SAMAB 19th Annual Conference

Southern Appalachian Man and the Biosphere

Climate Change in the Southern Appalachians

Asheville, North Carolina

November 17-19, 2009

Program and Abstracts

Climate Change in the Southern Appalachians

19th Annual SAMAB Conference
November 17-19, 2009 ~ Asheville, North Carolina

Agenda Overview

Tuesday, November 17, 2009		
8:30 a.m.	Registration opens (Laurel Foyer)	
9:30 a.m.	Welcome and Introductions, Gary Peeples, U.S. Fish and Wildlife Service **Plenary Address: Steve McNulty**, U.S. Forest Service, Southern Research Station; *Changing Times: Likely Impacts of Climate Change on Southern Appalachian Forests* **Keynote Address: Sam Pearsall**, Environmental Defense Fund; *Climate Disruption and the Southern Appalachians: Is Adaptation Possible?* (Roan-Pisgah rooms)	
noon	Lunch on your own	
1:30 p.m.	**Climate Change Research** (Roan room)	**Adaptation and Mitigation** (Pisgah room)
3:00 p.m.	Break	
3:30 p.m.	**Climate Change Research** (cont'd) (Roan room)	**Adaptation and Mitigation** (cont'd) (Pisgah room)
6:00 p.m.	**Poster Session** with light hors d'oeuvres and cash bar (Mitchell room)	
Wednesday, November 18, 2009		
7:45 a.m.	Registration (Laurel Foyer) and continental breakfast (Mitchell room)	
8:30 a.m.	**Land Use Patterns and Changes** (Roan room)	**Addressing Climate Change Issues in the Appalachian Highlands from the Bottom Up** (Pisgah room)
10:30 a.m.	Break	
11:00 a.m.	**Land Use Patterns and Changes** (cont'd) (Roan room)	**Addressing Climate Change Issues in the Appalachian Highlands from the Bottom Up** (cont'd) (Pisgah room)
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6:00 p.m.	**Evening Social** at the Crowne Plaza Resort. Buffet dinner plus entertainment…a very special Appalachian collaboration between the bluegrass band, ***Frogtown Four***, and commentary from ***Jeff Biggers***, Appalachian author and historian. (Overlook Ballroom)	
Thursday, November 19, 2009		
7:45 a.m.	Registration (Laurel Foyer) and continental breakfast (Biltmore Foyer, outside Roan-Pisgah rooms)	
8:30 a.m.	**Water Supply and Stress** (Roan room)	**Resource Restoration and Management** (Pisgah room)
10:30 a.m.	Break	
11:00 a.m.	**Water Supply and Stress** (cont'd) (Roan room)	**Resource Restoration and Management** (cont'd) (Pisgah room)
12:00 p.m.	Formal session adjourns. Field trip attendees have lunch on their own prior to departure.	
1:15 p.m.	**Blue Ridge Parkway Field Trip** including a hike at Craggy Gardens (depart from hotel's Convention Entrance outside Laurel lobby)	**NCDC/NEMAC Field Trip** (depart from hotel's Convention Entrance outside Laurel lobby**)**
5:00-5:15pm	Field trip returns to hotel by 5:15 p.m.	Field trip returns to hotel by 5:00 p.m.

19th Annual SAMAB Conference

Climate Change in the Southern Appalachians

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10:30 a.m.	Break	
11:00 a.m.	**Keynote Address: Sam Pearsall**, Environmental Defense Fund; *Climate Disruption and the Southern Appalachians: Is Adaptation Possible?*	
Noon	*Lunch*	
1:30 p.m.	**Climate Change Research** (Roan room) Moderator – Paul Super, National Park Service 1:30 Jake Weltzin, *Taking the pulse of our planet: The USA National Phenology Network* 2:00 Beverly Collins and Dan Pittillo, *Does flowering phenology of native plants indicate climate change?* 2:30 Neil Pederson, Ryan McEwan, and James Dyer, *Episodes of regional extended drought and stand dynamics prior to European settlement in Quercus-dominated forests*	**Adaptation and Mitigation** (Pisgah room) Moderator – Alice Cohen, U.S. Forest Service, National Forests in North Carolina 1:30 Todd Pierce, et al., *The Western North Carolina Report Card on Sustainability: Using visualization support tools to help decision makers understand climate change* 2:00 Karin Lichtenstein, et al., *The power of "what-if" thinking: Exploring climate effects and tradeoffs using a decision framework* 2:30 Steve Norman, et al., *The power of "what-if" thinking: Predicting climate-wildfire risks in the Pisgah National Forest*
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3:30 p.m.	3:30 Lenny Bernstein, *Climate change impacts on the Appalachian Trail* 4:00 Jerry Olson, *Environment and heredity – change on Appalachian, continental, and biospheric scales* 4:30 Robert Warren and Mark Bradford, *Climate change: Ecologists think global, climate acts local* 5:00 Mark Anderson and Thomas Minney, *Conservation in a changing climate: Science and collaboration for a resilient and adaptive future for biodiversity in the Appalachians*	3:30 William Hargrove, et al., *Toward a national early warning system for forest disturbances using remotely sensed canopy phenology* 4:00 Barbara Crane and Kevin Potter, *Rating the risk of climate change to southern Appalachian tree species, a tool for gene conservation decision-making* 4:30 Kevin Hamed and Mathew Gray, *Changes in salamander distributions along an elevation gradient in the Mount Rogers National Recreation Area* 5:00 Ryan Kirk and Paul Bolstad, *Land use change and terrestrial carbon accrual in Western North Carolina, 1850-2030*
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	Henry McNab and David White, *The rise and fall of southern yellow pines in the Bent Creek Experimental Forest* Steve Norman, et al., *How climate and leaf phenology regulate the fire season of the southern Appalachians* Yuri Potawsky, et al., *Sustainability indicators of land use change near public lands in western North Carolina* Anita Rose and Jim Rosson, *Potential East-West trends in down woody material across the southern U.S.* Pete Stone, *Greater drought vulnerability of mountain and Appalachian Piedmont ground water supplies, including stream baseflow and valley seepage: A lightly calibrated conceptual comparison with the Coastal Plain* Josh Taylor, et al., *Three centuries of fire and forest history in an old-growth* Quercus *forest on the Cumberland Plateau* Carolyn Wells, *U.S. Fish and Wildlife Service strategies for preparing and responding to climate change* Philip White and Saskia van de Gevel, *The dendroecology and disturbance regime of the red spruce-Fraser fir forest of Roan Mountain, Cherokee and Pisgah National Forests* Matt Winn, et al., *Digital picture tree crown evaluation software to monitor change*

Wednesday, November 18, 2009		
7:45 a.m.	Registration (Laurel Foyer) and continental breakfast (Mitchell room)	
8:30 a.m.	**Land Use Patterns and Changes** (Roan room) Moderator – Barry Clinton, U.S. Forest Service, Southern Research Station 8:30 PANEL – Population growth and resource management in the face of climate change: A southern Appalachian perspective Panelists: ▪ Larry Band, et al., *Landslide hazard in the southern Appalachians: Hydrological and ecological controls* ▪ Rick Wooten, et al., *Landslide hazard mapping in Macon, Watauga, and Buncombe Counties and investigations elsewhere in western North Carolina: Findings, observations, and implications* ▪ Stacy Guffey, *The 2008 Mountain Landscapes Initiative*	**Addressing Climate Change Issues in the Appalachian Highlands from the Bottom Up** (Pisgah room) Moderator –Carolyn Wells, U.S. Fish & Wildlife Service 8:30 PANEL – In the first panel, field-level personnel will profile examples of climate-sensitive natural resources unique or otherwise critical to the southern Appalachian landscape, and their uncertainties with respect to how best to manage these resources in the face of accelerated climate change. Panelists: ▪ *Chris Ulrey, Blue Ridge Parkway* ▪ *Megan Sutton, The Nature Conservancy* ▪ *Cleve Fox, U.S. Forest Service* ▪ *Jason Robinson, University of Tennessee* ▪ *Nancy Finley, Great Smoky Mountains National Park*
10:30 a.m.	*Break*	
11:00 a.m.	**Land Use Patterns and Changes (cont'd)**(Roan room) Panel presentations continue: ▪ Jim Stokoe, *Linking lands and communities in the Land-of-Sky* ▪ D. J. Gerken, *Growth trends and policy choices in the mountains region*	**Addressing Climate Change Issues in the Appalachian Highlands from the Bottom Up (cont'd)** (Pisgah room) Moderator – John Peine, U.S. Geological Survey 11:00 PANEL – A second panel of program managers will overview emerging regional initiatives and

	▪ Lewis Penland, *Macon County North Carolina land use ordinance development*	strategies (including monitoring, modeling, decision-support and risk assessment tools) and suggest how these programs could help address the specific issues presented in the first panel. Panelists: ▪ *Danny Lee,* U.S. Forest Service ▪ *Dave Meriwether,* U.S. Forest Service ▪ *Doug Burns, U. S. Geological Survey*
Noon	***Lunch***	
1:30 p.m.	**Land Use Patterns and Changes (cont'd)** (Roan room) Moderator –Judy Francis, NC DENR 1:30 Joey Wisby and Sally Palmer, *Modeling the distribution of Tennessee's population growth through 2025: Projected land use changes and implications for State wildlife action plan conservation priorities* 2:00 Chris Badurek, Austin Chamberlain, and Lloyd Edwards, *GIS modeling of exurban growth processes to guide environmental planning in Watauga County, NC* 2:30 Leah Mathews, *The benefits associated with agricultural land: Results from the Farmland Values Project*	**Addressing Climate Change Issues in the Appalachian Highlands from the Bottom Up (cont'd)** (Pisgah room) Moderator – John Peine, U.S. Geological Survey 1:30 PANEL – The second panel continues with more panelists describing regional initiatives and strategies (including monitoring, modeling, decision-support and risk assessment tools) and suggest how these programs could help address the specific issues presented in the first panel. Panelists: ▪ *Pete Murdoch, U.S. Geological Survey* ▪ *Sherry Morgan, U.S. Fish & Wildlife Serv.* ▪ *Thomas Minney and Mark Anderson, The Nature Conservancy* ▪ *Mallory Martin, NC Wildlife Resources Commission*
3:00	*Break*	

