Coweeta LTER Summer Symposium and Meeting Agenda
June 3 and 4, 2015

Wednesday June 3 – Research Review

8:00 Light breakfast

8:30 Welcome (Love/Miniat)
8:40 Summary of Coweeta Hydrologic Laboratory research (Miniat)
9:05 **Simulating vegetation controls on hurricane-induced shallow landslides with a distributed ecohydrological model.** Taehee Hwang, Lawrence E. Band, T. C. Hales, Chelcy F. Miniat, James M. Vose, Paul V. Bolstad, Brian Miles, and Katie Price
9:30 **Using stable isotopes of water to assess baseflow characteristics along two Coweeta streams**. Ryan Emanuel
9:55 **Long-term changes in carbon and nitrogen pools in the Coweeta terrestrial gradient plots.** Jennifer Knoepp, Craig See, Jim Clark, Jim Vose, Chelcy Miniat

10:20 Break (15 minutes)

10:35 **Forecasting the forest and the trees: climate impacts from individuals to communities to traits.** Jim Clark, Bijan Seyednasrollah, and Bradley Tomasek

Special Session: Visitors from Other Southern Appalachian Ecosystem Investigations

11:00 **Eight years of catching hydrometeors in the Great Smoky Mountains National Park and Pigeon River Basin.** Douglas K. Miller, Ana Barros, and Anna Wilson. From the APHEX project based at Duke University.
11:25 **Conservation planning in the Appalachians.** Rob Baldwin and Paul Leonard. From the Appalachian LLC.
11:50 **NEON – A southern Appalachian perspective.** David Mitchell. From the Oak Ridge NEON site.

12:15 Lunch (1 hour 15 minutes)

1:30 **Ecology of insectivorous songbirds in the Coweeta Basin, 2005-2015.** Robert J. Cooper, Mason H. Cline, Joanna L. Hatt, Richard B. Chandler, Ryan W. Chitwood, Samuel Merker, Heather Abernathy, Michael J. Conroy, Jeffrey Hepinstall-Cymerman, and Kirt W. Stodola
1:55 **The influence of exurban neighborhood age on stream salamander assemblages in the southern Appalachians .** Nathan Weaver and Kyle Barrett (Clemson University)
2:20 **Cryptic long-distance seed dispersal via bird nest foraging.** Robert Warren, Jason Love, and Mark Bradford
2:45 **Thoughts on the renewal: long term conceptual framework, core long term data, the four review principles, review panel composition, schedule** (Jackson)

3:10 Break (20 minutes)

3:30 Poster Session in Main Conference Room

- **Assessing effects of managing an aggressive riparian shrub, *Rhododendron maximum*, on headwater stream ecosystems in the southern Appalachians** (Maura Dudley and Cathy Pringle)
- **Characterizing two genera of dominant shredder (*Tallaperla* and *Pycnopsyche*) associated with little detritus, and its relation with riparian vegetation in headwater streams of the southern Appalachians** (João Vitor de S. Messeder, Maura Dudley, and Cathy Pringle)
- **Responses of macroinvertebrates to removal of the riparian *Rhododendron* understory in southern Appalachian streams** (Kevin Eliason and Fred Benfield)
- **Quantifying age-related hydraulic and biochemical constraints on tree photosynthesis in the southern Appalachian mountains** (Justine Missik, Michael Benson, Chris Oishi, Kim Novick)
- **Hydro-climatological influences on multi-decadal trends of dissolved organic carbon in a southern Appalachian headwater stream** (Nitin K. Singh, Wilmer M. Reyes, Emily S. Bernhardt, Ruchi Bhattacharya, Judy L. Meyer, Jennifer D. Knoepp, and Ryan E. Emanuel)
- **Landscape patterns of bioenergy production in a changing climate** (Rose A. Graves, Scott M. Pearson, and Monica G. Turner)
- **Distribution of two biodiversity-based cultural ecosystem services in the French Broad River Basin** (Rose A. Graves, Scott M. Pearson, and Monica G. Turner)
- **Advancing socioecological insights into long-term ecological change through the sustained co-production of ecological knowledge: lessons from the Coweeta Listening Project (CLP)** (Nik Heynen, Jennifer Rice, Brian Burke, Seth Gustafson, Ted Gragson, and Meredith Welch-Devine)
- **Explaining diverse perceptions of and reactions to environmental change in the Asheville area – Research for the PIAF project** (Stéphanie Vincent-Sweet, Anne Soudril, Meredith Welch-Devine, and Brian J. Burke)
- **Evergreen shrubs alter canopy structure: evaluation using LiDAR and field measurements** (Paul V. Bolstad, Katherine J. Elliott, Chelcy F. Miniat) [tentative]

4:30-6:00 *SAC meeting in Callahan Room*

5:00 Social at Coweeta Dorm

6:00 Dinner at Coweeta Dorm

<u>Thursday June 4 – Renewal Proposal Work Day</u>

8:00 Light breakfast

8:30 Morning announcements (Love and Miniat)
8:35 Renewal ideas from the Biodiversity group (Clark et al.)
9:00 Status of the Rhododendron removal project (Elliott and Wenger)
9:25 Renewal ideas from the Regionalization group (Bolstad)

9:45 Renewal ideas from the Social Science group (Heynen)
10:05 Group discussion – is the conceptual framework working? Does it tie our work together and tie it to our past research and long-term framework?

10:25 Break (15 minutes)

10:40 Research group work sessions

12:00 Lunch – group leaders check in with Rhett

1:00-3:00 Open group discussion of research ideas and proposal content. Continued work group sessions if needed.

