Award 0823293 - Annual Project Report

Cover

Federal Agency and Organization Element to Which Report is Submitted:	4900
Federal Grant or Other Identifying Number Assigned by Agency:	0823293
Project Title:	Southern Appalachia on the Edge - Exurbanization & Climate Interaction in the Southeast
PD/PI Name:	Theodore L Gragson, Principal Investigator
Submitting Official (if other than PD\PI):	Theodore L Gragson Principal Investigator
Submission Date:	09/17/2013
Recipient Organization:	University of Georgia Research Foundation Inc
Project/Grant Period:	11/01/2008 - 10/31/2014
Reporting Period:	11/01/2012 - 10/31/2013
Signature of Submitting Official (signature shall be submitted in accordance with agency specific instructions)	Theodore L Gragson

Accomplishments

* What are the major goals of the project?

The Coweeta LTER addresses how key ecosystem processes and the focal ecosystem services of water quantity, water quality, and biodiversity in southern Appalachia will be impacted by the transition in land uses from wildland to peri-urban, changes in climate, and the interaction between changes in land use and climate. Research activities are organized into five thematic areas and take place along gradients designed to achieve a regional understanding of the socio-ecological process entailed by our guiding question. The five thematic areas are: 1) Parcel-level to regional decision making; 2) Longitudinal variation in hillslope, riparian, and stream ecology; 3) Impacts of climate and land Use change on biodiversity; 4) Baseline data and temporal reconstruction; and, 5) Synthesis & scaled integration.

* What was accomplished under these goals (you must provide information for at least one of the 4 categories below)?

Major Activities:

1. Parcel-Level to Regional Decision-Making
Development and testing continued on the Stream Visual Assessment Protocol (SVAP) for the Southern Appalachians (saSVAP) so that it can provide a 'snapshot assessment' of wadable streams of the Blue Ridge eco-region. The saSVAP was field-test this summer at 40 headwater streams, the majority of which overlap with previous synoptic sampling sites and intensive hill slope sites. Several studies are in the final stages of write-up: the impact of water contamination on vacant land sales; how economic incentives influence the decision to conserve land; county-wide survey of non-market values; perception of values and management of stream-side private property.

2. Longitudinal Variation in Hillslope, Riparian, and Stream Ecology
Activities centered on compiling, summarizing, and writing up results from bi-weekly water samples drawn from shallow wells, lysimeters and rainfall collectors at each

of four hillslope sites to understand hillslope water balances and how they vary among sites characterized by different land uses. Some publications in process include: an analysis of channel and habitat data from geomorphic surveys of riparian conditions along 49 synoptic stream sites; using the water level, rating curve, suspended sediment, and specific conductivity data from the 12 intensively monitored watersheds to develop sediment yields per watershed and characterize hysteretic behavior of the sediment concentrations.

3. Impacts of Climate and Land Use Change on Biodiversity
Work continued on measuring forest ecosystem structure, particularly height, biomass, productivity, and leaf area along environmental gradients, and estimating the impact of changes in climate on these structural attributes and the hydrologic cycle in southern Appalachian forests. Work continued on the distribution and activity of soil nitrifier communities with basic implications for hill-slope nitrogen cycling and understanding how changes in land-use influence water quality. Work continued on sampling our long-term biotic monitoring and experimental plots within the Coweeta basin, Great Smoky Mtns Nat. Park, Duke Forest and Mars Hill. Long-term monitoring continued on salamanders at a subset of synoptic and intensive hillslope sites along an elevation gradient within the Coweeta basin. Some publications currently under way include: how differences in temperature and current or past land use affect forest birds; and statistical modeling to understand the regional and local controls on the spread of M. vimineum and the compound effects of land use on biogeochemical cycling.

4. Baseline Data and Temporal Reconstruction
Long-term data collection projects continued including: vegetation dynamics (30+ yrs), aboveground biomass and nutrient accumulation in Watershed 7; dendrochronologic sampling for disturbance history and climate-growth interactions across southern Appalachia; weekly sampling of hillslope plots; quarterly collection of storm samples; bi-annual tree census of terrestrial gradient plots.

5. Synthesis and Scaled Integration
Activities concentrated on sampling a hillslope transect to supplement core hillslope hydrologic measurements with denser soil moisture sampling; remote sensing analysis of forest canopy hillslope gradients over the last three decades, during the period of climate warming; remote sensing of forest canopy phenology patterns and relations to temperature, photoperiod and water stress patterns; and simulation of forest canopy adjustment to hydroclimate over the past thirty years. There was also development and extension of RHESSys models for scaling to larger extents and facilitating its use to a larger community.

Supplemental funds were received in support of the following six activities:
Coweeta Schoolyard LTER - Funds ($24,000) were received to purchase materials and supplies for events, restocking cience Boxes, the Porters Creek Restoration project, and collaboration with Muddy Sneakers environmental educators. The Schoolyard program expanded to 8th graders through a "Kids in the Creek" field day that corresponds to the NC standard course of study on the hydrosphere. Students finalized a riparian corridor restoration project on school property. The Science Study Box program was extended to make material available to teachers in 14 counties in northeastern Georgia.

REU Request - Funds ($16,000) were received to support two REU students during AY13. Sara de la Torre Beron worked with Dr. Gragson on an ILTER collaboration examining land transformation of mountain landscapes. Alexander Terry worked

with Dr. Maerz to evaluate historic hydroclimate effects on salamander and bird abundance.

Release Request - Funds ($120,000) were received representing 10% of the base funding withheld for budgetary reasons from the Coweeta LTER renewal award as initially issued. These funds were used in partial support of full-time field and laboratory technical personnel, graduate students, operational materials and supplies, and institutional indirect costs.

RAHSS - Funds ($5,500) were received to support one high school student at Coweeta Hydrologic Laboratory during the summer of 2013. Daniel Reategui worked side-by-side with CWT LTER researchers and conducted a summer research project comparing fish bio-monitoring results to Southern Appalachian Stream Visual Assessment Protocol (saSVAP) scores at sites annually monitored by the Little Tennessee Land Trust in the upper Little Tennessee River Basin.

Ethnographic Methodology - Funds ($20,816) were received from SBE to facilitate communication and interaction between scientific CWT LTER researchers and community members. The "Translational Dialogue" methodology served as the foundation for establishing the Coweeta Listening Project (described in more detail below).

IM - Funds ($119,500) provided partial support to adapt the CWT LTER IMS for use with PASTA. A “dark data caseworker” was hired in January 2013 to evaluate Metacat legacy entries and other sources, and identified 354 potential packages. Existing data must be reprocessed to operationalize the machine-driven PASTA protocol and ensure metadata accurately describes data (i.e., congruency). We use the GCE MatLab Toolbox and the CWT Metabase to do this. Our workflow consists of: pulling data into Toolbox and checking its structural integrity; writing the metadata into Toolbox and revising to meet the LTER EB "standards for discovery-level metadata"; generating a congruent data + metadata package; and using Metabase to generate an EML 2.1 compliant file. The package then goes to the LNO Staging Portal for validation and final irrevocable submission to PASTA.