3:30	3:30 Phil Araman, Dan Hindman, and Matt Winn, *Wood waste options for reuse and recycling at a green housing development that reduces energy needs* 4:00 Ken Stolte, et al., *Exotic plant species and climate change in the southern Appalachians* 4:30 Virginia Dale, et al., *Modeling transient response of Tennessee forests to climate change*	**Addressing Climate Change Issues in the Appalachian Highlands from the Bottom Up** **(cont'd)** (Pisgah room) 3:30 Panel discussion continues Panelists: ▪ *Dr. Y.Q. Wang, Rhode Island University* ▪ *Jim Fox, National Environmental Modeling and Analysis Center* Discussion with all panelists.
6:00 – 10:00 pm	**Evening Social** at the Crowne Plaza Resort. Buffet dinner plus entertainment…a very special Appalachian collaboration between the bluegrass band, ***Frogtown Four***, and commentary from ***Jeff Biggers***, Appalachian author and historian. (Overlook Ballroom)	

Thursday, November 19, 2009		
7:45 a.m.	Registration (Laurel Foyer) and continental breakfast (Biltmore Foyer)	
8:30 a.m.	**Water Supply and Stress** (Roan room) Moderator –Judy Francis, North Carolina Department of Environment and Natural Resources PANEL – Climate change and trout in the southern Appalachians: Biology to policy ▪ Current and expected habitat conditions and management strategies for trout in southern Appalachia ▪ Activities of NGOs as educators, advocates, and sources of technical expertise ▪ State and federal climate change policy ▪ Possible funding opportunities Panelists: ▪ *Nathanial Gillespie, Trout Unlimited* ▪ *Doug Besler, NC Wildlife Resources Commission* ▪ *Fred Harris, former deputy director, NC Wildlife Resources Commission, former president, American Fisheries Society* ▪ *Sheryl Bryan, U.S. Forest Service* ▪ *Capt. Michael "Squeak" Smith, Trout Unlimited* ▪ *Richard Mode, National Wildlife Federation*	**Resource Restoration and Management** (Pisgah room) Moderator – Michelle Aldridge, U.S. Forest Service, National Forests in North Carolina 8:30 Kevin Potter, William Hargrove, and Frank Koch, *North American forest trees, climate change, and genetic peril: A forest health monitoring project* 9:00 Laura DeWald and Stephanie Grant, *Response of southern Appalachian tree species to climate change: Should we intervene?* 9:30 Jason Fridley, *Present and future near-ground microclimates across Great Smoky Mountains National park: Forecasts from the GSMNP temperature network* 10:00 Hugh Irwin, *Potential for climate adaptation within elevation and latitude gradients in the southern Appalachians*
10:30 a.m.	*Break*	
11:00 a.m.	**Water Supply and Stress** **(cont'd)** (Roan room) Moderator –Alice Cohen, U.S. Forest Service, National Forests in North Carolina	**Resource Restoration and Management** **(cont'd)** (Pisgah room)

	11:00 Ge Sun and Steve McNulty, *Impacts of climate change on watershed hydrology and water supply stress in the southern Appalachians region* 11:30 Jon Calabria, Carter Cone, and Rockie English, *Benthic macroinvertebrates response to imperviousness: Rapid bioassessment findings in the southern Appalachians*	11:00 Scott Pearson and Jennifer Fraterrigo, *Habitat quality, niche breath, temporal stochasticity, and the persistence of populations in heterogeneous landscapes* 11:30 Chris Fusting, Gary Kauffman, and Neil Thomas, *Employing LiDAR data for vegetation management on Roan Mountain*
Noon	*Lunch*	
1:15 p.m.	**Field Trip – Blue Ridge Parkway with focus on Climate Change *(includes a hike at Craggy Gardens)*** Buses for field trips depart from the covered porch area just outside Laurel lobby. Bus returns to hotel at 5:15 p.m.	**Field Trip – Insider's tour of National Climatic Data Center and the new National Environmental Monitoring and Analysis Center exhibit space** (downtown Asheville) Buses for field trips depart from the covered porch area just outside Laurel lobby. Bus returns to hotel at 5:00 p.m.

Acknowledgements

SAMAB greatly appreciates the outstanding assistance and cooperation of the following individuals and organizations that have worked to make this conference a success:

Conference Co-Sponsors

U.S. Forest Service
U.S. Fish & Wildlife Service
Oak Ridge National Laboratory
North Carolina Department of Environment and Natural Resources
SAMAB Foundation and SAMAB Cooperative

19th Annual SAMAB Conference Planning Committee

Nancy Herbert, Conference Chairperson, U.S. Forest Service, Southern Research Station
Barry Clinton, U.S. Forest Service, Southern Research Station
Judy Francis, North Carolina Department of Environment and Natural Resources
Carolyn Wells, U.S. Fish & Wildlife Service
Zoe Hoyle, U.S. Forest Service, Southern Research Station
Alice Cohen, U.S. Forest Service, National Forests in North Carolina
Michelle Aldridge, U.S. Forest Service, National Forests in North Carolina
Steve McNulty, U.S. Forest Service, Southern Research Station
Gary Peeples, U.S. Fish & Wildlife Service
John Peine, U.S. Geological Society, Southern Appalachian Field Lab
Susan Schexnayder, University of Tennessee
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Julie Dennis, Cradle of Forestry Interpretive Association
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Rick Durbrow, Environmental Protection Agency; SAMAB Executive Committee, Past-Chair
Gary Peeples, U.S. Fish & Wildlife Service; SAMAB Executive Committee, Chair
Charles VanSickle, SAMAB Foundation President

19th Annual SAMAB Conference

Climate Change in the Southern Appalachians

ABSTRACTS

Plenary Address

Changing Times: Likely Impacts of Climate Change on Southern Appalachian Forests

Tuesday, November 17, 2009, 9:30 a.m. (Roan-Pisgah rooms)

Steven G. McNulty

Research Ecologist, Southern Global Change Program, U.S. Forest Service, Southern Research Station

The southern Appalachians are socially, ecologically and economically important to the United States (US). Timber, sources of clean water, carbon capture, landscape beauty, and wildlife habitats are a few of the services provided by these ecosystems. However, since 1850 atmospheric concentrations of carbon dioxide and other greenhouse gases associated with global warming have changed the climate of the US, and that rate of change is increasing. Southern Appalachian forests have slowly evolved over thousands of years, and the impacts of rapid climate change on ecosystem health and natural resource supply is uncertain. However, there is sufficient evidence to indicate the general direction if not magnitude of change. Climate variability (i.e., daily to inter-annual scale) is likely to increase, bringing more intense precipitation events, droughts, and heat waves. These changes, in turn, will likely increase soil erosion, stream sedimentation, and wildfire occurrence. Increases in insect and disease outbreaks will likely be worsened by a synergism with other pollutant stresses (e.g., ozone, acid rain). Long-term climate change (i.e., decadal and beyond) associated with increasing temperature and shifts in precipitation patterns and seasonality will likely lead to changes in ecosystem composition, fisheries, and wildlife habitat, forest and range land productivity, and stream flow. The severity of climate change may alter both the composition and function of southern Appalachian forests. Forest and rangeland managers to have a role in mitigating climate change. Land managers will also need to develop and apply adaptation tools and strategies to minimize the negative impacts of climate variability and change on these ecosystems. An introduction to climate change and a discussion of the interactions between climate change and other environmental stresses on southern Appalachian forest health will be presented in this talk.

Steven G. McNulty
U.S. Forest Service, Southern Research Station
920 Main Campus Dr., Suite 300, Raleigh, NC 2760
(919) 515-9489; steve_mcnulty@ncsu.edu

Keynote Address

Climate Disruption and the Southern Appalachians: Is Adaptation Possible?

Tuesday, November 17, 2009, 11:00 (Roan-Pisgah rooms)

Dr. Sam Pearsall

SE Regional Manager for Land Water & Wildlife, Environmental Defense Fund

Climate disruption is certain to be a powerful re-organizer of ecosystems. There is a range of potential outcomes, beginning with drastic simplification and collapse on the least optimistic end of the continuum. The goal for adaptation should be to maintain complexity and functionality even as ecosystems are transformed by climate disruption into entirely new systems. In general, the strategy should consist of determining the vulnerabilities – the places where simplification is most likely to be driven by climate disruption – and then applying the basic tools of adaptive ecosystem management to reduce simplification, or at least the rate at which it happens. Successful application should conserve complexity of composition, structure and function even as the components of each are transformed, sometimes drastically. We need to implement this approach as quickly and systematically as we can, which means we need to rely mainly on the ecosystem management tools we already have, as we also work to design new tools. Adaptive management to maintain or enhance ecosystem resilience in the face of climate disruption will require us to use the tools we do have in innovative ways. It will not be enough to maintain the health of the systems we presently manage in the context of the current environment and hope for the best. In the Southern Appalachians, with their extraordinary diversity driven in very large part by microclimatic variation, adaptation to climate disruption will be as challenging as anywhere on the planet.