3:00 Meeting Adjourns

2015 Coweeta LTER Summer Symposium

3 June 2015

Oral Abstracts

Simulating vegetation controls on hurricane-induced shallow landslides with a distributed ecohydrological model

Taehee Hwang[1,2], Lawrence E. Band[1,3], T. C. Hales[4], Chelcy F. Miniat[5], James M. Vose[6], Paul V. Bolstad[7], Brian Miles[2], and Katie Price[8]

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[2]Now at Department of Geography, Indiana University Bloomington, Bloomington, IN, USA
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[4]School of Earth and Ocean Sciences, Cardiff University, Cardiff, UK
[5]Coweeta Hydrologic Laboratory, USDA Forest Service, Otto, NC, USA
[6]Southern Research Station, USDA Forest Service, Raleigh, NC, USA
[7]Department of Forest Resources, University of Minnesota, Saint Paul, MN, USA
[8]Department of Geosciences, Georgia State University, Atlanta, GA, USA

The spatial distribution of shallow landslides in steep forested mountains is strongly controlled by aboveground and belowground biomass, including the distribution of root cohesion. While remote sensing of aboveground canopy properties is relatively advanced, estimating the spatial distribution of root cohesion at the forest landscape scale remains challenging. We utilize canopy height information estimated using lidar (light detecting and ranging) technology as a tool to produce a spatially distributed root cohesion model for landslide hazard prediction. We characterize spatial patterns of total belowground biomass based on the empirically derived allometric relationship developed from soil pit measurements in the Coweeta Hydrologic Laboratory, North Carolina. The vertical distribution of roots and tensile strength were sampled at soil pits allowing us to directly relate canopy height to root cohesion and use this model within a distributed ecohydrological modeling framework, providing transient estimates of runoff, subsurface flow, soil moisture, and pore pressures. We tested our model in mountainous southern Appalachian catchments that experienced a number of landslides during the 2004 hurricane season. Slope stability estimates under the assumption of spatially uniform root cohesion significantly underpredicted both the total number of landslides and the number of "false positives," unfailed areas of the landscape that were predicted to fail. When we incorporate spatially distributed root cohesion, the accuracy of the slope stability forecast improves dramatically. With the growing availability of lidar data that can be used to infer belowground information, these methods may provide a wider utility for improving landslide hazard prediction and forecasting.

Using stable isotopes of water to assess baseflow characteristics along two Coweeta streams

Ryan Emanuel and Nitin Singh

Department of Forestry and Environmental Resources, North Carolina State University, Raleigh, NC

In the Southern Appalachians, deeply weathered soils and saprolite are believed to supply baseflow to sustain perennial streams in many headwater catchments. Although the importance of baseflow is well recognized, its variability, both in space and time, is poorly understood. Likewise, the influence of hillslope characteristics and

catchment structure on baseflow are poorly understood. We used stable isotopes of water, combined with other hydrologic observations and geospatial analysis to assess the spatial and temporal variability of baseflow over a two-year period (2011-2013) in two Coweeta watersheds. We identified both spatial and temporal characteristics of baseflow $\delta^{18}O$ that help us better understand baseflow contributions by hillslopes within each watershed. This basic understanding has broader implications for the natural ecosystems and human communities that rely on perennial streamflow generated in forested headwaters such as these.

Long-term changes in carbon and nitrogen pools in the Coweeta terrestrial gradient plots

Jennifer D. Knoepp[1], Craig R. See[2], Jim M. Vose[3], Jim S. Clark[4], and Chelcy F. Miniat[1]

[1]USDA Forest Service, Southern Research Station, Coweeta Hydrologic Laboratory, Otto, NC
[2]Coweeta LTER, Warnell School of Forestry and Natural Resources, University of Georgia, Athens, GA
[3]USDA Forest Service, Southern Research Station, Center for Integrated Forest Science and Synthesis, Raleigh, NC
[4]Nicholas School of the Environment, Department of Statistical Science, Duke University, Durham, NC

The role of forests in C sequestration is of global interest; and while recent progress in characterizing terrestrial C pools and fluxes at global scales has been made, challenges remain in characterizing how C pools and fluxes vary in time and space, particularly in landscapes with high variability in precipitation and temperature, vegetation diversity, and topography, such as southern Appalachian mountain forests.

In 1991 as part of the Coweeta Long-term Ecological Research (LTER) program, we established five large permanent plots across an elevation, precipitation, and vegetation gradient within Coweeta Hydrologic Laboratory. The gradient forest communities include mixed oak-pine, low elevation mixed oak, high elevation mixed oak, cove hardwood and northern hardwoods; elevation ranges from 790 to 1390 m. Annual precipitation ranges 187 to 238 cm and air temperature ranges 12.9 to 9.6 °C along the gradient. We analyzed a 20-yr record of ecosystem C and N. Variables included surface soil total C and N; aboveground species composition, growth, biomass, and C stocks; coarse wood and forest floor C and N; leaf litterfall and fine wood C and N flux; and changes over time with soil temperature and moisture (sampling intervals varied). We found that aboveground and belowground total C and N pool sizes are characteristic of vegetation, soil moisture availability and temperature regimes. Data show site variability in patterns of C and N pool losses and accumulation rates. Deciduous leaf litter N concentrations show a tendency to increase over time on all sites; litterfall N is correlated with soil water content and NH4-N deposition.

Forecasting the forest and the trees: climate impacts from individuals to communities to traits

Jim Clark, Bijan Seyednasrollah, and Bradley Tomasek

Nicholas School of the Environment, Duke University, Durham, NC

Probabilistic forecasting of biodiversity risks requires a joint distribution of climate change and forest response. Intensifying drought will have interactive effects on individuals competing within communities across heterogeneous landscapes. Responses of individuals that vary in their exposure to competition for light and moisture depend on the size-species distribution of their local environment. Although responses are individual, models to forecast communities must be assimilated at the community scale. Current projections come from

models fitted to individuals, not populations, and not communities. This mismatch of scales cannot accommodate the joint distribution of competing species, subject to climate change.