We have processed one data package through final submission into PASTA as proof of concept. Once a data package is through our workflow, it takes approximately 2 hours for final submission to PASTA. Of the 354 potential data packages identified, 76 have been fully processed, 94 are at various stages in the workflow, and the recovery cost of the balance must be further evaluated (these are simultaneous activities). We expect data package upload to PASTA will start the end of the third quarter and rapidly accelerate in the fourth quarter so that approximately 75% of data holdings will be in PASTA by early 2014.

We are also using the GCE Data Toolbox to shift all CWT field sensor data to automated data workflows. An NSF Field Station and Marine Lab (NSF1226983) grant allowed us to retrofit fourteen existing long-term sensors for data streaming, and double the network by next summer. Our results indicate we can dramatically reduce the cost of data post-processing and publication, and vastly improve the quality of annual updates into PASTA. We also engaged in a collaborative software and instructional documentation project with the GCE LTER to improve the usability of the GCE Data Toolbox and disseminated the work in a Network-wide workshop supported by the LNO.

Specific Objectives: Ecosystem patterns were assessed relative to the co-evolution of topographic,

ecosystem and hydrologic subsystems, hydrologic downslope subsidy of ecosystems (ridge to stream), and landscape scale optimization. Hillslope hydrologic measurements were coupled with denser soil moisture sampling over our instrumented hillslopes, then space/time soil moisture patterns analyzed and their statistical association with groundwater determined with an emphasis on streamflow. Significant effort went in to remote sensing analysis of forest canopy hillslope gradients, forest canopy phenology patterns and their relation to temperature, photoperiod and water stress patterns. The objective is to understand differences in water balance among sites relative to land use and hydrologically-relevant landscape variables, and assess the implications these patterns have for current and future water resource availability in the region. We also sought to understand if precipitation patterns respond to changing land cover and how the urban land cover - hydroclimate relationship impacts flooding and land slide activity. We are building a topographically-corrected precipitation surface database at 1 km spatial resolution for Southern Appalachia with the objective of identifying the spatiotemporal distribution of extreme precipitation events for the period 1980-2011. This will be paired with a multivariate index describing exposure of populations and infrastructure to extreme precipitation.

Biodiversity-centered research focused on evaluating the effects of land-use and climate change on biodiversity, and determining the broad-scale impacts of changes in biodiversity on ecosystem function. Some of this research examined exotic invasive species such as Microstegium vimineum (Japanese stiltgrass) and Adelges tsugae (hemlock woolly adelgid). Collection of field data and statistical modeling is beginning to help us understand the regional and local controls on the spread of M. vimineum and the compound effects of M. vimineum invasion and land use on biogeochemical cycling. Work on terrestrial salamander population dynamics along an elevation gradient within the Coweeta basin focused on several major questions including: (1) how does climate and weather regulate the performance of terrestrial salamanders, (2) what is the effect of climate on population dynamics of terrestrial salamanders, (3) how do climate and land use interact to affect dispersal and population fragmentation, (4) how does climate regulate interactions between terrestrial salamander species, and (5) what are the effects of terrestrial salamanders on forest ecosystem processes and plant diversity. The long-term goal is to incorporate evolutionary processes into population models to forecast species responses to climate change. Using the results of an ongoing salamander removal study we are looking at responses in plant distribution and abundance. A pilot study was initiated to determine whether historic hydrocliamte differences in the region correlated with geographic variation in the composition and abundance of birds and salamanders. Using a PRISM model, sites were identified that differ in precipitation levels over the past 30 years, and these served for estimating the population on those sites to see if abundance correlates with hydroclimate.

In other research we examined the influence of different soil chemical parameters (as influenced by land use) on the diversity and relative abundance of bacterial and archeal ammonia oxidizers in forested watersheds. Our decomposition and macroinvertebrate studies are advancing understanding of the impact of the changing land use along the hill slope on the structure and function of the associated streams. Land use in southern Appalachia has transitioned from "exurbanization" to "suburbanization" making it particularly relevant to understand the consequences of peri-urban development and climate change. For example, how do peri-urban development and climate change influence the success and impacts of invasive species; how do they influence keystone seed-dispersing ants, which play an essential role in maintaining the floristic diversity of the forested

system; and do they influence organic matter decomposition rates. By comparing the effects of land use on avian communities by quantifying the effects of land management on avian extinction and colonization. We are also able to relate differences in avian community composition and nest predation to nest predator community differences across forests, suspended developments, and residential sites, as well as species-specific responses to the structural and human components of development.

Using synoptic geomorphic surveys we are evaluating the effect of local riparian vegetation condition on a full suite of related geomorphic and physical habitat characteristics of stream reaches. We recorded local riparian conditions at 49 stream sites to evaluate the effect of local riparian vegetation condition on a full suite of related geomorphic and physical habitat characteristics of stream reaches. Due to reduced wood inputs and the resulting reduction in channel roughness, we hypothesized that stream segments with little riparian forest would feature reduced active channel widths, reduced channel width variability, reduced wood frequency, and less diverse and simpler habitat. Due to reduced filtration of overland flow from adjacent lands, we hypothesized that stream segments with little riparian forest would feature reduced median particle sizes and increased fine sediment percentages. Through an investigation of water temperatures in southern Appalachian stream reaches we assessed whether it varied systematically according to hyporheic exchange theory. The small observed differences in stream temperatures indicate that hyporheic exchange is not a dominant driver of mesoscale habitat temperatures in this basin, and temperature differences between habitat units were so small they were unlikely to have ecological significance.

Finally, we sought to understand how interdisciplinary groups such as the CWT LTER function to produce scientific knowledge and how that knowledge is communicated and contributed to the larger community. Through Translational Dialogues we brought the scientific and public communities into dialogue to co-produce knowledge. Through other Coweeta Listening Project activities we are making the CWT LTER more visible in the community, and by listening to the community in a co-production of knowledge process, we are able to translate scientific knowledge into forms that are readily understandable by local groups. It also makes it possible to serve as a trusted source of information regarding polemical issues such as climate change and regulating steep slope development.

Significant Results:

Roads facilitate invasive species through a dual mechanism: they provide favorable habitat conditions for invasive plant growth and reproduction, and they promote the spread of invasive plants by promoting dispersal up to 25-times further than for populations away from roads (Warren et al. 2013). Peri-urban development alters the distance and direction that seed-dispersing ants disperse seeds through habitat alteration and not necessarily through promotion of invasive ants, as previously presumed. Ants also transition from being sub-dominant soil macrofauna in the mountains to dominant soil macrofauna in the piedmont, representing a transition in the region that reflects the broader-scale transition from temperate into tropical regions. Notably, keystone seed-dispersing ants did not reflect this patterning, and they decreased in abundance from the mountains to the piedmont, perhaps explaining why understory herbs that rely on ants for dispersal are in decline in many parts of the piedmont. The most surprising ecological finding from this work challenges the idea that the ant-plant seed-dispersal mutualism is actually a mutualism. Instead, our data suggest that the relationship is a commensalism not a mutualism (Warren and Chick 2013). Our results indicate that climate is not the predominant regional scale control on wood decay rates, rather it is fungi which

challenges how we currently model organic matter decay (Keiser et al. 2013).

Many of the large effects of drought actually occur on moist sites while competition for light has the strongest effects on moist sites and in dry years. Individuals under the greatest competitive stress respond least to changes in temperature and drought. Integration with FIA data allow projection of our results to the eastern US and lead us to predict that warming will have the greatest impact on biodiversity in the Upper Midwest and Northeast while aridity will have its greatest impact in the Upper Midwest. We do not find evidence that trees are migrating fast enough to track current rates of warming. Overall turnover in forests (recruitment, growth, mortality) is more consistent with regional climate differences, being fastest in warm climates (Zhu et al. 2012).