Dr. Sam Pearsall
Environmental Defense Fund
4000 Westchase Boulevard, Suite 510, Raleigh, NC 27607
919-881-2938; SPearsall@edf.org

Session: Climate Change Research

November 17, 2009; 1:30–5:30 p.m. (Roan room)

Session Moderator:
Paul Super, National Park Service,
Great Smoky Mountains National Park

Taking the pulse of our planet: The USA National Phenology Network

Jake F. Weltzin, Director, U.S. Geological Survey, USA National Phenology Network, Tucson, AZ (520) 626-3821; jweltzin@usgs.gov

Patterns of phenology for plants and animals control ecosystem processes, determine land surface properties, control biosphere-atmosphere interactions, and affect food production, health, conservation, and recreation. Although phenological data and models have applications related to scientific research, education and outreach, agriculture, tourism and recreation, human health, and natural resource conservation and management, until recently there was no coordinated effort to understand phenology at the national scale in the United States. The USA National Phenology Network (USA-NPN; www.usanpn.org), established in 2007, is an emerging and exciting partnership between federal agencies, the academic community, and the general public to establish a national science and monitoring initiative focused on phenology. USA-NPN will integrate with other formal and informal science observation networks, utilize and enhance remote sensing products, emerging technologies and data management capabilities, and capitalize on myriad educational opportunities and a new readiness of the public to participate in investigations of nature on a national scale. This talk will illustrate how phenology is an emerging integrative science for assessing impacts of climate change and for increasing citizen awareness and participation in understanding environmental impacts of human activities on Earth systems.

Does flowering phenology of native plants indicate climate change?

Beverly Collins[1] and Dan Pittillo[2]
[1] Department of Biology, Western Carolina University, Cullowhee, NC 28723 (828) 227-3663; collinsb@email.wcu.edu
[2] Cane Creek, Cullowhee, NC 28723 (828) 293-9661; dpittillo@gmail.com

Phenology of temperate forest plants often tracks soil or air temperature and can indicate climate change. We examined trends in flowering phenology in a suite of understory herbs and one shrub (*Lindera benzoin*) that were planted in a common garden and have been monitored since 1976. For all species,

there was considerable year-to-year variation in flowering date, with definite early (e.g., 1976) and late (e.g., 2001) years. Regression of flowering date against time and comparison of 1976-1980 with 2004-2008 average flowering dates revealed a significant trend toward earlier flowering dates over time in some species, including the early-flowering *Carex plataginea* and later-flowering *Geranium maculatum*. However, 24 percent (4/17) of plants with average flowering date between March 14 and 31 flowered earlier in years with warmer spring temperatures and an additional 35 percent (6/17) showed a similar, but weaker and not significant trend. These results suggest a continuing trend of warmer springs could result in earlier flowering of native spring herbs.

Episodes of regional extended drought and stand dynamics prior to European settlement in *Quercus*-dominated forests

Neil Pederson[1], Ryan W. McEwan[2], and James M. Dyer[3]
[1] Cumberland Laboratory of Forest Science, Dept. of Biological Sciences, Eastern Kentucky University, Richmond, KY 40475
[2] Laboratory of Environmental Ecology, Dept. of Biology, University of Dayton, Dayton, OH 45469
[3] Dept. of Geography, Ohio University, Athens, OH 45701

Death of individual trees, singularly or in small clumps has been shown to provide important opportunities for canopy accession in eastern deciduous forests, especially those in the southern Appalachian Mountains. Yet, paleoecological studies often reveal historical events where forest types simultaneously change in composition across a broad geographic region. Here we present annually-resolved data composed of three species across the southern Appalachian region that in two ways suggests 1) the occurrence of a simultaneous canopy accession event and 2) episodic recruitment of *Quercus* trees through time. An additional tree-ring record from a fourth species and a regional drought reconstruction suggests that the canopy accession event occurred during a climatic transition between a three-decade drought to a decade-long pluvial event. The spatiotemporal patterns within this data set support paleoecological records and suggest climate as an important factor of stand dynamics. It does not negate gap-phase dynamics, but suggests stand composition in the southern Appalachians can be strongly influenced by episodic, regional events. Because the data set was collected by different investigators with differing objectives and sampling schemes and there is a striking pattern of tree recruitment and a simultaneous increase in ring width across the region, it suggests that this somewhat small data set has some revelatory power about the historical ecology of extant old-growth forests in this region.

Climate Change Impacts on the Appalachian Trail

Lenny Bernstein, PhD., 488 Kimberly Ave., Asheville, NC 28804
(828) 236-0192; Lsberns@att.net

The Appalachian Trail Conservancy (ATC) is a volunteer-based organization dedicated to the preservation and management of the natural, scenic, historic, and cultural resources associated with the 2,178 mile Appalachian Trail (A.T.) in order to provide primitive outdoor-recreation and educational opportunities for Trail visitors. ATC's Board of Directors has committed the Conservancy to educating members and Trail visitors about the impacts of climate change on the A.T. To do this effectively, we needed a projection of climate change over the A.T.

We used Climate Wizard, a downscaling tool developed by The Nature Conservancy, University of Washington and University of Southern Mississippi, to project climate over the A.T. for the period 2041 to 2060. These projections showed up to 3°C (5.4°F) warming over the A.T. in the Southern Appalachians during the summer, and no increase or a decrease in precipitation. This combination would make drought much more common over A.T., significantly affecting the hiker experience, and increasing the potential for treadway erosion.

The warming of the last 35 years has had a significant impact on the composition of forests along the A.T. in the Southern Appalachians. Boreal tree species, such as red spruce, have moved upslope; further warming could lead to their disappearance. Birds and animals dependent on these tree species would also disappear. The combination of disruption due to die-off of some tree species and climate change could increase the prevalence of invasive species. The next step in our program will be to factor these projections into long-term plans for managing the Trail.

Environment and heredity—Change on Appalachian, continental, and biospheric scales

Jerry S. Olson, Global Patterns Co., 508 Eblen Cave Road, Lenoir City TN 37771
(865) 376-2250; Jerryolson80@yahoo.com

Recent syntheses confirm biospheric carbon's important but variable influence on net change of greenhouse gases. As absorption of these diminishes in the ocean, South America and South Asia, and western U.S. lands, it is important to verify possible carbon build-up in eastern states, and possibly Africa and northern Australia. Regrowth of biomass and soil in SAMAB and Cumberland Plateau counties needs to be compared with Midwestern and Canadian predictions, for contrasting hypotheses about roles of potential bioenergy inventories and harvest timing. Contrasting climatic outcomes for Appalachia and America include drastic increase of drought ("savanna climate?) in and around Tennessee, and compression and/or altered burning risks for mountain zones. If cellulosic or other biofuel prospects become real, Tennessee and Midwestern provinces would experience significant but distinct trends. These imply contrasting reactions on human land stewardship roles, for either drastic or moderate climate future changes. Coarse mapping of ecosystems suffices for showing how ecosystems (and their changes) modify momentum, energy, and moisture of air mass, because air moves so rapidly. Weighted averages of surface roughness, canopy, and water exchange

may suffice, but can be improved as supercomputer model resolution keeps improving. However, impacts of climate on ecosystems can be modeled only with even better map resolution—and dealing with patterns, not just variance, within coarse cells of air models.

Great existing biodiversity around SAMAB study centers MAY allow deliberate or accidental adaptation of species and ecotypes in wild and cultural communities. Experiments on hemlock (*Tsuga canadensis*—30 genetic sources) showed high-altitude parents "programmed" offspring into dormancy earlier than lowland ecotypes (*e.g.* Newfound Gap *vs.* Pigeon Forge). Might genetic variability adapt rapidly—maybe also to adelgid survivability? Or will long generation lags leave many trees poorly "tuned" to the annual and diurnal cycles of their lives?

Climate change: Ecologists think global, climate acts local

Robert J. Warren II[1] and Mark A. Bradford, School of Forestry & Environmental Studies, Yale University, New Haven, CT 06511
[1](828) 506-1253; Hexastylis@gmail.com

An enormous discrepancy exists between climate trends at global and regional scales as the global mean exhibits a steady upward tendency not reflected in many regions. Further divergence is driven by regional-scale oscillations that cause separation between warm and cool season climate drivers. These discrepancies mean that insights from existing ecological research may be suspect. Indeed, the Intergovernmental Panel on Climate Change report that existing research emphasizes global-scale patterns and that there is an urgent need for studies disaggregated to regional and local scales. We tested the perspective that researchers commonly assume global and annual means in explaining local or regional ecological patterns by quantifying the results of climate change research reported in 2008 in four top ecology journals. The significance of the results of our literature survey is then illustrated through a case study focused on historical climate at the local scale. Specifically, we first assessed climate trends (1931-2004) in the southern Appalachian region. Next, we tested whether regional warm and cool season temperature and precipitation trends reflected that of the global mean or the North Atlantic Oscillation (NAO) index. Lastly, we examined whether global temperature trends or NAO better predicted stream salamander abundance in the region.

Our results suggest that more than half of the climate change research in the ecological literature assumes annual global means rather than regional climate when explaining ecological trends. These results are disconcerting in light of our findings that global trends poorly correspond with southern Appalachian temperatures and precipitation while seasonal fluctuations in the NAO are tightly coupled with temperature and precipitation trends as well as salamander abundance. Our findings highlight that cool and warm season climate trends may have different drivers, and that global trends may be poor surrogates for local climates. Ecologists need to explicitly recognize this to permit

informed prediction of ecological response to projected climate change.