Building from joint distributions of size-species structure and climate we develop a probabilistic framework for biodiversity response to climate change. Integrating 20 yr of long-term forest plots, 20,000 USFS forest inventory sites, and long-term climate records I evaluate which species and size classes are vulnerable in which regions to combinations of climate variables and competition. The framework provides inference for the variables and life history stages that limit population spread at margins. It extends coherently to species traits, showing geographic regions of the eastern US most responsive to temperature and moisture change. It extends directly to aggregate trait relationships with climate. I summarize how scale issues are resolved, resulting in probability statements that emerge directly from data assimilated at the prediction scale.

A single model helps address long-standing questions concerning the demographic processes that determine species range limits, how distribution and abundance can change with climate, and how competition and climate interact to affect distributions of species. With an application to long-term and spatially extensive forest plots in eastern North America I show which species respond most to climate, the extent to which local moisture gradients can alleviate negative impacts of increasing aridity, and how competition exacerbates effects of climate change in different ways for different species.

Eight years of catching hydrometeors in the Great Smoky Mountains National Park and Pigeon River Basin

Douglas K. Miller[1], Ana Barros[2], and Anna Wilson[2]

[1]Department of Atmospheric Sciences, University of North Carolina at Asheville, Asheville, NC
[2]Department of Civil and Environmental Engineering, Duke University, Durham, NC

A high elevation rain gauge has been in place in the Great Smoky Mountains National Park and Pigeon River Basin for eight years as part of a joint study between Duke University, UNC Asheville, and NASA. The presentation will focus on what has been learned over the eight years (e.g., examples of extreme rainfall at high elevations, improved understanding of regional precipitation differences, effective for calibration of operational QPE gridded data), a review of the recent IPHEx field experiment, and a look to the future for what will be possible for extending the hydrological record and scientific collaboration.

Conservation planning in the Appalachians

Rob Baldwin[1] and Paul Leonard[1,2]

[1]Department of Forestry and Environmental Conservation, Clemson University, Clemson, SC
[2]Appalachian Landscape Conservation Cooperative

Conservation planning seeks to optimize where and when future conservation actions occur, in the context of ecological irreplaceability, landscape connectivity, and costs. Ecoregion-scale planning uses coarse-fine filter strategies to facilitate multi-scale options. The Appalachian spine stretches from the SE US to Eastern Canada and has had complementary region-scale planning efforts touching all or part of its geography. The Central and Southern Appalachians have experienced fewer such efforts. With 15% of the geography in public lands, and >7000 conservation easements the region has a robust conservation history. Nonetheless the spatial

arrangement of conservation lands may not be optimal. We are 50% complete with a conservation design process for the Appalachian LCC geography (589,000 km^2) in which we integrate conservation targets and goals for habitat surrogates, special systems, landscape connectivity, resilience, and climate vulnerability. Targets and goals are evaluated to map an efficient network of conserved areas. Threats from land use change and energy development are compared to irreplaceability to create a priority matrix. To better parameterize these models in such an ecologically complex region, we request greater involvement in the Appalachian LCC, by regional scientists.

NEON- A Southern Appalachian Perspective

David Mitchell

NEON, Inc., Oak Ridge, TN

The mission of the National Ecological Observatory Network (NEON) is to enable understanding and forecasting of the impacts of climate change, land use change and invasive species on continental-scale ecology – by providing infrastructure and consistent methodologies to support research and education in these areas. NEON monitors the responses to change observed in biodiversity, ecohydrology, infectious disease and biogeochemistry through aquatic, organismal, biogeochemical, and airborne sampling. Domain 7 covers the Southern Appalachians and Cumberland Plateau region.

Ecology of insectivorous songbirds in the Coweeta Basin, 2005-2015

Robert J. Cooper[1], Mason H. Cline[1], Joanna L. Hatt[1], Richard B. Chandler[1], Ryan W. Chitwood[1], Samuel Merker[1], Heather Abernathy[1], Michael J. Conroy[1], Jeffrey Hepinstall-Cymerman[1], and Kirt W. Stodola[2]

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[2]Department of Natural Resources and Environmental Sciences, University of Illinois at Urbana-Champaign, Urbana, IL

Starting in 2005, we have been studying the ecology of Nearctic-Neotropical migratory songbirds in and around the Coweeta Basin. As a group, these are small insectivorous species that feed extensively on Lepidoptera larvae during the breeding season. Because caterpillars are the main herbivores of leaves of deciduous trees, this tri-trophic system would appear to be an informative model system for studying the greater forest ecosystem in the Coweeta Basin, including the effects of climate change on that system. Many of these bird species are in decline in the southern Appalachians, and a trophic mismatch caused by earlier, warmer springs, may be a cause. Although we have performed various experiments, several of which involved cross-site comparisons with similar studies conducted at the Hubbard Brook LTER, the main objective of our research is to intensively follow a model species, the Black-throated Blue Warbler, at a range of elevations. Birds settling at lower elevations may arrive too late to take advantage of the early spring pulse of caterpillars, whereas birds arriving at higher elevations are feeding young at a time when food is most abundant. Caterpillar numbers varied greatly both among and within years, with bird productivity largely varying accordingly, but in general caterpillars emerged earlier and were not as abundant at lower elevations. Although fledging success was similar across elevations, birds at lower elevations fed their young fewer caterpillars, and fledged young with lower mass, which has implications for fledgling survival. As predicted, this species declined in abundance at the lowest elevation site to only 2 pairs of birds, and we discontinued working there in 2009. The study has now expanded to include a group of >20 species whose southern range limits occurs in the southern Appalachian

Mountains. We will be assessing the hypothesis that populations in this region were diverging from northern populations prior to recent changes in climate and forest structure, which may eliminate these populations or force them to move north. We will also assess the impacts of losing such a large suite of species on ecosystem services. To understand the factors affecting demographics and genetics of these populations, we will combine abundance surveys at an extensive array of sites with mark-recapture work at intensive sites located along precipitation and temperature gradients.