We found that M. vimineum response to local abiotic environmental variables was conserved across the region, whereas its response to biotic variables (the biomass of other understory herbaceous species) varied regionally. Niche models indicate that M. vimineum responds positively to light and soil moisture, and negatively to percentage of clay in the soil, consistent with the findings of other studies. In contrast, the relationship between M. vimineum performance and the biomass of other herbaceous species varied regionally and was best fit by a model with site-specific slopes for herb biomass. We fit a second linear model to the data that included macroclimate variables and found strong support for this model relative to the model without macroclimate variables finding a significant positive relationship between site-specific slope between biomass and days with > 0.254 cm of precipitation, and a significant negative relationship between the site-specific slopes and mean temperature. Findings suggest that M. vimineum response to local biotic effects shifts across the macroclimatic gradient with interspecific competition having stronger effects on invader performance in warmer, drier sites and weaker effects on invader performance in cooler, wetter sites. Thus, the role of biotic factors as controls on the distribution and spread of M. vimineum varies across regional gradients of temperature and moisture (Mayfield et al. 2013; Anderson et al. 2013; Fraterrigo et al nd). Related research suggests that the effects of M. vimineum on C and N dynamics differ in magnitude depending on the land-use context of invasion with impacts being greatest in rural compared to urban areas (Anderson et al. 2013; Pearson et al. nd).

The ways in which land-use history may mediate plant community responses to climate change is not well understood. Forest herbs are particularly susceptible to the combined effects of multiple drivers because many species have low fecundity, delayed first reproduction, and limited dispersal. Our studies explored the interacting effects of logging history and climate on forest herbs and their pollinators in the Southern Appalachian region using field measurements and a seed sowing experiment to examine how plant performance of four focal species of forest herb (Caulophyllum thalictroides, Prosartes lanuginosa, Sanguinaria Canadensis, and Arisaema triphyllum) differed between old (logged > 100 years prior to the study) and young (logged 20-40 years prior to the study) forest stands along an elevation gradient. This study was carried out over a three-year time period that included years with strikingly different patterns of precipitation (Jackson et al. 2013). We found that populations of focal herb species in recently logged stands showed evidence of reduced performance, with lower recruitment, higher within-plot variation in recruitment density, greater mortality, and greater proportional biomass allocation to leaves versus stem than in old stands. Population growth rates for P. lanuginosa were lower in young stands and following a drought spring. The demographic mechanisms underlying population responses to drought were different across stand

age, being driven primarily by reduced fecundity in old stands and by reduced growth from vegetative to flowering life stages in young stands. Importantly, logging legacies negatively affected some species beyond the dispersal stage. Collectively, these forest herb studies emphasize the importance of assessing the responses of multiple indicators of plant performance to climate and land-use legacies.

Many Southern Appalachian forests are recovering from past logging, but the effects of logging on forest insect pollinators and potential interactions between habitat alteration and climate have not been well studied. We asked how insect pollinator abundance and community composition varied with logging legacies (time since logging and distance from logging roads) and temperature. The pollinator community was surveyed along gradients of stand age, elevation (a surrogate for temperature), and distance to logging roads during summer 2011 and spring 2012. A new multilevel modeling (MLM) approach (Jackson et al. 2012) was used to investigate the effects of these drivers on pollinators at the family and community-level. Many important pollinator families were found in higher abundance in recently logged stands and close to roads, especially in summer when logging roads provide supplemental light and floral resources for insects, but the beneficial effects of roads on the bee community appeared to diminish as forests matured (Jackson 2012).

In avian community research, we documented how the negative effects of exurban development were greater on forest bird species that are Neotropical migrants (Lumpkin & Pearson 2013) with species found at higher elevations being particularly sensitive. Surprisingly, edge and shrubland species did not benefit from the forest clearing associated with residential development likely due to how vegetation is altered and managed around homesites. In the work on stopover habitat use by migrant birds, we found that Red-eyed Vireos, are sensitive to the amount and spatial pattern of hardwood forests in landscapes used during migration (Beasley 2013). Hardwood forests are the highest quality habitat for migrating forest birds and migrant birds had the most success in landscapes in which the hardwood forests were relatively fragmented. While habitat fragmentation is harmful in most situations, for migrating birds the highly dispersed patches of high quality habitat allowed them to find food resources relatively quickly during the migration stopover.

Key outcomes or Other achievements:

The Coweeta Schoolyard LTER program directly engaged with 830 students from North Carolina and Georgia on 5 separate occasions. Coweeta Schoolyard LTER coordinated and led the fourth annual Migration Celebration where we collaborated with the non-profit Southern Appalachian Raptor Research (SARR) and Land Trust for the Little Tennessee (LTLT) to lead over 340 5th and 6th grade students from Mountain View Intermediate in activities concerning migration, including tagging Monarch butterflies, banding migratory songbirds, and learning the different strategies that animals use to cope with scarce resources. This year we had our first successful 4-day Kids in the Creek field trip in April for approximately 260 8th graders from Macon Middle School, Nantahala School, Highlands School, Rabun Gap-Nacoochee School, and Trimont Christian School. The event was spearheaded by the Coweeta LTER Schoolyard program, but also involves aquatic biologists from the Land Trust for the Little Tennessee, U.S. Fish and Wildlife Service, North Carolina Division of Water Quality, North Carolina Wildlife Resources Commission, and North Carolina Natural Heritage Program. The program met 8th grade science curriculum standards, focusing on the hydrosphere and water quality as part of the North Carolina Standard Course of Study (see competency goal 3: http://www.ncpublicschools.org/curriculum/science/scos/2004/21grade8). The program included follow-up classroom work. In June, thirty 5th, 6th, and 7th grade

students took part in a week-long Coweeta Aquatic Camp, which was a collaborative venture between Mountain View Intermediate School, Coweeta LTER, and Coweeta Hydrologic Lab. The students learned about stream macroinvertebrates, stream salamanders, and water quality at Coweeta. Later, they created stop-gap animation podcasts summarizing one of the topics they learned about during their stay at Coweeta. The Science Study Boxes continued to be used by local teachers and were checked out a total of 11 times during the 2012/2013 academic year, serving over 1748 students. We used Schoolyard funds to purchase equipment for additional boxes and worked with Northeast Georgia Youth Science Technology Center to expand the use of these boxes in Northeast Georgia. Word is still getting out about these additional Science Study Boxes. Nevertheless, from December 2012 through March 2013 the new boxes were checked out 4 times from 4 different schools and served 711 students.