Conservation in a changing climate: Science and collaboration for a resilient and adaptive future for biodiversity in the Appalachians

Dr. Mark Anderson[1] and Thomas Minney[2]
[1]Director of Science for the Eastern Division of The Nature Conservancy
[2]Central Appalachians Project Director for The Nature Conservancy

The Appalachian Mountains represent a globally important example of temperate broadleaf forest, freshwater ecosystems, small patch endemics, and cave and karst systems. To effectively conserve these systems and the high levels of biodiversity they support in the face of climate change, scientists must renew focus on what factors create and maintain these systems and their associated patterns of biodiversity. Practitioners will also need to develop an Appalachians wide network of landscapes and connections that will allow large-scale ecological functions and processes to be maintained. Mark Anderson from The Nature Conservancy (TNC) will explore how the conservation of species in a changing climate requires a renewed focus on the factors that create and maintain biodiversity, and will highlight TNC's approach to defining those factors and developing a network of landscapes that offer the most resilience in the face of climate change. Thomas Minney will then present how Anderson's work has been applied in the Appalachians, and how TNC is using the work to catalyze partnerships with public agencies to create an Appalachian network. In particular, Minney will overview how TNC is currently assessing climate change in its Conservation Action Plan (CAP) for the Central Appalachians, and discuss that organizations' strategy for applying a similar CAP approach in the southern Appalachians.

Session: Adaptation and Mitigation

November 17, 2009; 1:30-5:30 p.m. (Pisgah room)

Session Moderator:
Alice Cohen, U.S. Forest Service, National Forests in North Carolina

The Western North Carolina Report Card on Sustainability: Using visualization support tools to help decision makers understand climate change

Todd Pierce, UNC Asheville's National Environmental Modeling and Analysis Center (NEMAC)
Collaborators: Jim Fox, Jeff Hicks, Matt Hutchins, Karin Lichtenstein, Bridget O'Hara, Beth Porter, NEMAC; Susan Fox, Mary Carol Koester, U.S. Forest Service

Communities in western North Carolina are very concerned with climate change, but do not have the proper tools to address the effects or impacts expected from our changing climate. This shortcoming is due largely to uncertainties in climate models and the lack of properly scaled data. In addition, policy makers do not make decisions regarding future resource planning based on climate change issues alone. Instead, they would prefer to make these decisions by linking climate change information to other value drivers in their communities such as quality of life indicators, sustainable economic growth, open space preservation, and biodiversity protection.

To address these challenges, the Western North Carolina Report Card on Sustainability was created. This project is a collaboration between the U.S. Forest Service Southern Research Station (SRS) and UNC Asheville's National Environmental Modeling and Analysis Center (NEMAC). The Report Card provides a trusted source of data covering economic, ecological, biological, and social factors relevant to forest sustainability in an eighteen-county region in western North Carolina. The Report Card also includes historical climate information, explains climate change predictions, and shows how climate change affects sustainability indicators.

However, providing data in a visual format is not sufficient; users also must be guided in their use of the data. An additional collaboration between SRS, the Eastern Forest Environmental Threat Assessment Center (EFETAC) and NEMAC supports this need by applying the data and visualizations in group decision-making settings. Through a decision making process called the Comparative Risk Assessment Framework and Tools (CRAFT), community groups, forest managers and

planners can use the Report Card and its related tools to ensure that desired values are protected.

The power of "what-if" thinking: Exploring climate effects and tradeoffs using a decision framework (Part 1)
Karin Lichtenstein, UNC Asheville's National Environmental Modeling and Analysis Center (NEMAC)
Collaborators: Jim Fox, Matt Hutchins, NEMAC; Danny Lee, Steve Norman, U.S. Forest Service

Forest planners and resource managers continually face difficult and complex decisions. Many obstacles are inherent to decision making such as capturing stakeholder viewpoints, processing data and information, and dealing with uncertainties about possible actions and environmental threats. The cumulative uncertainties associated with climate change present seemingly insurmountable challenges for decision making. Without a clear understanding of the tradeoffs and effects from possible actions dealing with climate change, stakeholders and decision makers are often unable to form strategies to cope with future change. In order to answer the "what if" questions that decision makers face with climate change, the U.S. Forest Service has developed a NEPA-based decision making process called the Comparative Risk Assessment Framework and Tools (CRAFT). CRAFT is designed to help groups understand the uncertainties they face and provides them with the tools to make decisions efficiently and effectively. With CRAFT, groups are led through a process that results in a transparent and science-based decision. This presentation will describe the process and tools that CRAFT employs, including how managers can conceptualize climate change, how they can structure and organize objectives up-front, and ways they can accurately explore solutions and tradeoffs. The processes and tools in CRAFT can help managers better understand the likely effects and tradeoffs associated with climate change and how it might be mitigated.

The power of "what-if" thinking: Predicting climate-wildfire risks in the Pisgah National Forest (Part 2)
Steve Norman, U.S. Forest Service, Eastern Forest Threat Assessment Center (EFETAC), 200 WT Weaver Blvd., Asheville NC 28804 (828) 259-0535; stevenorman@fs.fed.us
Collaborators: Danny Lee, EFETAC; Frank Obusek, Tom Tribble (Center for Geographic Information and Analysis, Swannanoa, NC); Karin Lichtenstein, Matt Hutchins, Jim Fox (UNC Asheville's NEMAC).

Fire is both a catalyst of ecological change and a means of restoring forest resilience. These roles are important for predicting how forest values will respond to climate change. To predict fire effects, managers rely on fire behavior models that use spatial data that is often inaccurately mapped or inherently unknowable with precision. Vegetation-based fuels have proven especially difficult to accurately map, and future fire

weather is best viewed probabilistically. In addition to these uncertainties, existing fire models were developed with assumptions that are more valid for coniferous forests and they fail to incorporate the seasonal canopy dynamics of deciduous forests that dominate the east. The eastern fire season largely occurs in the spring and fall as it is thought to be constrained by leaf phenology. In this presentation, we demonstrate how uncertainties related to fire behavior predictions can affect the quality of decisions.

Using a portion of the Pisgah National Forest, we modeled fire intensity using different assumptions of canopy cover, weather and fuels within a probabilistic influence model. We generated climate change scenarios by altering the weights of historical weather conditions. Climate scenarios affected the duration of the fire season (by affecting canopy leaf phenology) and fuel moisture. We addressed the effects of uncertain fuel maps by comparing an existing map and one we developed ourselves based on remote sensing. Our model demonstrates how uncertainties related to canopy conditions, fuels and climate are cumulative, but that some mitigation strategies may be more useful than others. This approach allows for a transparent exploration of uncertainties associated with data quality, climate change and mitigation alternatives, all within a single planning and analysis framework.

Toward A national early warning system for forest disturbances using remotely sensed canopy phenology

William W. Hargrove[1], Joseph P. Spruce[2], Gerald E. Gasser[3], and Forrest M. Hoffman[4]
[1]Eastern Forest Threat Assessment Center(EFETAC), U.S. Forest Service, Southern Research Station, 200 WT Weaver Boulevard, Asheville, NC 28804-3454 (828) 257-4846; hnw@geobabble.org
[2]SSAI, Building 1105, John C. Stennis Space Center, MS 39522
[3]Lockheed Martin Civil Programs, Bldg. 5100, John C. Stennis Space Center, MS 39522
[4]Oak Ridge National Laboratory (ORNL), Computational Earth Sciences Group, Building 5600, Room C221, MS 6016, P.O. Box 2008, Oak Ridge TN 37831-6016

We are using a statistical clustering method for delineating homogeneous ecoregions as a basis for identifying changes in forests through time over large areas, up to national and global extents. Such changes can be shown relative to past conditions, or can be predicted relative to present conditions, as with forecasts of future climatic change. This quantitative ecoregion approach can be used to predict destinations for populations whose local environments are forecast to become unsuitable and are forced to migrate as their habitat shifts, and is also useful for predicting the susceptibility of new locations to invasive species such as sudden oak death. EFETAC and our sister western center WWETAC, along with our NASA and ORNL collaborators, is designing a new national-scale early warning system for forest threats, called FIRST. Envisioned as a change-detection system, FIRST will identify all changes,

and then try to discriminate normal, expected seasonal changes from locations having unusual activity that may represent potential forest threats. As a start, we have developed new national data sets every 16 days from 2002 through 2008, based on land surface phenology, or timing of leaf-out in the spring and brown-down in the fall. Changes in such phenological maps will be shown to contain important information about the status, vigor and health of vegetation across the United States.

Rating the risk of climate change to Southern Appalachian tree species, a tool for gene conservation decision-making

Barbara S. Crane[1] and Kevin M. Potter[2]
[1] U.S. Forest Service, Southern Region, National Forest System, Atlanta, GA 30309
[2]Department of Forestry and Environmental Resources, North Carolina State University, Research Triangle Park, NC 27709

Climate change may pose a severe threat to the viability of many forest tree species as their environment is impacted by changes in temperature, precipitation, soil moisture, and/or rising sea levels. These threats will impact tree species by forcing them to either adapt to new conditions or to shift to more favorable environments. Several forest tree species of the Southern Appalachians may be at particular risk because they occur in limited high-elevation ranges and/or are currently threatened by non-native insects and diseases. For some species, *in situ* and *ex situ* gene conservation actions may be required to avoid the extirpation of populations or the extinction of entire species. Partners, both internal and external (such as the National Forests' Genetics Lab, National Seed Lab, Camcore and ARS National Center for Genetic Resource Preservation) are assisting the U.S. Forest Service with these types of gene conservation measures.

To help facilitate the effective use of limited resources for on-site management activities and off-site gene conservation efforts for southern Appalachian forest tree species, a risk rating system has been developed. This system rates each species' risk of genetic degradation resulting from climate change. The strategy is to outline a rating system based on associated risk factors from two categories: intrinsic factors and extrinsic factors. Intrinsic factors, relating to a species' biology, includes population structure characteristics (range size, number of populations); reproductive attributes (fecundity, mode of seed dispersal); and habitat characteristics (site specialization or limitation to high elevations). Extrinsic factors, associated with human-related influences, include exotic pest or pathogen infestation, over-exploitation and magnitude of expected range shift with climate change. The scores from both intrinsic and extrinsic factors are then summed to give an overall risk rating for each species. We will present examples of southern Appalachian forest tree species with high, moderate and low expected risk of climate change-related genetic degradation, and the gene conservation strategies for those species.