The influence of exurban neighborhood age on stream salamander assemblages in the southern Appalachians

Nathan Weaver and Kyle Barrett

College of Agriculture, Forestry and Life Sciences, Clemson University, Clemson, SC

The southern Appalachian Mountains have experienced large population growth over the past 30 years. Land use practices are shifting and forests are being converted into residential land. The majority of development has been low density, suburban land, especially in the Southeast. Stream and riparian ecosystems are severely degraded by conversion of rural land to urban land. The long-term effects of urbanization in the southeastern Appalachian Mountains are not well known and even less is known in respect to stream salamander response to urbanization. Salamander assemblages, vegetation, stream morphology, and water chemistry were sampled across 35 headwater streams in the Southern Appalachian Mountains. There are 27 exurban streams ranging from neighborhoods with an average building age of 4 years, to an average building age of 50 years. We seek to determine if in the long-term salamander populations, vegetation and stream characteristics remain degraded similar to recently developed areas, or if they will return to a more “natural” state relative to the control sites. Data are still being collected but preliminary analyses have been completed.

Cryptic long-distance seed dispersal via bird nest foraging

Robert Warren[1], Jason Love[2], and Mark Bradford[3]

[1]Biology Department, Buffalo State College, Buffalo, NY
[2]Warnell School of Forestry and Natural Resources, University of Georgia, Athens, GA
[3]Yale School of Forestry and Environmental Studies, Yale University, New Haven, CT

Long-distance plant dispersal (>25-50 m) generally remains a mystery. Often, dispersal mode is inferred from plant movement and patterning, but tracking seeds > 1-2 m is difficult. For example, several studies find that seeds of the invasive grass *Microstegium vimineum* only travel 1-2 m, yet the plant populations move rapidly along forest edges and roadways. We examined a novel seed dispersal mode by germinating bird nests. Given that many plants, particularly grasses, harbor viable seeds in their stems, we hypothesized that these seeds may overwinter in senesced plants that get retrieved by birds as nesting materials. We germinated approx. 120 species of plants from bird nests, but many of those were wind dispersed and may have been captured by the nests. We used closed nest boxes to examine species actively transported by birds, and found approx. 60 species. We found *M. vimineum* transported 50-100 m from putative source populations to nest boxes. Interestingly, mixed mating systems with selfed seeds retained in stems only occur in 0.1% of angiosperm species worldwide, but 61% of the species in bird nests employ this system. We introduce foliachory ('nest dispersal') as a major dispersal mode for plants, particularly those with mixed mating systems.

Poster Abstracts

Assessing effects of managing an aggressive riparian shrub, *Rhododendron maximum*, on headwater stream ecosystems in the southern Appalachians

Maura P. Dudley and Catherine Pringle

Odum School of Ecology, University of Georgia, Athens, GA

Changes in the species composition of riparian communities along headwater streams can affect stream ecosystem function by changing the quantity, quality and type of basal energy resources available to aquatic food webs. Over the last century, riparian communities in the southern Appalachian forests have experienced substantial change from the loss of two keystone tree species, *Castanea dentata* and *Tsuga canadensis*, due to human-spread pathogens, and subsequent dominance by a native understory shrub, *Rhododendron maximum* L. In areas where rhododendron increasingly dominates riparian communities and inhibits the recruitment of hardwood overstory species, available benthic energy resources may be significantly altered due to a reduction in primary production from increased understory shade, and an increase in recalcitrant leaf litter inputs that are less palatable to aquatic invertebrates. While the control of rhododendron may ultimately have some long-term benefits for stream ecosystems once hardwood overstory species become established, the short-term consequences of rhododendron control may be substantial. Management strategies aimed at reducing the impact of rhododendron include cutting, burning, herbicide, or a combination of all three. The type and intensity of these management techniques may affect numerous biotic and abiotic attributes of the stream, as well as stream ecosystem processes. Our collaborative study, between the USDA Forest Service and the Coweeta Long Term Ecological Research Project (LTER), aims to assess the short-term impact of rhododendron management in riparian areas on stream benthic resources and ecosystem function. Our research objectives are to determine how rhododendron management practices affect: (1) algal and detrital resources, and how changes in these basal resources affect stream metabolism; (2) stream trophic interactions and changes in top-down control by macroconsumers on rates of algal accrual and leaf decomposition; and (3) stream nutrient dynamics including the effect on nutrient uptake and stoichiometric quality of basal resources.

Characterizing two genera of dominant shredder (*Tallaperla* and *Pycnopsyche*) associated with little detritus, and its relation with riparian vegetation in headwater streams of the southern Appalachians

João Vitor de S. Messeder[1,2,3], Maura Dudley[1], and Catherine M. Pringle[1]

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[3]Universidade Federal de Minas Gerais, Belo Horizonte, MG, Brazil

Headwater streams are highly complex and ecologically important ecosystems within the watershed. Terrestrial leaf litter inputs to headwater streams are an important food resource for benthic macroinvertebrates. Shredders, one of five main functional feeding groups, play a key role in linking terrestrial and aquatic ecosystems by processing leaf litter inputs through the conversion of coarse particulate organic matter into fine particulate organic matter, making it available to other organisms. The main objective of this study was to evaluate the influence of in-stream leaf litter and leaf litter inputs on the abundance and biomass of two important shredder genera *Tallaperla* (Plecoptera: Peltoperlidae) and *Pycnopsyche* (Trichoptera: Limnephilidae). We hypothesized that there would be a strong positive correlation between shredder biomass and in-stream

leaf litter dry mass. We conducted bimonthly sampling of in-stream leaf litter and the associated macroinvertebrates from June to December at four headwater streams in the Southern Appalachian Mountain Range. Leaf litter collection baskets were used to measure the leaf litter input from September through December during leaf-off. Our results showed a positive correlation between the biomass of both shredder genera and in-stream leaf litter mass. We also observed a general increase in shredder biomass and in-stream leaf litter mass as the season changed from summer to fall; however, *Tallaperla* were found to be more dependent on the amount of leaf litter than *Pycnopsyche.* These findings are consistent with the findings of previous studies and our understanding of the life cycle and natural history of both species.