Within the Little Tennessee River Basin, distributions of dominant land uses and patterns of recent land use change do not occur uniformly across the landscape. They occur in specific regions of the basin best identified by a land use suitability index (LUSI) that incorporates both natural and anthropogenic spatial variables. Land use change associated with both loss of forest area and increase of residential area from 1986-2006 occur largely at lower elevation, low slope areas, and are likely to have different patterns of soil and groundwater recharge and runoff generation. A novel synthesis of stable isotope and hydrometric (i.e. volumetric water content and shallow ground water stage) facilitates ongoing testing of hypotheses associated with water sources for hillslopes dominated by forested and agricultural land uses. Preliminary results from our experimental hillslopes reveal that forested sites were characterized by relatively large storage changes and downslope water fluxes in the unsaturated zone and relatively small shallow groundwater fluctuations or fluxes, except during brief storm periods. Agricultural sites were characterized by relatively large downslope fluxes of shallow groundwater relative to unsaturated zone fluxes. These differences in the partitioning of downslope flow are likely influenced by differences in land cover as well as differences in soil characteristics associated with disturbance histories of the sites. These differences are also inextricably linked to the topographic landscape positions that are characteristically occupied by each land use type (i.e. forested hillslopes on relatively steep slopes with small contributing areas and agricultural hillslopes on relatively shallow slopes with large contributing areas). Variations in stable isotopes of soil water (18O and 2H) on each experimental hillslope suggest that forested and agricultural hillslopes may differ substantially in local versus nonlocal (i.e. upslope) contributions to soil water. (Water isotope samples from hillslopes dominated by residential land use remain to be analyzed and incorporated into this analysis.) These differences in partitioning of flow have implications for the transport of sediment, dissolved and particulate organic material and potential contaminants into adjacent streams.

The Coweeta Listening Project (CLP), under development for the last two years went public this year with the objective of translating long-term ecological science within the Southern Appalachians into forms of knowledge that can have meaningful ramifications for a wide range of groups (citizens, public institutions, etc.) The CLP ultimately seeks to improve understanding of the steps necessary for translating scientific results about ecological issues into more democratically produced forms of information that can benefit larger proportions of local communities. The CLP is a collaborative between several CWT LTER co-PIs, graduate and undergraduate students that partners with the community-based organization Land Trust for the Little Tennessee to 1) facilitate communication between Coweeta LTER researchers, local residents, existing environmental organizations, and policy

makers in North Carolina; 2) explain research done through the Coweeta LTER and translate results so clear links are made between science, policy, and personal and community impacts; 3) serve as an impartial clearinghouse of information related to local ecological issues; and 4) provide information about how community members can use these research results to participate more effectively in personal and community decision making regarding land use and land change. CLP activities have included 1) conducting interviews with all CWT co-PIs and a subset of graduate students to explore questions of interdisciplinarity, the public-science interface, scientific literacy, and science-policy issues. 2) Publishing a bi-weekly editorial that runs in a local paper and runs under the tag-line "Science, Public Policy, Community". 3) Leading "Translational Dialogues" in which LTER scientists present their knowledge to residents of the region in an effort to open up information exchange, stimulate group reflection and listening to local residents. And, 4) working with a set of local groups that are interested in climate change adaptation by participating in meetings and contributing scientific experience and knowledge from the LTER and elsewhere. Translational Dialogues have been carried out in diverse venues including the Rickman Store in Cowee, Trouts Unlimited in Silva, and the League of Women Voters and the Rotary Club in Franklin (all in North Carolina). The CLP is spearheading dissemination of the saSVAP tool described above, while the CLP umbrella, activities and community partnerships are integral to a core graduate course in the University of Georgia's recently established Integrative Conservation PHD program that is a partnership between Anthropology, Geography, Ecology and Forestry. The objectives, methodology, and results from the CLP have been communicated now through a public website (http://listening.coweeta.uga.edu/), a workshop at the 2012 LTER All Scientists Meeting, 25 columns in the Franklin Press (author: Coweeta Listening Project), and three publications now in press in BioScience, Ecology & Society, and Professional Geographer.

*** What opportunities for training and professional development has the project provided?**

Coweeta Co-PIs provided numerous opportunities for training and professional development to high school, undergraduate, and graduate students from their home institutions and elsewhere as well as staff both from the project as well as other LTER projects. In addition, several co-PIs incorporate portions of their research in to regularly taught courses, lead multi-day field trips to the project area in which students engage in field work, or offered mini-courses on selected topics that emerge from their Coweeta LTER research.

Over 40 graduate students (both MS and PHD) and 12 undergraduates worked directly on Coweeta LTER research this year either in the capacity of advisees and/or summer hourly workers with project co-PIs gaining valuable training in the general areas of sample collection, sample processing, data entry, data analysis, writing, and professional presentation. The scientific domains they were working in included: plant community ecology, aquatic ecology, vertebrate ecology, geochemistry, geomorphology, anthropology, geography and ecohydrology, with particular development of skills in occupancy and hierarchical modeling, installing and programming diverse field sensors, conducting biotic surveys (plants and animals). In addition, one summer high-school intern was involved in a project built around using the GCE Data Toolbox. A second high-school student worked with aquatic biologists from the Land Trust for the Little Tenneessee on their annual fish IBI surveys and testing the Southern Appalachian Stream Visual Assessment Protocol (saSVAP) instrument being developed as a citizen science tool to allow the public to quickly and easily assess the physical condition of a stream using 10 discrete metrics. Two REU students were involved respectively in an ILTER collaborative project and in long-term salamander monitoring.

Additional noteworthy activities this year included:
Co-PI Band developed and delivered two short courses on using the RHESSys model that benefited graduate students in the Coweeta project as well as from other NSF sponsored projects.

In collaboration with the Georgia Coastal Ecosystems (GCE-LTER), CWT LTER hosted a two and a half day training workshop for 15 senior members of the LTER community and developed publicly available documentation and podcasts for use of the GCE Data Toolbox. These on-line projects provide ongoing opportunities for training and development for anyone with access to a Matlab license and the Internet.

Co-PIs Hepinstall and Shepherd leveraged their involvement with CWT LTER to obtain a second $35,000 Improving Teacher Quality grant funded by the US Department of Education to train middle and high school teachers on climate change and testing for effects of climate change on ecological systems. The three day workshop with 12 teachers was completed in mid-June 2013 and included a full day field trip to Coweeta during which site manager Jason Love presented the history and mission of the Coweeta Hydrology lab and Coweeta LTER, and other CWT personnel assisted by describing the eddy flux tower.

Graduate student Barlow hosted two meetings with Macon County landowners as part of the structured decision making project where she presented information on forest management practices, including different methods of timber harvest, the Present Use Value program, and permanent conservation easements.

Co-PI Webster took a group of 18 undergraduates, as he does every year as part of their aquatic ecology course at Virginia Tech, on a field trip to Coweeta where they talked about the rich history of research and looked at many of the ongoing projects.

Coweeta research is a source for major content of courses taught last year at the University of Georgia by co-PI Leigh: General Geomorphology Class (GEOG 3010), Fluvial Geomorphology Class (GEOG 4020), and Geomorphology Seminar (GEOG 8020), and co-PIs Heynen and Pringle: Application of Integrative Principles and Perspectives (ICON 8002).

Co-PI Clark organized an NSF-funded workshop, Emerging Methods in Global Change Science, delivered to 15 postdoctoral students selected from competitive applications globally. He also organized the workshop New Perspectives on Data Assimilation in Global Change Science, at Woods Hole also funded by NSF that was delivered to 30 young investigators (postdocs, assistant professors), selected by application.