Changes in salamander distributions along an elevation gradient in the Mount Rogers National Recreation Area

M. Kevin Hamed[1], Dr. Mathew J. Gray[2]
The University of Tennessee, Institute of Agriculture, Department of Forestry, Wildlife and Fisheries, 274 Ellington Plant Sciences Building, Knoxville, TN 37996-4563;
[1]mhamed@utk.edu; [2]mgray11@utk.edu

Amphibian populations worldwide have been declining for at least the past 25 years and climate change has been identified as one of the possible mechanisms. The Southern Appalachian Mountains are home to the world's greatest diversity of salamander. Many of these salamanders reside on isolated mountain peaks which provide cool moist habitat needed for their survival. In the 1950s, Dr. Jim Organ established 10 transects along independent elevational gradients throughout the Mount Rogers National Recreation Area (MRNA), Virginia, to determine salamander distributions. Each transect was divided into 100-ft elevational increments, and collectively they traversed 3,000-5,400ft. Dr. Organ sampled these transects in the 1950s and 1990s. These baseline data provided a unique opportunity to examine possible historical changes in salamander distributions. We re-sampled 7 of these transects in 2008 – 2009 and compared results to the baseline data. *Plethodon welleri* decreased its minimum elevation on all transects, while *P. cylindraceus* became absent from most low-elevation sites. Many stream-dwelling *Desmognathus* salamanders lowered their maximum elevation whereas *P. yohahlossee* and *D. wrighti* increased their maximum elevation. Our results suggest that historical distributions of some salamander species have changed along elevational gradients in the MRNA. Mechanisms responsible for these changes are unknown but may include climate change, habitat succession or degradation, and interspecific competition. Future analyses will include relating distribution shifts to changes in climate, forest structure, and competitive dominance.

Land Use Change and Terrestrial Carbon Accrual in Western North Carolina, 1850-2030

Dr. Ryan Kirk, Department of Environmental Studies, Elon University,
Campus Box 2335, Elon, NC 27244
(336) 278-6477; rkirk2@elon.edu
Collaborator: Dr. Paul Bolstad, Department of Forest Resources, University of Minnesota, pbolstad@umn.edu

Land-use change is a primary driver of changing carbon pools in terrestrial ecosystems. Throughout the United States, recovery from agriculture expansion and abandonment, increased fire suppression, and reduced timber harvest have resulted in a large net sink of carbon from the atmosphere. However, the rates and magnitudes of this historic sink are uncertain for many regions, and detailed land-use based studies provide opportunities for evaluating the sink.

This presentation summarizes a two-part research project in 1) modeling spatially explicit decadal land use change between 1850-2030 across the 21-county "Mountains of North Carolina" Forest Service FIA Unit and a detailed case study in Macon County, and 2) applying terrain-based aboveground forest

biomass accrual curves to estimate historic and future changes in terrestrial carbon storage due to agriculture, development, and forest harvest.

We estimate that 34% of the 21-county area in the region was cultivated at some time, and that the total area footprint of residential and commercial development has doubled since 1970 and tripled since 1950. We forecast that agricultural area will decline 12% by 2030 and the total forest area, which peaked in the 1980s following recovery from widespread agriculture abandonment, will decrease 4.8% as development pressures continue. We estimate in Macon County that aboveground biomass decreased from an average of 201 Mg Carbon/Ha in 1850 to a low of 40 Mg/Ha in 1930, and has since been recovering at a decreasing rate from 26% per decade during 1940-1970 to 5% per decade since 1990. We forecast that although total forest area in Macon County will decrease 4% from 2000 to 2030 due to expanding development, carbon accrual in aboveground woody biomass will increase by 10%. Overall, industrial logging between 1880-1930 accounted for 84% of the net carbon loss, while agricultural expansion accounted for 16%.

Poster Session

November 17, 2009; 6:00–8:00 p.m. (Mitchell room)

Organizer and Moderator:
Barry Clinton, U.S. Forest Service, Southern Research Station,
Coweeta Hydrologic Laboratory

Defining southern Appalachian riparian zone width using structure and function

Barton D. Clinton[1], James M. Vose[1], Jennifer D. Knoepp[1], Katherine J. Elliott[1], Barbara K. Reynolds[2]
[1] U.S. Forest Service Southern Research Station Coweeta Hydrologic Laboratory 3160 Coweeta Lab Road, Otto, NC 28763 US
[2]University of North Carolina at Asheville, Asheville, NC
[1](828) 524-2128 x124, bclinton@fs.fed.us

Effectively defining riparian zone width is at the center of an ongoing debate about the protection of critical aquatic and terrestrial processes and habitats in southern Appalachian ecosystems. In this study we characterized structural and functional variation along 50-m transects from the stream-side into the uplands. Our objective was to identify parameters that exhibited significant transitions along these transects to aide in defining riparian zone width. Four sites were selected and eight transects were installed perpendicular to the stream on each site. Both structural and functional components were examined. For structure, we quantified CWD and forest floor mass N and C, total soil C and N by horizon, soil depth, woody and herbaceous vegetation, litter fall amount and quality by species, and microclimate. Functional parameters included litter decomposition, soil micro-arthropods, soil CO_2 evolution, soil solution chemistry, and exchangeable ions. Some parameters exhibited distinct transitions along the stream-side to upland gradient. For example, forest floor litter mass, N and C all increased significantly with distance from stream with a transition point of approximately 10 to 20-m from the stream. Soil depth also increased significantly with distance from stream and transitioned around 10-m from the stream. In contrast, litter fall rate (kg N $ha^{-1}d^{-1}$), CWD, soil C and N in the A-horizon, and soil solution [NO_3] all decreased with distance from stream and all showed significant transition points along the transects. Certain overstory tree species were more abundant at one extreme of the gradient or the other, and herbaceous species were similar in number but varied in their proportions along the stream to upland gradient consistent with specific microsite preferences. Taken together, these results

suggest a key riparian to upland transition at about 10 to 20 m from the stream.

Alternative crops in an agroforestry system

K. Connor[1], R. Barlow[2], L. Dimov[3], M. Smith[4]
[1] U.S. Forest Service, Southern Research Station, Auburn, AL
kconnor@fs.fed.us
[2] Auburn University, School of Forestry & Wildlife Sciences, Auburn University, AL
rjb0003@auburn.edu
[3] Alabama A&M University, Department of Natural Resources and Environmental Sciences, Normal, AL
Luben.Dimov@gmail.com
[4] Auburn University, School of Forestry & Wildlife Sciences, Auburn University, AL
mds0007@auburn.edu

Silvopasture or agroforestry with row cropping can be developed from existing natural stands, plantations, or from pasturelands. They can also provide economic alternatives, such as livestock or agricultural crop production. Additional non-wood products and services include wildlife, traditional medicinal plants, plants and seeds for restoration projects, carbon credits, or biofuels, providing landowners with more frequent income while waiting for overstory trees to become merchantable. The possibilities for alternate income sources associated with agroforestry that do not involve livestock are numerous and may represent substantial income opportunities in uncertain economic times. Crops can also be adapted for multiple land use objectives and for any overstory and climate. Alternative income possibilities will be discussed as will the necessity to locate and secure dependable market outlets to supply a steady cash flow for forest landowners who want to maintain a productive, sustainable, agroforestry or pastoral land base.

Locating and quantifying old-growth forests in eastern Kentucky

Adrienne Cooper
Cumberland Laboratory of Forest Science, Dept. of Biological Sciences, Eastern Kentucky University, Richmond, KY 40475

The Cumberland Plateau is an ecoregion of global importance and yet the extent of old growth forest in the region is not well known or documented. Old-growth forests serve many scientific and ecological purposes such as serving as controls for silvicultural purposes and providing habitat for a number of organisms. Faced with global climate change, rising human population, and resource demand old-growth forests will become increasingly important to ecosystem conservation. This study will locate potential old-growth forests in eastern Kentucky's Cumberland Plateau region and quantify age structure, forest composition and structure, and disturbance history of those forests. Age structure and disturbance history will be used to determine the current condition of each study forest. Forest structure will be quantified for total density of trees and snags, volume of course woody debris, total basal area, and species importance values. Forests found to have several trees, especially of high quality timber species and form, established prior to

1780 will be considered old-growth forest. Additionally, to aid in determining old-growth status, structural attributes of each forest investigated will be compared to ranges typical of mixed-mesophytic, old-growth forests. These forests should fall within established ranges for tree density, basal area, canopy species diversity and course woody debris. Identifying and quantifying old-growth forests on the Cumberland Plateau will provide insight into the health of the ecoregion, refine ranges typical of old-growth structural characteristics, and help guide regional conservation and recovery efforts.

SouthWings

Meredith Dowling
Southwings, Asheville, NC
(828) 225-594, Meredith@southwings.org
Will@southwings.org

Founded in 1996, SouthWings is a conservation and public benefit aviation non-profit that provides skilled pilots and aerial education to enhance conservation efforts across the Southeast. Our service is unique, combining knowledge of conservation issues with experienced piloting skills. We enable those we fly to better understand, from an otherwise inaccessible vantage point, the globally significant ecosystems of the Southeast. Through the aerial perspective, SouthWings' service provides experiential understanding of environmental challenges and opportunities for conservation. This perspective fosters a better understanding of scale/magnitude, and the relationships of cumulative and compounding environmental effects. We provide a means to educate public and elected officials, media, community leaders, researchers, funders, and conservation organizations.