Responses of macroinvertebrates to removal of the riparian *Rhododendron* understory in southern Appalachian streams

Kevin Eliason and Fred Benfield

Department of Biological Sciences, Virginia Polytechnic Institute, Blacksburg, VA

Southern Appalachian forests are in a time of change, as the eastern hemlock, once a dominant canopy species, is dying out due to attack by the hemlock wooly adelgid. The void left by hemlock loss is being filled by a *Rhododendron* understory. *Rhododendron* is a strong competitor with understory and mid-story forest plants and may limit the establishment of overstory trees through the production of acid soils and allelochemics, especially in riparian areas. An intercollegiate team of graduate students and professors, working in conjunction with the U.S. Forest Service at the Coweeta LTER, is beginning a study of the interaction between riparian *Rhododendron* and streams. The proposed 6 year project involves manipulation of the riparian *Rhododendron* understory along 4 streams in the Wine Spring Creek basin in the Nantahala National Forest in western North Carolina. The sites were chosen based on the abundance of riparian *Rhododendron* and dead hemlock canopy. The treatments for the riparian *Rhododendron* are (i) cut and burn in place, (ii) cut and burn in piles, and (iii) burn groundcover, and one site will be left for reference. The removal of *Rhododendron* is expected to change stream chemistry and in- stream processes. Macro-invertebrate assemblages and the functional feeding groups that compose them are also expected to change. I will be working the next 2 years to collect short term data relating to the pre- and- post experimental treatment density and functional feeding group composition of the macroinvertebrates in the 4 streams. The information gained from this experiment is hoped to aid in restoration and conservation efforts of as well to understand the implications of losing the eastern hemlock and expansion of *Rhododendron*.

Quantifying age-related hydraulic and biochemical constraints on tree photosynthesis in the southern Appalachian Mountains

Justine Missik[1], Michael Benson[1], Chris Oishi[2], Kim Novick[1]

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The accumulation rate of carbon in forest ecosystems generally declines with age, a trend largely attributed to reductions in gross primary production (GPP) with stand age. The mechanism causing GPP to decline with age remains somewhat unclear, but likely involves both hydraulic and biochemical factors. In order to investigate the effects of stand age and height on tree hydraulic characteristics and photosynthetic capacity, we propose to quantify how hydraulic and biochemical factors constraining photosynthesis vary with stand age in the southern Appalachian mountains. We will conduct measurements of hydraulic and biochemical parameters, including leaf

water potential (ψ_{leaf}), photosynthetic capacity, and xylem cavitation vulnerability and native xylem hydraulic conductance (*k*) across stands in a forest chronosequence near Coweeta Hydrologic Laboratory.

Preliminary data collected during the 2014 growing season displayed increasing ψ_{leaf} with stand age and height, a trend inconsistent with previous studies. This result could suggest that the degree of isohydry/anisohydry exhibited by trees varies with stand age, with younger trees exhibiting more anisohydric behavior than older trees. Measurements of ψ_{leaf}, xylem cavitation vulnerability and native *k* collected during the 2015 growing season will allow us to investigate relationships between stomatal behavior and xylem physiological characteristics, and better characterize tree hydraulic functioning across stand ages. In addition, we will investigate variability in photosynthetic capacity across the chronosequence using A-Ci curves. These data will allow us to assess how tree photosynthetic capacity and hydraulic characteristics vary on both seasonal and successional time scales, and investigate factors determining carbon gains in forest stands of varying age.

Hydro-climatological influences on multi-decadal trends of dissolved organic carbon in a southern Appalachian headwater stream

Nitin K. Singh[1], Wilmer M. Reyes[1], Emily S. Bernhardt[2], Ruchi Bhattacharya[1], Judy L. Meyer[3], Jennifer D. Knoepp[4], and Ryan E. Emanuel[1]

[1]Department of Forestry and Environmental Resources, North Carolina State University, Raleigh, NC
[2]Department of Biology and Nicholas School of the Environment, Duke University, Durham, NC
[3]Odum School of Ecology, University of Georgia, Athens, GA
[4]USDA Forest Service, Southern Research Station, Coweeta Hydrologic Lab, Otto, NC

In the past decade, significant increases in surface water dissolved organic carbon (DOC) have been reported for large aquatic ecosystems of the Northern Hemisphere and have been attributed variously to global warming, recovery from acid rain, or altered hydrologic conditions. Here, we analyzed one of the longest DOC records (1988-2012) available for a forested headwater stream in the United States. In contrast to the unidirectional increasing DOC trends reported for many northern temperate watersheds, we documented two distinct regimes of DOC concentration and flux occurred within 1997-2001 for this headwater stream. From 1988-2001, annual mean volume-weighted DOC concentration (DOC_{vw}, mg L^{-1}) and annual DOC flux (kg ha^{-1} yr^{-1}) declined by 34% and 56%, respectively. This decline reversed between 1997-2012, as DOC_{vw} and DOC flux increased by 141% and 165%, respectively. Climatic data show a significant rise in annual maximum air temperature by 1.25^{o}C during the 25-year period with strong warming trends in a few growing season months. Annual precipitation and annual runoff declined by 26% and 37%, respectively during the study period. Declining DOC_{vw} from 1988 to 2001 corresponded to a decline in growing season runoff, which has the potential to affect the mobilization of DOC from watershed uplands to the stream. Increasing DOC_{vw} from 1997 to 2012 corresponded to increased precipitation early in the growing season, and an increase in number and intensity of short-duration fall storms. Fall storms have the potential to mobilize long accrued DOC from forest floor and soil profiles. Our study highlights the critical role of long-term datasets and analyses for understanding impacts of climate change on carbon cycles, water cycles and associated functions of aquatic and terrestrial ecosystems.