*** How have the results been disseminated to communities of interest?**

In addition to publications and thesis as listed elsewhere, co-PIs and students presented at the following national/international professional meetings representative of distinct communities of interest to which Coweeta LTER results pertain:

CUAHSI 3rd Biennial Colloquium on Hydrologic Science and Engineering
98th Ecological Society of America meeting
Geological Society of America Annual meeting
American Geophysical Union Fall Meeting
3rd International Conference on Forests and Water in a Changing Environment (Fukuoka, Japan)
Annual SSSA Meeting (Cincinnati, OH)
12th North American Forest Soils Conference (Whitefish, MT)
World Congress of Herpetology (Vancouver, Canada)
Society of Freshwater Science
North American Forest Soils Conference
International Ecology Society Conference (INTECOL)
Society of Freshwater Science Annual Meeting

In addition to presentations at professional meetings, personnel associated with the Coweeta LTER provided tours and presentation at the Coweeta Hydrologic Laboratory and the surrounding area for a total of 442 individuals as follows:
10/11/2012 Southern Appalachian Plant Society 18 Environmental Group
10/10/2012 Southwestern Community College Env. Sci. Class 16 University
10/05/2012 Sandra and Dave Hawthorne, 2 Scientists

11/09/2012 NCSU Extension agents 9 Consultants or Other Resource Managers
11/09/2012 NCNF Forest Plan Group 9 Land Managers- Nat'l/State Forest Service
11/28/2012 Chris Oishi, Scientist
12/11/2012 Franklin Rotary Club Civic Group, 35
12/19/2012 Cheryl Jefferson 1 Administrator/Legislator
02/25/2013 Highlands Biological Station 3 University/College
03/01/2013 Melina & Parents 2 Administrator/Legislator
03/06/2013 Associate Chief of the FS, R8 Regional Forester and SRS Station Director 3 Land Managers- Nat'l/State Forest Service
03/19/2013 University of Kentucky Silviculture Class 22 University/College
03/15/2013 NIH, Ecology and Evolution of Infectious Diseases Workshop 6 Scientists
02/23/2013 Western Carolina University 33 University/College
03/28/2013 KSKV Kachchh University (India) 2 Foreign Visitors
03/28/2013 Forest Service - WO/SRS - Engineering 4 Land Managers- Nat'l/State Forest Service
04/05/2013 University of Georgia Soil Ecology Class 11 University/College
04/20/2013 University of Georgia Mountain Geography Class 4 University/College
05/08/2013 USDA-FS-SRS Engineering & Contract Officer 3 Land Managers- Nat'l/State Forest Service
05/16/2013 South Macon Elementary 20 School K-8
05/02/2013 EURING Analytical Meeting and Workshop 22 Consultants or Other Resource Managers
05/22/2013 Rabun Nacoochee School Science Students 13 High School
05/23/2013 University of Georgia Silviculture Class 20 University/College
05/30/2013 Clemson University 3 University/College
05/24/2013 Franklin Bird Club 9 Environmental Group
06/06/2013 Land Owner Workshop on Low Volume Private Access Road Construction and Maintenance 30 Civic Group
06/14/2013 Michael Bolt from the Eastern Band of Cherokee Indians 2 Foreign Visitor
06/14/2013 University of Georgia/GA science teachers 15 School K-8
06/27/2013 University of North Georgia Stream and Wetland Class 17 University/College
06/13/2013 NASA-funded Climate Change Teacher Training Group (UGA) 20 High School
06/18-20/2013; 6/25-26/2013 Mountain View Intermediate Coweeta Aquatic Camp 35 School K-8
07/17/2013 Drs. Stephanie Paladino and Rocio Rodiles 3 Scientists
07/08/2013 UNC-Charlotte Hydrology of North Carolina 13 University/College
07/09/2013 Research Hydrologist applicant 2 Consultants or Other Resource Managers
08/13/2013 WDECA/NC Extension 47 Cooperators

* What do you plan to do during the next reporting period to accomplish the goals?

Continued sampling on the experimental hillslope plots, which includes collecting weekly stream, lysimeter, groundwater, and rainwater samples, collecting soil and forest floor samples for analysis of C, N, and other macro and micro-nutrients, and to collect quarterly storm samples for analysis of discharge, TSS, OSS, and various other stream water quality chemistry measurements (e.g. nitrate, cations, etc.). NCSU will analyze remaining water isotope samples from residential hillslopes and incorporate the results into the ongoing isotopic study. Hydrometric and isotopic data, results and analyses will be combined with results from other project teams in a synthesis study that seeks a holistic understanding of how ecological and hydrological processes interact on hillslopes and how these processes and their interactions affect water quantity and quality, including stream ecological conditions, within the region.

Long-term biotic monitoring and experimental plots within the Coweeta basin, Great Smoky Mtns Nat. Park, Duke Forest and Mars Hill will be resampled. These are the basis for examining the evolution and interaction of space/time patterns of the forest canopy relative to watershed geomorphology, hydrologic cycling and transport. Sampling included tree growth and development and seed production. In addition, baseline samples will be collected of soil and forest floor chemistry for the expanded gradient plots in the Great Smokey Mountain National Park.

Long-term monitoring on salamanders will continue at a subset of synoptic and intensive hillslope sites to assess interannual variation in estimates and terrestrial salamander population dynamics along an elevation gradient within the

Coweeta basin. This terrestrial work focuses on how climate and weather regulate the performance of terrestrial salamanders, the effect of climate on population dynamics, how climate and land use interact to affect dispersal and population fragmentation, how climate regulates interactions between terrestrial salamander species, and the effects of terrestrial salamanders on forest ecosystem processes and plant diversity. We will also begin to monitor responses of understory herb communities to removal of salamanders and associated increases in ant populations, and will repeat and expand the hydroclimate variability research to additional sites.

Within the Coweeta Basin, long-term data collection will continue on vegetation dynamics, aboveground biomass and nutrient accumulation in Watershed 7. Hillslope plots will be resampled for below ground nutrient cycling measurements along with forest floor and soil chemistry and soil solution and groundwater chemistry. We will conduct the routine 5 year sample collections of the LTER gradient plots. In the larger region, dendrochrologic sampling will continue directed at relating disturbance history and climate-growth interactions.

Sampling of experimental units (wood posts) for decay, microbial, and faunal communities will continue, a regional-scale study into controls on forest structure and function. There will also be continued sampling in to how habitat structure influences invasive plant species spread.

Deployment of near-real-time sensor network will be completed, and in-hand CWT LTER data will be migrated to PASTA. We will continue to seek funding to improve the core software and instructional materials for the GCE Data Toolbox for MATLAB.

Three projects will be completed that pertain to the impact on property values of invasive species, the impact of water contamination surrounding an industrial site on vacant land sales, and on how economic incentives influence the decision to conserve land. These studies complements previous research on how proximate and distant conditions and amenities influence property values and conservation in southern Appalachia.

We plan to close out the longitudinal variation in hillslope, riparian, and stream ecology research project and finish processing the hundreds of forest floor and bulk density samples collected for this project so the Coweeta Analytical Lab can begin analyzing these samples.

For the Coweeta LTER Schoolyard program, we will continue the Migration Celebration in the fall and the Kids in the Creek in the spring. In addition, we will have a citizen science lichen bioblitz at Coweeta Hydrologic Lab to teach local citizens about lichens and to compile a preliminary list of lichen species from the lab. We will also continue to update and replenish supplies and activities in our Science Study Boxes.

