join us for future gatherings.

External Scientific Advisors (with affiliations and area of expertise):

Thomas Heberlein - University of Wisconsin-Madison and NTL LTER site (Socio-economic)

Pat Mulholland - Oak Ridge National Lab (Streams)

Boyd Strain - Duke University (Plant Physiological Ecology)

Keith Van Cleve - retired (Forest Soils, Nutrient Cycling)

Outreach Activities
Our research site has participated in a number of outreach activities during the past year. First, we have organized a contributed paper session at the Annual Ecological Society of America (ESA) Meeting to be held in Albuquerque, NM on 10-14 August 97. This session, titled "Quantifying the Impact of Past, Present, and Future Human and Natural Disturbance on Changing Terrestrial and Aquatic Ecosystems of the Southern Appalachians" will highlight thirteen presentations from our site dealing with a range of topics around site disturbance ranging from the impact of human values on land use to nutrient dynamics resulting from site disturbance (see attached listing of presentations from the ESA Program Guide).

Second, our site has again been fortunate to have received three Research Experience for Undergraduate (REU) stipends. This past year, one student reported his findings at the ESA Annual Meeting and the other two students presented findings at the Annual Southern Appalachian Man and the Biosphere Conference. Research by our current three students focuses on small mammal distribution, high elevation nitrogen mineralization, and a social study on the shifts in the beliefs and values of southern Appalachian residents as related to shifts in land use.

Third, site personnel have continued to dedicate part of their time to lead tours for a variety of scientists, professionals, 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 the impacts of hurricane Opal on our steep mountain terrain.

** In addition to the five pages dedicated for the topics above, the report format distributed by Scott Collins at NSF suggested one to two additional pages for the following items.**

Cross-Site Research Projects
There are several cross-site research projects involving the Coweeta LTER site. The first is a cross-site ant ecology project headed by Michael Kaspari at the University of Oklahoma who is being assisted by a post-doctoral scientist, Leeanne Alonso. The project, titled "Climatic Regulation of Ant Assemblages in North and Central America" is being conducted at seven sites, three of which (Coweeta, Andrews, and Sevilleta) are LTER sites. A series of manipulations with temperature tiles at various elevations is being conducted along with line transect sampling to determine ant diversity and

abundance. These transects have been co-located with long-term monthly soil moisture transects in four watersheds at Coweeta. These soil moisture readings have formed an excellent backbone on which to sample ant diversity and abundance and should yield some very interesting results. Field work is currently underway on this project and initial results should become available in six to twelve months.

The second 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 in our In Press and Submitted publication sections at the end of this annual report.

The third project is NSF funded and concentrates on fine and coarse root growth and dynamics across a series of sites, both LTER and non-LTER, which is coordinated by Ronald Hendrick at the University of Georgia for the Coweeta sampling. Ron is a new Co-PI at our site and has been brought on board to further develop the understanding of belowground processes in our terrestrial ecosystems. One of the sampling sites for this cross-site study is located on a Gradient project study site and has benefited from the six 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.

The fourth project is one which was initiated by a cross-site travel grant to two of our graduate students, Bryan Dail (advisor John Fitzgerald) and Christina Wright (advisor Dave Coleman). Bryan and ChrisÆ research at Coweeta studying sulfur dynamics and litter decomposition and root growth led to this project comparing decomposition rates at three LTER sites: Coweeta, Harvard Forest, and Hubbard Brook. Field work is complete on this project and publications are being prepared. Two papers by Bryan Dail and his advisor are listed in our Submitted Publications section.

Network Level Activities

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

Brian Kloeppel, Coweeta LTER Site Manager and Co-PI, attended the International LTER trip to Tsukuba, Japan in March 1997 to participate in the Second East Asia - Pacific Regional International LTER Conference. This conference, attended by representatives from seven LTER sites, was an opportunity to display the network system that our NSF funded LTER sites use as a model to promote further cooperation within and between sites in East Asia and rest of the world. Brian presented a poster on research projects currently underway at Coweeta and also participated in site visits to two potential LTER sites in southern Japan following the conference.

Dave Coleman, Coweeta Lead PI, was elected chairman of the LTER Publications Committee which is advising on all LTER publications, including the LTER synthesis volumes series, to be published by Oxford University Press. Dave brings much

experience to this position from previous book and synthesis publication projects including his recently published book with D.A. Crossley, Jr., Fundamentals of Soil Ecology, 1996, Academic Press, 205 pages.

Two of our stream Co-PIs, Jack Webster and Judy Meyer, have both been important players in our site since the inception of the LTER project at Coweeta 19 years ago. Recently, they have undertaken a large project along with Pat Mulholland and Bruce Peterson to study the nitrogen dynamics of streams across an array of LTER sites along with several key streams outside of the LTER network. This valuable project is yet another effort by this group and all of our stream Co-PIs who have continued to focus on research not only at Coweeta, but also across the LTER Network of sites for both comparison and synthesis of results. The citation of their research grant is located below as well as at the end of this report along with other Coweeta LTER related grants.

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