Landscape patterns of bioenergy production in a changing climate

Rose A. Graves[1], Scott M. Pearson[2], and Monica G. Turner[1]

[1]Ecosystem and Landscape Ecology Lab, Department of Zoology, University of Wisconsin, Madison, WI
[2]Department of Natural Sciences, Mars Hill University, Mars Hill, NC

Rural landscapes face changing climate, shifting development pressure, and agricultural land abandonment. Perennial bioenergy crops grown on existing agricultural land may provide an opportunity to conserve rural landscapes while addressing increased demand for biofuels. Heterogeneity of climate, soils, and land uses complicate assessment of bioenergy potential in complex landscapes. Using a process-based crop model (ALMANAC), we assessed potential bioenergy crop growth through 2100 in a southern Appalachian Mountain region and asked: (1) How does mean annual yield differ among three crops (switchgrass, giant miscanthus, and hybrid poplar) under current climate and moderate and extreme climate change scenarios; (2) how do maximum landscape yield, optimal spatial allocation of crops, and bioenergy hotspots (areas with highest potential yield) varied among climate scenarios; and (3) how often do bioenergy hotspots overlap with current crop production or lands with high development pressure? Under both climate change scenarios, mean annual yield of perennial grasses decreased (-4% to -39%), but yield of hybrid poplar increased (+8% to +20%) resulting in a switch to woody crops to maximize crop production. In total, maximum landscape yield increased by up to 90,000 Mg/yr (6%) in the 21st Century due to increased poplar production. Bioenergy hotspots (>18 Mg/ha/yr) consistently overlapped with areas at high risk of suburban/exurban development and existing row crop production. Constraining bioenergy production to marginal (non-crop) lands decreased landscape yield by 27% while removing lands with high development risk from production resulted in losses of up to 670,000 Mg/yr (40%). This study highlights potential tradeoffs among bioenergy production, crop production, and exurban expansion in complex and changing rural landscapes.

Distribution of two biodiversity-based cultural ecosystem services in the French Broad River Basin

Rose A. Graves[1], Scott M. Pearson[2], and Monica G. Turner[1]

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Cultural ecosystem services i.e., non-material benefits received from nature, contribute substantially to nature-based economies in rural regions and may be especially impacted by shifts in land use. In regions experiencing exurban transitions, incomplete knowledge of the links between land-use patterns, biodiversity, and ecosystem services can lead to unintended losses of biodiversity-based cultural ecosystem services. We measured wildflower and bird communities at 58 sites across a rural-to-urban gradient in the French Broad River Basin, North Carolina during the summer of 2014 to establish the spatial-temporal distribution of two biodiversity-based cultural ecosystem services (wildflower viewing and bird watching). We asked: (1) what factors influence the distribution of wildflower blooms and bird observations across the landscape? and (2) how do spatial patterns of wildflower blooms and bird communities change within the spring to late-summer seasons? The number of flowering species across all sites averaged 12 (CV= 1.5) and exhibited strong seasonal and spatial variation. Total flower availability peaked during early summer but ranged from early April to late July. Peak bloom abundance was significantly related to soil organic matter and texture, tree basal area, and precipitation. Number of flowering species declined over the season and with increasing building density suggesting seasonal and spatial variation in wildflower viewing opportunities. Bird species richness averaged 27 (CV=0.27) and

declined with increasing building density. Eight of the 10 most observed bird species were synanthropic, benefiting from and cohabiting with humans, but community composition varied seasonally. Seasonal and spatial variation in wildflowers and birds suggest shifts in cultural ecosystem service provision in the Southern Appalachian landscape.

Advancing socioecological insights into long-term ecological change through the sustained co-production of ecological knowledge: lessons from the Coweeta Listening Project (CLP)

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The past decade has seen ongoing calls for engagement, exchange, and meaningful partnerships between ecological scientists, public officials, and citizens. Despite a proliferation of efforts to produce science that is more relevant and useful to society, the goals of substantive interaction and collaboration are often poorly defined and not fully realized. This poster outlines some key challenges of effective public engagement in ecological science, discusses two distinct types of knowledge co-production that involve ecological scientists, and offers a new model of public engagement that has been field-tested to improve success. We illustrate two methods of engagement through our work at the Coweeta Listening Project (CLP) as part of the wider Coweeta Long Term Ecological Research (LTER) site. We discuss how these methods facilitate multi-directional interactions between scientists, residents, and decision-makers, and how iteration between various engagement activities can enhance their effectiveness for understanding long-term socioecological change.

Explaining diverse perceptions of and reactions to environmental change in the Asheville area – Research for the PIAF project.

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This research examines what kinds of change people notice in their environment, how they interpret these changes, and what is their response to them, with a focus on biodiversity change. This offers insight into local perspectives in the context of global environmental transformations and pressures. In the analysis we will seek to understand the influence of certain variables in Ashevillians' perceptions of environmental change including length of stay, profession, age, background, social networks and leisure activities. I am also questioning how people define the "environment" differently in the urban setting, especially in Asheville where "nature" is omnipresent. I have completed 30 of the 50 interviews required for this research over two and a half months, and conducted free-lists and participant observation. This research is part of the PIAF project (Interdisciplinary Program on local indicators of Fauna and Flora) which is a multidisciplinary and comparative research project

studying perceptions of environmental change in rural and urban areas of France, the USA, Cameroon and Zimbabwe. The Coweeta LTER are partners in this project. Asheville, North Carolina, is the US urban site

Evergreen shrubs alter canopy structure: evaluation using LiDAR and field measurements