Products

Journals

Anderson, D.P., Turner, M., Pearson, S.M., Albright, T.P., Peet, R.K. and Wieben, A. (2013). Predicting Microstegium vimineum invasion in natural plant communities of the southern Blue Ridge Mountains, USA.. *Biological Invasions*. 15 (6), 1217.

Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes ; DOI: 10.1007/s10530-012-0361-3

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Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes ; DOI: 10.1007/s10021-012-9572-9

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Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes ; DOI: 10.1093/jpe/rts035

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Status = PUBLISHED; Acknowledgment of Federal Support = No ; Peer Reviewed = Yes ; DOI: 10.3832/ifor0609-009

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Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes ; DOI: 10.1111/j.1365-2427.2012.02813.x

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Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes ; DOI: 10.2166/nh.2012.067

Belden, Lisa K., William E. Peterman, Stephen A. Smith, Lauren R. Brooks, E.F. Benfield, Wesley P. Black, Zhaomin Yang and Jeremy M. Wojdak (2012). Metagonimoides oregonensis (Heterophyidae: Digenea) Infection In Pleurocerid Snails and Desmognathus quadramaculatus Salamander Larvae In Southern Appalachian Streams.. *Journal of Parasitology*. 98 (4), 760.

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Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes ; DOI: 10.1111/gcb.12169

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Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes ; DOI: 10.1007/s10530-012-0313-y

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Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes ; DOI: 10.1643/CE-12-120

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Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes ; DOI: 10.1007/s10533-012-9822-0

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Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes ; DOI: 10.1890/12-1339.1

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Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes ; DOI: 10.1371/journal.pone.0061171

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establishment of an invasive grass.. *Plant and Soil*. .

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Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes ; DOI: 10.1111/gec3.12025

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Status = AWAITING_PUBLICATION; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes ; DOI: 10.5814/j.issn.1674-764x.2012.02.003

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Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes

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Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes ; DOI: 10.1007/s11104-012-1416-z

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Status = PUBLISHED; Acknowledgement of Federal Support = No ; Peer Reviewed = Yes ; DOI: 10.1016/B978-0-12-384719-5.00417-2.

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Status = PUBLISHED; Acknowledgement of Federal Support = Yes ; Peer Reviewed = Yes

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Acknowledgment of Federal Support = Yes

Coughlan, Michael R.. *Fire Use, Landscape Transition, and the Socioecological Strategies of Households in the French Western Pyrenees*. (2013). University of Georgia.

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Acknowledgment of Federal Support = Yes

Jensen, Carrie Killeen. *Scales and arrangements of large wood in streams of the Blue Ridge Mountains. MA Thesis.*. (2013). University of Georgia.

Acknowledgment of Federal Support = Yes

Beasley, Camille Joanna. *Avian communities in suspended development. MS Thesis.*. (2013). University of Georgia.

Acknowledgment of Federal Support = Yes

Conference Papers and Presentations

Elliott, Katherine J., James M. Vose, Jennifer D. Knoepp and William Jackson (2012). *Effects of Wildfire and Liming of Pine-Oak-Heath Communities in the Linville Gorge Wilderness, Western North Carolina.*. Proceedings of the 4th Fire in Eastern Oak Forests Conference. Springfield, MO.

Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Other Publications

Cary, R.H. and Chamblee, J.F. (2013). *GCE and CWT Host Successful Workshop to Demonstrate, Improve, and Promote the Adoption of the GCE Data Toolbox for Matlab.*. LTER Databits: Spring 2013, Published by LTER Network Office.

Status = OTHER; Acknowledgement of Federal Support = Yes

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Status = OTHER; Acknowledgement of Federal Support = Yes

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Status = OTHER; Acknowledgement of Federal Support = Yes

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Status = OTHER; Acknowledgement of Federal Support = Yes

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Status = OTHER; Acknowledgement of Federal Support = Yes

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Status = OTHER; Acknowledgement of Federal Support = Yes

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Status = OTHER; Acknowledgement of Federal Support = Yes

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Status = OTHER; Acknowledgement of Federal Support = Yes

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Status = OTHER; Acknowledgement of Federal Support = Yes

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Status = OTHER; Acknowledgement of Federal Support = Yes

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Status = OTHER; Acknowledgement of Federal Support = Yes

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Status = OTHER; Acknowledgement of Federal Support = Yes

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Status = OTHER; Acknowledgement of Federal Support = Yes

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Status = OTHER; Acknowledgement of Federal Support = Yes

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Status = OTHER; Acknowledgement of Federal Support = Yes

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Status = OTHER; Acknowledgement of Federal Support = Yes

Coweeta Listening Project (Writing Collective) (2013). *Science, Public Policy, and Community: What powers these mountains?*. Page B4 in: The Franklin Press: June 7, Franklin, NC.

Status = OTHER; Acknowledgement of Federal Support = Yes

Coweeta Listening Project (Writing Collective) (2013). *Science, Public Policy, and Community: Coweeta Aquatic Camp.*. Page B4 in: The Franklin Press: July 3, Franklin, NC.

Status = OTHER; Acknowledgement of Federal Support = Yes

Coweeta Listening Project (Writing Collective) (2013). *Science, Public Policy, and Community: The fate of the Southern Appalachian salamanders.*. Page B4 in: The Franklin Press: July 19, Franklin, NC.

Status = OTHER; Acknowledgement of Federal Support = Yes

Technologies or Techniques
Nothing to report.

Patents
Nothing to report.

Inventions
Nothing to report.

Licenses
Nothing to report.

Websites

Title: Coweeta LTER

URL: http://coweeta.uga.edu/

Description: Coweeta LTER site providing access to research, publications, data, and other resources resulting from and supporting the project.

Title: Coweeta Listening Project

URL: http://listening.coweeta.uga.edu/

Description: Coweeta Listening Project site providing access to CLP objectives, resources and community links.

Other Products
Nothing to report.

Participants

Research Experience for Undergraduates (REU) funding

How many REU applications were received during this reporting period? 6

How many REU applicants were selected and agreed to participate during this reporting period? 2

What individuals have worked on the project?

Name	Most Senior Project Role	Nearest Person Month Worked
Shannon West	Other	1
Mark Bradford	Co-Investigator	1
Seth Younger	Graduate Student (research assistant)	1
Jackson Webster	Co-Investigator	1
Benjamin Woodard	Undergraduate Student	5
Ed Williams	Other	1
Robert Warren	Other	1
Tara Ursell	Graduate Student (research assistant)	12
Monica Turner	Co-Investigator	1
Alexander Terry	Research Experience for Undergraduates (REU) Participant	3
Brian Strahm	Other	1
Rebecca Stewart	Graduate Student (research assistant)	12
Bhavya Sridhar	Graduate Student (research assistant)	12
Eric Sokol	Postdoctoral (scholar, fellow or other postdoctoral position)	12
Stephanie Smathers	Other	1
Marshall Shepherd	Co-Investigator	1
Katharine Servidio	Graduate Student (research assistant)	12
Charles Scaife	Graduate Student (research assistant)	12