At the request of organizations whose work would benefit from the aerial perspective, SouthWings conducts flights around conservation issues including (but not limited to):

- water quality and wetlands;
- mining and related issues (esp. mountaintop removal mining);
- forest protection and restoration on private and public lands;
- wildlife habitat;
- land conservation;
- land use, such as development and sprawl.

Headquartered in Asheville, NC, SouthWings works in eleven southeastern states, ranging from West Virginia to Louisiana. Our work wouldn't be possible without the highly-skilled volunteer pilots who donate their time and resources to fly SouthWings' missions. SouthWings staff members will be available at a table at the SAMAB conference to discuss how our volunteer pilots may be able to assist your organization's conservation efforts.

Streamflow reconstructions in southern Appalachian mountain headwaters

Tate Geren, Ross Ogle, Amanda Bowen, Henri Grissino-Mayer and Glenn Tootle
University of Tennessee, Knoxville, TN
(865) 974-7777; gtootle@utk.edu

The recent drought in the southeast U.S. (e.g., Lake Lanier, GA) has greatly

stressed the water supply and availability of many systems. This has resulted in increased interest in re-evaluating the various agreements and compacts for water deliverability. The current research project will use proxy records derived from tree rings to examine climatic controls on streamflow and assess how natural interdecadal variability might impact streamflow. The proposed research will initially review existing tree-ring chronologies in and around watersheds in the Tennessee Valley and Southern Appalachian Mountains. Next, unimpaired or naturalized streamflow records will be identified for streams of interest. Finally, an investigation of long-term streamflow variability, focusing on extreme events such as mega-droughts, will be performed. This investigation includes evaluating the influence of various atmospheric – oceanic influences [e.g., El Niño-Southern Oscillation (ENSO), Pacific Decadal Oscillation (PDO), Atlantic Multidecadal Oscillation (AMO)] on streamflow. This analysis will also address how large-scale climatic drivers affect the spatial distribution of droughts and the results of the research will be used to develop probabilistic drought forecasts. These forecasts would utilize both empirical probabilities for drought risk derived from the tree-ring record and links between streamflow and climatic drivers like ENSO and the PDO.

USGS hydrologic data collection in the southern Appalachians

Bill Hazell[1], Brad Huffman[2], Jeanne Robbins[2], Shaun Wicklein[3], John Shelton[4], Brian McCallum[5], Rick Treece[6], Rodney Knight[7], and Ronald Evaldi[8]

[1]U.S. Geological Survey, 44 Buck Shoals Road, Suite A-2, Arden, NC 28704
[2]North Carolina Water Science Center
[3]Virginia Water Science Center
[4]South Carolina Water Science Center
[5]Georgia Water Science Center
[6]Alabama Water Science Center
[7]Tennessee Water Science Center
[8]West Virginia Water Science Center

The United States Geological Survey (USGS) has a long history of collecting hydrologic data in the Southern Appalachians. Hydrologic data collection and interpretation is performed by seven different USGS Water Science Centers in this area including the Alabama, Georgia, North Carolina, South Carolina, Tennessee, Virginia, and West Virginia Water Science Centers. Each Water Science Center operates independently within a regional and national framework, but the standards and methods for data collection are consistent throughout, resulting in comparable data across political boundaries. There are 10 streamgages with more than 100 years of data in the Southern Appalachians including the oldest active continuous streamgage in the Eastern United States. Data collection began at French Broad River near Asheville, NC (USGS station number 03451500) in 1895. In addition to these 10 sites there are 86 sites with at least 60 years of data. There also are 35 recording groundwater wells in this area with up to 56 years of record.

Current (August, 2009) hydrologic data collection stations include;

Station Type	*Number of Sites*
River Stage and Streamflow	269
Precipitation	72
Groundwater Level	35

Streamflow and precipitation data have been valuable in documenting floods and droughts. Peak streamflow and water levels for the widespread floods of 1916, 1940, 1955, and 2004 were recorded and these data have been used to compute flood frequency statistics and document flood-prone areas. Streamflow data also were important in documenting the sustained droughts of 1906, 1925, 1956, 2002, and 2008 including the lowest recorded streamflow in 113 years that occurred in August 2008 on the French Broad River.

Groundwater flow in the fractured bedrock aquifer of the Southern Appalachians is complex. Water levels can vary significantly over short distances so a relatively dense monitoring network is desirable. The relative lack of groundwater data in the Southern Appalachians makes it difficult to fully understand surface-water/groundwater relations, including effects of pumping on small streams.

The power of "what-if" thinking: The CRAFT Toolset

Matt Hutchins (UNC Asheville's NEMAC)
Collaborators: Jim Fox, Karin Lichtenstein (UNC Asheville's NEMAC); Danny Lee, Steve Norman (U.S. Forest Service)

Efficient and knowledge-based decision making is central to planning and natural resource management. Uncertainties and threats dealing with climate change are particularly great and present problems with no easy solutions. In order to deal with planning and management problems such as climate change, the U.S. Forest Service developed a NEPA-based decision making process called the Comparative Risk Assessment Framework and Tools (CRAFT), which provides a process and a toolset to identify actions that best suit the problem at hand. Together, the CRAFT process and the CRAFT Toolset result in a transparent and science-based decision.

The process of CRAFT allows project team members to conceptualize climate change, organize objectives, and explore tradeoffs. Supporting the NEPA-based process, the CRAFT Toolset (www.craft.forestthreats.org) encourages interaction among team members and offers in-depth analysis techniques within reach of the user. The CRAFT Toolset supports the decision making process by integrating web-based tools and techniques to strengthen the analysis of the problem and to improve transparency of the decision. The CRAFT Toolset allows for group collaboration, facilitates the multi-disciplinary nature of climate change, and provides remote access to geospatial data and thorough testing of "what if" climate change impact scenarios.

In May, 2009 a CRAFT Workshop, hosted by the Eastern Forest Environmental Threat Assessment Center (EFETAC) (U.S. Forest Service) and UNC Asheville's National Environmental Modeling and Analysis Center (NEMAC), brought together planners, managers, experts, and other stakeholder groups to look at climate change and understand how CRAFT might help to develop strategies to deal with the impacts from climate change in Western North Carolina and in the Southern Appalachians. This workshop introduced

the tools and techniques used in CRAFT and provided attendees with the knowledge about how CRAFT can help inform decisions. This poster details the web-based tools used with CRAFT and shows how they supported the May 2009 CRAFT Workshop on climate change.

Potential for climate adaptation within elevation and latitude gradients in the southern Appalachians

Hugh Irwin
Conservation Planner/Program Director, Southern Appalachian Forest Coalition, 46 Haywood Street, Suite 323, Asheville, NC 28801
(828) 252-9223, hugh@safc.org; www.safc.org

The importance of landscape corridors has been widely recognized in conservation biology. Corridors provide routes for genetic interchange and permit animal and plant movements for adaptation. Corridors can also help mitigate local extirpations and contribute to the recovery of populations. Climate change will make landscape connectivity even more important as species are forced to adapt to changing climate conditions. Climate adaptation is often visualized and modeled occurring over a latitude gradient with sensitive species finding suitable habitat in more northern latitudes as climate pressure eliminates habitat in more southern latitudes. However, the elevation gradient in mountainous regions such as the Southern Appalachians provides potential for species adaptation in some areas and for some species over much shorter geographic ranges. As climate change is incorporated into conservation planning, it is important to anticipate how well the elevation gradient within existing conservation lands is capable of accommodating species adaptation and movements. It is also important to identify corridors across both latitude and elevation gradients that can provide escape routes for species under climate change. A methodology will be presented for creating a GIS based latitude-elevation gradient for evaluating changes in species habitat under climate change. This latitude-elevation model will also be used to illustrate corridor design to assure suitable latitude-elevation gradients between established landscape conservation areas.

Discoverability of information in the southern Appalachians: NBII-SAIN, a regional biological information resource

Terri S. Killeffer
Biodiversity Informatics Specialist, NBII-SAIN/IIa, 1055 Commerce Park Drive, Suite 110, P.O. Box 4219, Oak Ridge, TN 37831-4219
(865) 298-1230; Cell: (865) 686-2922; tkilleffer@iiaweb.com

The Southern Appalachian Information Node (SAIN) is a regional collaborative effort among diverse stakeholders with proven ability to connect people with high-quality biodiversity data, information, and tools. As a geographically themed node of the U.S. Geological Survey National Biological Information Infrastructure (NBII), SAIN makes regional biological information from various individual and multi-agency resources discoverable.

Through partnerships with data generators, managers, and consumers, SAIN fosters better resource management and information access. To enhance networking abilities and to support existing partnerships, SAIN established the Southeast Collaboration and Partnership (SECAP) online portal community my.nbii.gov/SECAP. Within SECAP, multi-disciplinary groups have their own password protected space for document management, discussion threads, notifications, task management and a group calendar. On the SAIN web site sain.nbii.gov/, users gain one-stop access via a species mashup to species information from diverse sources like the Global Biodiversity Information Facility (GBIF), Integrated Taxonomic Information System (ITIS) and the NBII Metadata Clearinghouse without having to query multiple data sources. This easy-to-use web application focuses on vertebrate species of Greatest Conservation Need (GCN) identified by State Wildlife Action Plans (SWAP) of eight Southeastern states providing information about habitat, distribution, life history, data sets and more for each species. In addition to continued enhancement of the species mashup, SAIN is working with the University of Tennessee at Knoxville (UTK) School of Information Sciences (SIS) to synthesize information and resources on climate change, bioenergy and aquatic resources (management and restoration) in the Southeast. Initial efforts will focus on inventorying key initiatives, research efforts, data, and information holdings. Also through SIS, SAIN has an opportunity to build a connection with the Data Observation Network for Earth (DataONE).