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Context Vegetation structure is a basic characteristic of terrestrial ecosystems, and is often the result of complex interactions between the species, disturbance history, and terrain-mediated differences in substrate and microclimate. Airborne light detection and ranging (LiDAR) has made it possible to estimate forest structural characteristics remotely and continuously across large areas
Objectives Our primary goal was to evaluate LiDAR as a tool for estimating canopy height, aboveground biomass, and leaf area of deciduous forests within a complex mountainous terrain. We also sought to quantify the relationships between forest structural characteristics (tree height, density, biomass and leaf area; evergreen understory density; and canopy gap size and frequency) and terrain features (elevation, convexity, and exposure).
Methods We used a combination of LiDAR, satellite image data, and field measurements to sample southern Appalachian deciduous forest stands that had experienced no direct human disturbance over the past eighty years.
Results LiDAR accurately measured individual tree heights, based on a comparison of field-measured to LiDAR-estimated canopy heights. We found strong relationships between forest structure and landscape differences in understory evergreen plant density, and terrain convexity, elevation, and exposure (i.e., north vs. south aspect).
Conclusions Our analysis revealed robust, consistent, and measureable patterns that were related to elevation, exposure, and terrain convexity, and evergreen understory density across the landscape. In general, trees were shorter and had less biomass in more convex terrain positions (ridges relative to coves), on south facing slopes, and in areas with a denser evergreen understory. LAI was lower on ridges in areas with high evergreen understory density; and gaps were more frequent on south-facing slopes. The strongest responses in tree height and plot biomass were associated with changes in understory evergreen density, particularly at ridge and side-slope locations, with smaller but significant responses observed along terrain convexity, exposure, and elevation gradients.

Predicting antecedent soil moisture conditions in the riparian zone of a small forested headwater catchment using low-dimensional relationships

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How spatial soil moisture patterns vary from wet to dry periods is important for understanding the redistribution of soil water across the hillslope. Western et al. (1999) showed two dominant redistribution directions: (1) vertical into the soil and (2) horizontal towards the stream, where the magnitude was a function of how spatially organized the soil moisture was across the hillslope. The shifts between dominant redistribution pathways have implications for shallow groundwater recharge versus streamflow generation. These spatial patterns also contribute to overall catchment wetness prior to storm events and can be utilized to relate

antecedent moisture conditions to storm runoff response. However, measuring spatial soil moisture across even a single hillslope can be intensive. The goal of this study is to develop and test models that predict riparian soil moisture through time. Our study is located on a single instrumented hillslope within Watershed 14 of the Coweeta Hydrologic Lab. It is a northwest facing slope with 18 plots arranged into 3 transects. Transects roughly follow flowpath lines perpendicular to the stream. We synoptically sampled 0-6cm soil moisture using a portable Dynamax ThetaProbe at all 18 plots. Synoptic soil moisture measurements were collected on 19 separate occasions comprising over 3000 individual measurements. Data logged groundwater tables and soil moisture at 0-30cm and 30-60cm are also measured in 3 riparian plots. To start, we will focus our analysis only on days prior to storm events to simplify drainage characteristics to baseflow-like conditions. Then we will develop three models that correspond to (1) mass balance relationships of groundwater, soil moisture, and discharge, (2) spatial patterns of soil moisture, and (3) a combination of both. Below, these are outlined as three research objectives:

1. Relate antecendent soil moisture and riparian groundwater measurements to discharge at the catchment outlet.
2. Characterize hillslope-scale spatial soil moisture patterns from synoptic measurements.
3. Use mass balance and spatial relationships to develop models that predict near stream soil moisture.

Coweeta LTER 2015 Summer Meeting Notes
6/4/2015

Meeting started at 8:30 am with presentations from the different working groups.

Renewal ideas for Biodiversity group (Clark)

- Alternative futures for the SE US – models predict more droughts in the SE US, which may create savannahs in part of the SE
- Hydroclimate variation – effect of drought depends on the individual site
- In the panel review of our proposal, we were flogged for not testing theory; one theory we could test would involve manipulating the composition of the forest and look at effects on wet vs. dry sites, oak fitness vs. red maple fitness, and the interaction between these two factors
- Interactions can buffer or multiply effects
    - Will cool/moisture microhabitats provide refuges as surrounding habitats dry?
    - Or are the species that dominate moist habitats most vulnerable to drought?
- Indirect effects – competitors or predators may benefit from these indirect effects
- Step one: joint model for predictors/responses
- Why interaction theory?
    - Interaction – effect depends on other predictors (drought effects vary by site)
    - Indirect effect – effects depends on other responses (drought effects depend on responses of other species)
    - Synthesis – quantify effects in observational data, manipulate variables in experiment
- Oak savannah in the SE
    - Oaks/hickories insensitive to hydroclimate, flourish when competitors suffer moisture limitation/fire
    - Degree of hydroclimate variation where a tipping point reached, rapid transformation
- Example design
    - Species effect
        - Oak/hickory removal
        - Red maple/tulip removal
    - Stocking effect – thinning
- Today's discussion
    - Need to discuss experimental design
    - What needs to be measured?
    - Who can speak for Amy Rosemond?
    - How can this connect to regionalization?
    - Need to plan for integration, timing

Follow-up discussion

- Warren commented that this experiment would work well for herbs. He also liked the idea of having plots where we add water to subplots to assess increased wetness on herbs, etc. There are a host of other organisms that could be studied, including plant pathogens, fungi, etc.