Amy Rosemond	Other	1
Jennifer L. Rice	Co-Investigator	1
Daniel Reategui	Other	1
Kelsey Ream	Graduate Student (research assistant)	12
Thomas Prebyl	Graduate Student (research assistant)	12
Brian Phillips	Other	1
Christopher Strother	Graduate Student (research assistant)	6
Robert Northington	Graduate Student (research assistant)	12
Gary Peeples	Other	1
Jeff Norman	Graduate Student (research assistant)	12
Bobbie Niederlehner	Technician	12
Joseph Nicholson	Graduate Student (research assistant)	6
Denis Newbold	Other	1
Avishesh Neupane	Graduate Student (research assistant)	12
Jerry Miller	Other	1
Jason Meador	Other	1
Kristen Meador	Other	1
Bill McLarney	Other	1
Brian McGann	Undergraduate Student	3
Jacob McDonald	Graduate Student (research assistant)	12
Robert McCollum	Technician	12
John Maerz	Co-Investigator	1
Jennifer Love	Other	1
Dwight Long	Other	1

Laurence Lin	Graduate Student (research assistant)	12
Andrea Leslie	Other	1
David S Leigh	Co-Investigator	1
Kristin Kraseski	Graduate Student (research assistant)	12
Lillian Knoepp	Undergraduate Student	3
Jennifer Knoepp	Co-Investigator	1
Vanessa Kinney Terrell	Other Professional	1
Joshua King	Other	12
Ashley Keiser	Graduate Student (research assistant)	12
Carrie Jensen	Graduate Student (research assistant)	1
Taehee Hwang	Postdoctoral (scholar, fellow or other postdoctoral position)	12
Sally Horn	Other	1
Mark Hopey	Other	1
Jeff Hepinstall-Cymerman	Co-Investigator	1
Adam Hart	Graduate Student (research assistant)	12
Rose Graves	Graduate Student (research assistant)	12
Ben Gosak	Graduate Student (research assistant)	12
Matt Gifford	Other	1
Jennifer Fraterrigo	Co-Investigator	1
Stephen Fraley	Other	1
Tom Fox	Other	1
Chelcy Ford Miniat	Co-Investigator	1
Kathy Flowers	Other	1

Elizabeth Fisher	Graduate Student (research assistant)	5
Salli Dymond	Graduate Student (research assistant)	12
Jon Duncan	Graduate Student (research assistant)	12
Craig Depken	Co-Investigator	1
Thomas Crowther	Other	12
Matthew Craig	Graduate Student (research assistant)	12
Kris Covey	Other	1
Robert Cooper	Other	1
Michael Conroy	Other	1
Ryan Chitwood	Undergraduate Student	3
Kyle Coleman	Undergraduate Student	3
Beth Cheever	Graduate Student (research assistant)	12
Robert W Benson	Technician	6
Cindi L. Brown	Technician	1
Derek Booth	Other	12
Paul Bolstad	Co-Investigator	1
Sergio Bernades	Graduate Student (research assistant)	6
Jon Benstead	Other	1
Suzanne Bellflower	Other	1
Camille Beasley	Graduate Student (research assistant)	8
John Barrett	Co-Investigator	1
Paige Barlow	Graduate Student (research assistant)	7
Lawrence Band	Co-Investigator	1
Richard Baird	Other	12

Michelle (Gooch) Jackson	Graduate Student (research assistant)	12
Jacob Craig	Undergraduate Student	3
Daniel Maynard	Graduate Student (research assistant)	12
Robert Bahn	Other	12
Lynsey Long	Technician	12
Rhett Jackson	Co-Investigator	1
John F Chamblee	Other Professional	11
Steven Brantley	Postdoctoral (scholar, fellow or other postdoctoral position)	12
Stenka V Vulova	Technician	8
Jason Love	Other	12
Carol Harper	Technician	12
Sheila Gregory	Technician	12
Christine Hubinger	Technician	12
Joseph Davis	Technician	10
Joel Scott	Technician	11
Katherine Bower	Technician	11
Richard H Cary	Technician	6
Greg Wright	Undergraduate Student	3
Wade C. Sheldon	High School Student	3
Shelby Sutton	Undergraduate Student	3
Heather Abernathy	Undergraduate Student	3
Sara De La Torre Berón	Research Experience for Undergraduates (REU) Participant	6
Daniel Reategui	High School Student	3

Sakura Evans	Graduate Student (research assistant)	12
Karen Allen	Graduate Student (research assistant)	9
Theodore L Gragson	PD/PI	2
Michael Coughlan	Graduate Student (research assistant)	6

What other organizations have been involved as partners?

Name	Location
Duke University	Durham NC
Land Trust for the Little Tennessee	Franklin NC
Mars Hill College	Mars Hill NC
North Carolina State University	Raleigh NC
USFS Coweeta Hydrologic Laboratory	Otto NC
University of Illinois	Champaign IL
University of Minnesota	Minneapolis MN
University of North Carolina	Chapel Hill NC
University of Wisconsin	Madison WI
Virginia Polytechnic Institute & State University	Blacksburg VA
Yale University	New Haven CT

Have other collaborators or contacts been involved? N

Impacts

What is the impact on the development of the principal discipline(s) of the project?

Research over the last year contributed to the area of landscape ecology and ecohydrology. In landscape ecology, we demonstrated that canopy patterns at both large scale length scales, at the full mountain block, as well as shorter hillslope length scales adjust on both interannual and longer term time scales (30 years) to hydroclimate change. We can now observe, through long term remote sensing records, progressive shifts in patterns of leaf area in response to warming climate. In ecohydrology we have shown that hydrological response is closely associated with and predictable from the patterns of leaf display estimated by remote sensing methods, and that the hydrological behavior is closely tracking the adjustments of the forest ecosystem to warming climate.

Contribution was made to understanding the microbial mechanisms underlying nitrogen cycling in temperate forests. In

watershed-level studies performed at Coweeta and elsewhere, scale mismatches between catchment mass balance and microbial dynamics result in a "black box" of fundamental biogeochemical processes occurring in hillslope soils.

Findings are challenging ideas in ecology related to invasive species spread and impact by demonstrating that roadways provide not only dispersal corridors, but also favorable habitat. They challenge ideas about relationships between organisms by showing that a worldwide mutualism (ant-plant seed-dispersal) is instead a commensalism (at least in eastern U.S. forests). They provide data on social insect abundance across regional climate gradients in temperate systems, providing the first robust data on biogeographic patterns in eusocial insect (ants and termites) abundance and biomass in temperate forest floors in relation to other macrofauna providing the basis for investigating eusocial insect effects on ecosystem processes. Lastly, these data challenge expectation that climate is the predominant control on organic matter decomposition rates at broad spatial scales by applying new approaches in population ecology to ecosystem questions.

Hydrological results help situate ecological results and conclusions in the broader context of ecosystems that are interconnected by and often strongly influenced by hydrological processes that occur both at the land surface (e.g. evapotranspiration and infiltration) and in the shallow subsurface (e.g. runoff generation and groundwater recharge).

Our occupancy model parameterizations account for false positive detections, false negative detections, and heterogeneity across time and space and will have broad appeal across disciplines that attempt to model species occupancy.

Our research is demonstrating the fundamental importance of riparian vegetative condition on physical habitat characteristics at the local level. It is also illuminating the complications and numerous relevant dimensions to understanding stream temperature dynamics. Stream temperature is complicated, and not easily explained by any one variable, although riparian shading is unquestionably important on medium-sized streams.

Coweetal Listening Project research contributes to the expanding knowledge and theory around engaged and citizen science. The work is designed as an experiment that will have tangible, applicable outcomes. On the research side, it will increase our understanding about the co-production of knowledge, how the democratization of science may improve decision outcomes, science communication, and the value of engagement for the communities and the scientists involved.