Experiences in climate and weather Education

Brackin Kirkland, Program Director, CLIMBE at Montreat College (828) 669-8012 x3406; bkirkland@montreat.edu; Web site: www.CLIMBE.org

The Center for Learning and Investigation in Mountain Backcountry Ecosystems (CLIMBE) provides educational opportunities for middle and high school students in the southern Appalachian region who have an interest in field-based science. Each summer 60-120 students explore various scientific topics including the impact of climate and topography on forest ecosystems in the greater Mt. Mitchell area. During week-long, field-based trips, students live in the backcountry at remote research stations and collect climate and ecological data in four watersheds along an elevational gradient ranging from 2,500 to 6,800 feet.

The data collected include climate parameters, weather, vegetation, salamanders, and macroinvertebrates. This data is shared with collaborating agencies such as the National Climatic Data Center (NCDC) in Asheville and the Stream Monitoring Information Exchange (SMIE) and will be used to establish a baseline for the long-term ecological monitoring of these watershed ecosystems. CLIMBE follows established scientific protocols for data collection. Ultimately, the program provides young scientists with hands-on experiences in

field data collection, analysis and reporting as well as collaboration with Ph.D. scientists. After spending time learning about climate issues as related to forest ecosystems, our hope is that students will become advocates and researchers for ecosystem protection in their home communities.

Long-term climate trends at the Coweeta Hydrologic Laboratory

Stephanie H. Laseter, James M. Vose, Chelcy R. Ford and Lloyd Swift
U.S. Forest Service, Southern Research Station, Coweeta Hydrologic Laboratory, Otto, NC

Climate is defined as the daily and seasonal weather events for a given region that do not change significantly over time. Climate has long-term patterns and behavior, and can be highly variable over days, seasons and years. The southern Appalachians are located in a maritime, humid temperate climate. Our weather is strongly influenced by the oceanic atmosphere, we receive high levels of rainfall, and daily and seasonal temperatures do not fluctuate widely. Climate has been monitored at the Coweeta Hydrologic Laboratory since 1934. Measurements include temperature, rainfall, wind speed, relative humidity, solar radiation, and evaporation. Our objective was to analyze spatial and temporal variation in long-term climatic data using a variety of response metrics and analytical techniques. We used data from climate stations, weirs and rain gages located across the Coweeta basin at various elevations and slopes. For example, rainfall is greatest in late winter and early spring, and is greatest at high elevations. Fall months are driest, yet they are also generally the months where tropical storms bring record high rainfall events. Our preliminary analyses of long-term climate trends suggest that (1) drought conditions have occurred more frequently over the past 20 years, and (2) average temperature has been trending upward since the late 1970s, coupled with increases in the minimum nighttime temperature, and more frequent record high temperatures.

The rise and fall of southern yellow pines in the Bent Creek Experimental Forest

W. Henry McNab[1] and David L. White
[1]Research Forester, U.S. Forest Service, Southern Research Station, Bent Creek Experimental Forest, 1577 Brevard Rd., Asheville, NC 28806
(828) 667-5261x119; hmcnab@fs.fed.us
[2]Forest Ecologist, D.L. White Consultants, Inc., 1042 Mt. Tabor Church Rd., Pickens, SC 29621 (864) 898-2805, lwhite@hughes.net

Pine and pine-hardwood overstory types made up about 25 percent of the forested area of the 6,000-ac Bent Creek Experimental Forest in 1921. Southern yellow pines, primarily shortleaf (*Pinus echinata*) and pitch (*P. rigida*), were the major species that dominated low elevation areas of the experimental forest consisting of former agricultural lands that had been abandoned following acquisition by the Biltmore Estate around 1900. In the first published ecological study made in the experimental forest, in 1928, Reginald Balch (a Master of Science student at the New York State College of

Forestry) concluded that recurring outbreaks of southern pine beetle (*Dendroctonus frontalis*), in combination with the lack of site conditions suitable for natural regeneration of southern pines, would soon result in loss of pines as a major component of "plateau type" (i.e. Piedmont like) forests in the French Broad River Valley. In the 2002 outbreak of southern pine beetles in western NC, the shortleaf pine overstory of the last remaining pine-hardwood stand in the experimental forest was killed by the insect, thus completing the cycle of old field succession to stands dominated by upland hardwoods, primarily xerophytic oaks (*Quercus spp*). Eastern white pine (*P. strobus*), however, which has silvical characteristics different from that of southern pines, has increased in prominence on many sites during the past 100 years. The sequence of forest dynamics occurring at Bent Creek Experimental Forest is believed to be similar to other regions of the intermountain basins in the southern Appalachian Mountains of western NC, where land use of large areas has changed from agricultural to residential. The ecological implications of the change in forest species composition resulting from loss of southern pines are unknown.

How climate and leaf phenology regulate the fire season of the Southern Appalachians

Steve Norman, U.S. Forest Service, Eastern Forest Threat Assessment Center (EFETAC)
stevenorman@fs.fed.us
Collaborators: Stephen Creed, William Hargrove, EFETAC

The southern Appalachian fire season largely occurs during spring and fall with the onset and decline of deciduous canopy cover. It is unclear whether this seasonal change in fire hazard results from aspects of the seasonal climate itself or if it reflects fuel and canopy dynamics more directly. Hypothetically, canopy greenup could essentially close the spring fire season by reducing sunlight and fuel temperatures, reducing surface wind speeds and increasing transpiration and humidity. Under a closed canopy, cool-moist fuels are less likely to burn, making fires less likely to ignite and easier to suppress. If our summer fire hazard is currently constrained by canopy conditions, the expected increase in tree mortality related to drought stress, insects, pathogens and other factors of coming decades could extend the fire season into the summer, especially if fire weather becomes more severe.

This retrospective analysis compares the record of recent fire with moderate-resolution satellite-derived phenological imagery and climate data to better understand how fire hazards vary and how they may change under different climates.

Sustainability indicators of land use change near public lands in western North Carolina

Yuri Potawsky[1], Christopher A. Badurek[1], Greg Dobson[2], John Pine[1]
[1]Dept. of Geography and Planning, Appalachian State University, Boone, NC 28608
badurekca@appstate.edu

[2]*National Environmental Modeling and Analysis Center (NEMAC), University of North Carolina, Asheville, Asheville, NC 28804*

Federal land managers such as the U.S. Forest Service and the National Park Service administer large tracts of land for conservation purposes. These public lands provide recreational opportunities, resource extraction, and protection against private development and degradation. In addition, these federally protected areas serve as buffering agents against suburban and exurban growth. It is clear that public land boundaries and topography play an increasingly important role in restricting the growth of urbanization, particularly in relation to exurban development pressures. Wildland-urban buffering techniques provide possible solutions to alleviating the environmental ramifications of exurban growth in close proximity to public lands. This research focuses on a case study region of the Land-of-Sky Regional Council, containing four counties in western North Carolina encompassing the Asheville-Buncombe County area. In order to develop sustainability indicators based on metrics of residential development and land use change, GIS-based parcel density surface analysis was performed on federal and state land holdings within the study region to assess the extent of development and percentage of remaining developable parcels. In addition, a proposed 350 meter buffer was applied to the public lands to assess its potential for alleviating stresses that land cover change may have upon conservation areas. A 2,500-foot parcel buffer was also applied to public lands in Buncombe County to determine the difference in property values in proximity to public lands indicates a significant difference between parcels within the buffer and the county mean. Results indicate that formerly effective growth barriers of slope and public land ownership are becoming less effective in mitigating land cover change within the case study region.

Potential east-west trends in down woody material across the southern U.S.

Anita K. Rose[1], James F. Rosson, Jr.[2]
[1]Research Ecologist, U.S. Forest Service, Southern Research Station, 4700 Old Kingston Pike, Knoxville, TN 37919
anitarose@fs.fed.us
[2]Research Forester, U.S. Forest Service, Southern Research Station, 4700 Old Kingston Pike, Knoxville, TN 37919

An important part of forest ecosystem functioning is the return of nutrients to the system via decomposition. In these systems, deadwood can be a substantial pool of nutrients. In addition, standing and down-dead trees are important habitats for a wide variety of organisms, including microbes, invertebrates, fungi, and small mammals. Pools of down woody material (DWM) are impacted by various things including management, species composition, disturbance, as well as continental climatic regimes. At regional scales, the spatial pattern of DWM along latitudinal and longitudinal gradients is unknown. In this study, we focused on possible longitudinal patterns in DWM across select Southern States. We used data from the U.S. Forest Service, Forest

Inventory and Analysis Program, which began measuring DWM in 2001 as part of a larger forest health monitoring effort. DWM consisted of four components: 1) fine woody debris (FWD), [woody material < 3.0 inches in diameter], 2) coarse woody debris (CWD) [woody material ≥ 3.0 inches in diameter and ≥ 3.0 feet in length], 3) litter [loose plant material on the forest floor], and 4) duff [unidentifiable partially decomposed plant matter]. These attributes were measured on plots across the South at a sampling intensity of about one plot for every 93,000 acres. All four DWM components together showed declines on an east to west gradient. The frequency of plots with > 20.0 tons/acre of DWM declined from east west. Over 45 percent of plots in VA and NC had > 20.0 tons/acre of DWM, and about 15 percent of plots in Arkansas and Alabama had this amount. Duff and litter showed the strongest east to west trends, while trends in CWD and FWD were less distinct. Although our results show a general east to west trend, these results are confounded by species composition in the overstory, as well as by degrees of past disturbance and management regimes. A possible confounding latitudinal gradient that exists in these States also needs to be considered. Further analysis of these trends is warranted.

Greater drought vulnerability of mountain and Appalachian Piedmont ground water supplies, including stream baseflow and valley seepage: A lightly calibrated conceptual comparison with the Coastal Plain.