- Hwang asked if this manipulation be at the watershed scale? If so, it would be good to look at impacts on stream discharge. We could engage with NEON to see if we could use their planes to fly over the site.
- Miniat mentioned that this study has been thought about for a while. Stakeholders want this research – removing mesic species (red maple, tulip poplar) in favor of oak. On the flip side, we have watersheds that are highly disturbed (WS6) that are still pumping out loads of nitrogen that would be interesting to re-visit.
- Strahm commented that it seems logical to do it at a watershed scale to link terrestrial and stream components.
- Miniat told the group that they are thinking about doing this manipulation on WS31, which has been gauged since about 1980. We would probably want to remove rhododendron too and would likely need to herbicide stumps, etc. following the cutting.
- Benfield thought the manipulation would be interesting from a stream perspective, to assess impacts on stream macroinvertebrates, etc. as a different composition of leaves fall in the stream.

<u>Renewal ideas for Regionalization group</u> (Bolstad)

- Have been considering four projects (below), but will re-evaluate based on change to biodiversity proposal
    - Land use drivers and legacies
    - Regional ecohydrology
    - Biotic responses from landscape to regions
    - Hydroclimatic and land use scenarios
- Regional ecohydrology
    - Test RHESSys model in nested watersheds, WS2 through Little T & French Broad basins
    - Compare stream flow, soil moisture, leaf area, and measurements on ecohydric manipulation plots
- Hydroclimatic and Landuse Scenarios
    - e.g. does development patterns in Atlanta affect the weather in Macon County
    - Census-driven development models – large scale, 30-m scale, will run RHESSys on entire southern Appalachians
- Land use drivers and legacies
    - Need interaction with population ecologists & social scientists
    - Had proposed to relate land disturbance to biophysical
- Biotic responses from landscapes to regions
    - Work depends on activities proposed by the biodiversity/ecosystem groups. Had proposed to predict response variables for focal taxa across scales – dependent on TDE

Follow-up discussion

- Clark was wondering what type of questions the Regionalization group are focusing on. Bolstad replied that they need to get with the other groups to help define those questions.
- Miniat mentioned that we could easily link the species conversion experiment with regionalization to apply this work to surface drinking water for municipalities.

- Clark asked if RHESSys could be run with some of the manipulations we've talked about.
- Turner asked if RHESys was done on the regional scale and we have hydroclimatic variability across this scale, do historic legacies amplify or dampen the signal in RHESSys?
- Burke commented that If we are looking at regionalization, we need to think about humans. How can we integrate species conversion (human excluded) with human modified environment?

Status of rhododendron removal project (Elliott)

- Partnership between LTER and USFS
- Rationale
    - Hemlock often co-occurs with rhododendron in southern Apps
    - Hemlock mortality due to infestation by HWA
    - Hemlock loss will result in self-replacing rhodo and little tree recruitment
    - Rhodo inhibits tree recruitment
    - Restoration of hemlock stands to the pre-HWA state is most desirable
- Many people and partners have been involved thus far
- Over-arching hypothesis – removal of *Rhododendron maximum* will alter ecosystem structure and function
- Many specific hypotheses, both terrestrial and steam-based, as well as integrating hypotheses
- Kitty showed slides of the experimental designs and location of intensive and extensive plots
- Streams at Wine Springs sites seem to be reacting identically from a hydrologic standpoint, which is good
- Collecting stream chemistry once a week; nitrate higher and pH lower than Coweeta reference streams
- Soil moisture increased in the rhodo cut plots, which isn't surprising
- Higher soil temperature on the cut and remove, but lower in the cut and leave (mulch layer keeps soil more moist/cool)
- Seed bank in hardwood w/out rhodo vs. hardwood w/rhodo; seems to have higher herb richness seed bank in hardwood w/out rhodo
- In both hardwood and rhodo plots, *Betula* and *Rubus* seed make up the greatest proportion of seeds

Renewal ideas from the Social Science group (Heynen)

- Craig Depken still interested in doing some of the market-value work
- Social science group has downsized due to passing of Carolyn Dehring, John Chamblee moving to different job, and Don Nelson stepping down from the LTER
- 4 objectives/hypotheses
    - Governance of citizen knowledge that relates to drivers and feedbacks of socioecological change – we hypothesize that environmental knowledge is a central component of how humans, across scales and institutions, make decisions that redistribute the movement of energy, material, and organisms within

ecosystems. Need to figure out a way to get social science data (interviews, etc.) online given restrictions of IRB, etc. The objective of this research is to examine how environmental knowledge, decision-making, and landscape change interact, at both individual and collective scales.

- Multi-scale human population drivers of land management practices – We hypothesize that increased 2nd home ownership and in-migration produce stronger extralocal linkages to people and places outsides the focal regions, which in turn alters land management and hydroclimate perceptions in ways increasingly distinct from the practices and perceptions of long-term residents who have stronger local linkages (i.e., old timers vs. new comers conversation)
- Land market responses to socioecological change – We hypothesize that changes in vulnerability of land parcels to various hazards (e.g. landslides), and the resultant regulatory responses (or lack thereof), will influence land prices and development decisions over time. Are there thoughts about vulnerability about flooding? (Bolstad) Not yet, but something we might consider (Heynen).
- Indigenous land use and environmental management – We hypothesize that because the Eastern Band of the Cherokee Indians (EBCI) have sovereignty over increasing land holdings tied to increased economic development, their land use and environmental management are becoming increasingly important drivers of socioecological change and future landscape scenarios. The objective of this research is to examine future regional scenarios of the EBCI's increased land use and environmental management practices.

ASM Working groups

- Rhett announced the 4 ASM NEON-related working groups

Afterwards everyone split up into working groups. The majority of PIs met to discuss the whole-watershed experiment. Regionalization group split to meet both with the social and the whole-watershed experiment group. The rhodo group met briefly to discuss current field activities.

Current proposal development schedule:

- June 18 – first paste-up with all four research proposals (no integration)
- July 16 – Second paste-up with revised research statements, integrated research introduction, & synthesis
- August 21 – In-person meeting of lead writers & SAC
- Mid-September – full draft ready for external review; draft budgets
- Send proposal to Peter Groffman, Paul Hanson, and whom else?
  Work on budget while awaiting reviews