Our accurate characterization of precipitation patterns over space and time allows for a better understanding of changes in these patterns, including changes in the quantity, frequency and intensity of precipitation. We verified, to our knowledge for the first time, that extreme precipitation patterns are changing in the region surrounding the Coweeta LTER site. We also observed large variability in extreme dry and wet events in the area. These findings have multiple ecological and biogeographical implications, being linked to the survival and distribution of biota and the healthy functioning of key ecosystems in the Southeastern United States.

What is the impact on other disciplines?

In the field of hydrology we have shown that distributed watershed runoff model parameters can be effectively regionalized on the basis of both terrain attributes and the remote-sensed forest canopy patterns.

Results have appeared in the primary literature for ecology, statistics, computer science, hydrology, biogeochemistry, organismic biology, conservation, geography and geomorphology.

Our work on water contamination shows that land market perceptions of water contaminations do not necessarily conform to hydrological reality. That is, only land downstream (vs upstream) of the contamination site should be at risk from ground water contamination.

Our occupancy model parameterization can be applied in many types of research including multiple areas of ecology and disease detection. The structured decision making project is interdisciplinary, including ecology and social science.

Our projects assessing the effects of residential development on avian communities has potential application to fields such as urban and regional planning, conservation, and natural resource management.

Our geomorphic research is contributing to a better understanding of the prehistoric human influence on changes in the fluvial system, and specifically sedimentation rates. This is an important emerging area of geomorphology.

Our work on salamanders is bridging the ecosystem and organismal foci of Coweeta. By addressing the roles of salamanders in nutrient storage and demand within headwater streams, we have examined the responses of salamanders to shifts in stream nutrient supplies. We have also addressed how salamanders may impact other biodiversity through the manipulation of salamander abundance.

co-PI Maerz participated in community discussions associated with the Coweeta Listening Project to use salamander research as a means to illustrate the processes that regulate diversity in the region, how human activities are impacting that diversity, and how research could inform specific management interventions or policies.

Coweeta Listening Project activities were incorporated into a core conservation course in the University of Georgia's new Integrated Conservation PhD Program that is run through four different departments: Anthropology, Geography, Ecology, and Forest Resources. Coweeta co-PIs Heynen and Pringle, co-taught one of the program's core courses in 2012.

Conservation graduate students enrolled in the Integrated Conservation core course worked with stakeholders in southern Appalachia to implement practical / sustainable solutions to environmental issues of public concern (e.g.,second home development on steep erodable slopes prone to landslides). A publication resulted from this course that was led by one of the graduate students and published in 2013.

Some of the research impacts Geography and Anthropology through its examination of human responses to environmental change and processes of ecological knowledge production and the coproduction of science and decision-making.

What is the impact on the development of human resources?

Examples derived directly from our LTER research were included in the 4th edition of the textbook by co-PI Bolstad, GIS Fundamentals. So far more than 12,000 copies of the 4th edition have been sold (more than 65,000 copies total of all editions). The included work at Coweeta is exposed to the primarily undergraduate audience in spatial sciences at more then 400 universities across the country and globe.

IM workshops provided 14 individuals with the ability to get started using a well-established, rigorously tested software suite for metadata-based data management and publication. The provisioning of tools, documentation, and podcasts on the web extends that opportunity to anyone with a Matlab license and an internet connection.

Problems and solutions in this research are the basis for training graduate students on key techniques related to the processing of large amounts of data (Big Data) and the analysis of processing outputs. Given the multidisciplinary nature of the project, students in addition to training in ecology, are receiving training in physical geography, geospatial technologies, software development, and spatially distributed ecohydrological models.

What is the impact on physical resources that form infrastructure?

We upgraded 14 sensors in our distributed sensor network to provide streaming data in near-real time.

Additional long-term monitoring and experimental plots were installed in the Great Smoky Mountains National Park.

What is the impact on institutional resources that form infrastructure?

The Coweeta Listening Project has had positive impacts on creating institutional synergies for the LTER within the broader community and on the UGA campus with the Center for Integrative Conservation Research (CICR).

Our use of radiocarbon dating has contributed to the expansion of the UGA Center for Applied Isotope Analysis and their recent acquisition of a second accelerator mass spectrometer.

What is the impact on information resources that form infrastructure?

Automated workflows were developed and published for our ecohydrological models that facilitate automated access to landscape ecological data available on federal servers and registered data sets on other servers. Rather than replicating all data, our methods allow access to the data on demand.

The development of more efficient tools and appropriate instructional documentation makes it possible to educate scientific end-users on the importance of highly structured data and metadata-based analytical workflows. Adoption of such technologies increases the likelihood that data will be comparable across scientific projects.

What is the impact on technology transfer?

Open source Python libraries of automated workflows were published on Git:
https://github.com/selimnairb/RHESSysWorkflows

Instructional materials and open-source software for managing LTER data streams were disseminated through a web portal. This will help increase the likelihood that end-users can settle on common tools to solve common problems and has the potential build larger user communities that can work together to solve their data management and analysis problems.

A workshop to share information about the Hillslope study with private landowners who are participating in the project by allowing us access to their property.

What is the impact on society beyond science and technology?

Model and data preparation methods have been developed and tested for prediction of streamflow, landslides for specific forecast events, and low flows. This information was introduced and discussed in the Mountain Resources Commission, a state-appointed advisory created to take care of natural resources and sustain quality of life in western North Carolina.

Tools and approaches developed in the collaboration between the CWT LTER and the GCE LTER are bringing highly structured data and metadata-driven analytical frameworks on-line in near real time thus becoming available for private and governmental analysis of social and environmental problems.

Results on tree migration (Zhu et al. 2012) were widely reported in the popular press, highlighting the threat of climate change for tree populations.

Local public policy may be shaped by our estimates of loss to local property values from TCE contamination, which exceed what the EPA considers typical.

As a result of participating in both the avian community project and the structured decision making project, land owners in Macon County will have a better understanding of how their land management activities may affect ecological communities.

Our riparian research is helping the public and policy makers understand the importance of maintaining/restoring forested riparian zones for protecting and improving the physical habitat and biological health of streams.

Our salamander research has been central to engaging local citizens in the Coweeta Listening Project. In addition, our methods for measuring stream salamander responses to riparian land use have been adopted for school curricula and local NGO monitor of streams by students and citizen scientists working on stream restoration.

Members of the Coweeta Listening Project carried out activities with community of residents that live within the LTER study region that helped increase general understanding of environmental issues in the region, promoted LTER science and its application in the region, and the inclusion of local knowledge into the LTER. As a result of these activities, CLP members were invited to participate in speaking engagements as well as ongoing contributions to the regional climate adaptation group.

Our Southern Appalachian Stream Visual Assessment Protocol has involved environmental education of different user groups, and is now being integrated into environmental outreach through out collaboration with the Land Trust for the Little Tennessee.

Changes

Changes in approach and reason for change
Nothing to report.

Actual or Anticipated problems or delays and actions or plans to resolve them
Nothing to report.

Changes that have a significant impact on expenditures
Nothing to report.

Significant changes in use or care of human subjects
Nothing to report.

Significant changes in use or care of vertebrate animals
Nothing to report.

Significant changes in use or care of biohazards
Nothing to report.