Peter A. Stone
Ground Water / SC DHEC, Columbia, SC 29201
(803) 898-4151; stonepa@dhec.sc.gov

Ground water supplies in the mountains and piedmont are critically important for home wells and those public-supply systems relying on wells, but less obviously are critical in terms of seepage to streams at low-flow times (baseflow), to focused discharge as springs, and finally to semi-focused swale- or valley-side concentrated seepage that is increasingly recognized as important in certain ecological habitats. The basic nature of the eastern Appalachian regime (the valley-and-ridge province is unaddressed here) limits ground-water storage. The more-porous (say ~1/3 v/v) regolith on slopes and uplands, and above the hard rock, consists of saprolite and colluvium and is not only relatively thin (usually <100 feet) but also typically is saturated only in its lower half and often much less. At most only a few decades of recharge water appear to be stored there plus in the unsaturated zone above. The fractured hard crystalline rock lying below has low porosity and low total storage, though rock fractures are critical in transmitting ground water. Most ground water pumped or discharging in the eastern Appalachian province is thus very young (e.g., contains post-WWII H-bomb rainout tritium) and thus needs rapid replacement. Deficient rainfall, especially in the cool-months recharge season (when precipitation > evapotranspiration), quickly affects this vulnerable system, despite that winter drought is not as acutely noticeable by vegetation stress or forest fires. Ground

water levels dropped appreciably and eventually seepage discharge must have declined during recent years of winter drought. Steep slopes and deep valley incisement in mountains hasten this natural drainage of ground water in storage. The Coastal Plain instead contains porous and saturated sediments to much greater depths and over most of its area has thousands of years of recharge stored (shown both by saturated thickness and ground water ^{14}C ages from well water). Drought can reduce seepage discharge and streamflow there too, but in comparing similar topographic settings, say Carolina Sandhills and Appalachian piedmont rolling terrains, the coastal-plain sandhills streams tend to maintain much higher baseflow even in acute drought.

Three centuries of fire and forest history in an old-growth *Quercus* forest on the Cumberland Plateau

Taylor, Josh P.[1], Justin T. Price[1], Adrienne M. Cooper[1], Ryan W. McEwan[2], Neil Pederson[1]*
[1] Cumberland Laboratory of Forest Science, Dept. of Biological Sciences, Eastern Kentucky University, Richmond, KY 40475.
[2] Laboratory of Environmental Ecology, Dept. of Biology, University of Dayton, Dayton, OH 45469.
[*] Presenter

A dominant hypothesis regarding oak forests regeneration in the eastern U.S. is that successful regeneration is dependent on recurring fires that reduce competition from fire-sensitive species while creating optimal sites for oak recruitment. With this hypothesis in mind, we collected cross-sections of downed trees within Big Everidge Hollow (BEH), an old-growth watershed within the Lilley Cornett Woods Appalachian Research Station (LCWARS) on the Cumberland Plateau in southeastern Kentucky. Samples were taken within the oak-dominated forests to reconstruct fire history, establishment dates and examine growth prior to death of these trees. From June through mid-August 2009 we collected 39 cross-sections, 33 of which were from the upper portion of the east to southeast-facing ridges at the top of BEH while the remaining six were from lower elevation. Of these samples, 15 were *Quercus montana*, 13 *Q. alba*, 3 *Q. velutina*, 3 *Q. rubra*, 2 *Carya* spp., *1 Liriodendron tulipifera* and 1 *Tsuga canadensis*. The *Tsuga*, *Carya* and *Liriodendron* were from the lower forest. Calendar dates of each sample and corresponding fire scares, i.e., cross-dating, were established with the aid of a collection of dead *Q. alba* collected from LCWARS in the mid-1980s. Inner ring dates of our cross-sections ranged from 1703 to 1873. Releases from canopy disturbance were observed in tree ring width patterns since the late-1700s. This record represents one of the best replicated, oldest and cross-dated fire scar records from an old-growth oak forest in the southeastern U.S. Results from this study will give great insight into the long-term development of an uncut forest in the southern Appalachian region.

The dendroecology and disturbance regime of the red spruce-Fraser fir forest of Roan Mountain, Cherokee and Pisgah National Forests

Philip B. White, Saskia L. van de Gevel
Department of Geography and Planning, Appalachian State University

We used dendroecological techniques to assess the forest health and stand dynamics of the high-elevation disjunct boreal forest of Roan Mountain, Tennessee and North Carolina. The purpose of this study was to investigate the ecological status of the rare and threatened red spruce (*Picea rubens*) and Fraser fir (*Abies fraseri*) forest on the southern Appalachian Mountains in Cherokee and Pisgah National Forests. We collected increment cores from all trees within ten 0.05 ha plots within the spruce-fir ecosystem to document precise temporal information on the stand age, disturbance regime, recruitment patterns, and successional trajectory of the forest community. Red spruce and Fraser fir dominated the canopy composition of the forest, while yellow birch (*Betula alleghaniensis*), American mountain ash (*Sorbus Americana*), and pin cherry (*Prunus pensylvanica*) were present in limited numbers. Red spruce was the oldest dominant canopy species, while Fraser fir exhibited the most prolific recruitment patterns with high amounts of regeneration during the past 30 years. Shifts in forest structure and species richness coincided with stand-wide disturbance events such as balsam woolly adelgid (*Adelges piceae*) infestation. We found increased tree establishment and pulses in radial growth increments among living trees following such events, which we attributed to canopy opening effects of widespread Fraser fir mortality following infestation episodes that occurred during the late 20th century. Despite large-scale Fraser fir dieback in recent decades, the species remains the most vigorously regenerating tree in the understory and the most frequently occurring tree in intermediate canopy positions, suggesting that adelgid infestation events at Roan Mountain may not have removed as many reproducing adult Fraser first from the canopy as events reported at other locations. However, the forest may become increasingly red spruce dominated in the future, as potential adelgid infestations may remove more Fraser firs of reproducing age from the canopy.

Digital picture tree crown evaluation software to monitor change

Matthew F. Winn[1], Sang-Mook Lee[2], Philip A. Araman[1]
[1] U.S. Forest Service, Southern Research Station, Blacksburg, VA
[2]Bradley Department of Electrical Engineering, Virginia Tech, Blacksburg, VA

The U.S. Forest Service Southern Research Station in Blacksburg, Virginia is developing software to analyze digital pictures of tree crowns, partial tree crowns or groupings of tree crowns for foliage transparency. One program called URBANCROWNS can be used to evaluate transparency of complete or partial tree crowns in an urban setting from digital pictures. The software also provides estimates of crown volume and could potentially be used to determine leaf area. The second program called

FORESTCROWNS can be used to evaluate digital pictures of crowns from below in forested settings. Single trees, multiple intersecting trees or canopy area pictures can be analyzed to determine transparency. Examples will be presented. The software packages are nearly complete and will be made available for trial use.

URBANCROWNS can be used by urban foresters, horticulture professional and forest health people and others to analyze and monitor trees. Potential uses of FORESTCROWNS include:

- Monitoring yearly growth or decline of individual tree crowns
- Relating crown conditions with tree growth
- Early detection of insect or disease damage
- Monitoring health treatments
- Estimating light transmission to forest floors

U.S. Fish and Wildlife Service strategies for preparing and responding to climate change

Carolyn Wells, U.S. Fish and Wildlife Service, Ecological Services Field Office, Asheville, NC 28801
carolyn_wells@fws.gov

Secretary of the Interior Ken Salazar has issued an Order urging unprecedented levels of collaboration in response to climate change, and Director of the U.S. Fish and Wildlife Service (USFWS) Sam Hamilton has described climate change as "the transformational conservation challenge of our time". The Secretary's Order establishes a Climate Change Response Council to coordinate Departmental responses to climate change by a variety of mechanisms, including (1) eight national Climate Change Response Centers to integrate and apply climate change data, and (2) collaborative Landscape Conservation Cooperatives (LCC) to work with other federal, state, tribal, and local partners (both governmental and private) to develop landscape-level strategies for understanding and responding to climate change impacts. The USFWS has issued a draft climate change strategic plan to implement these and other components of the Secretary's Order, and is requesting public comment on the draft USFWS plan before November 23, 2009. This poster will summarize the content of the Secretary's Order and the USFWS draft climate change strategic plan for partners and other conference attendees, and provide helpful resources for those seeking more information.

Session: Land Use Patterns and Change

November 18, 2009; 8:30-12:00 (Roan room)

Moderator:
Barry Clinton, U.S. Forest Service, Southern Research Station

PANEL - Population Growth and Resource Management In The Face of Climate Change: A Southern Appalachian Perspective

Population growth in the southern Appalachians has posed many challenges to planners and administrators throughout the region. Many local governments in the region have been scrambling over the past several years to develop meaningful and effective regulations designed to minimize the negative effects of growth while at the same time accommodating its inevitability. Now, how can we mitigate or avoid some of the impacts of climate change through the implementation of specific planning techniques?

Climate change can be characterized in the region by the occurrence of more frequent extreme weather events; e.g., intense rainfall, longer periods of dry, hot weather. The increase in more frequent high intensity storm events associated with these climatic changes raises questions about slope stability in undisturbed settings, as well as on artificial slopes created during road or home site construction. Following a series of extreme weather events in 2004 that resulted in substantial property damage and loss of life, an awareness of the need to prevent similar catastrophic events in the future initiated an evaluation of the capacity of steep mountain landscapes to absorb population growth from the perspective of public safety and the prevention of property damage. Further, development along the urban / wildland interface poses the additional risk of more frequent property damage and public safety concerns as the potential for wildfires increases. Greater awareness of these factors and other phenomenon related to climate change, has resulted in the development of useful guidelines for growth management.

Moderator: *Barry Clinton*
bclinton@fs.fed.us.
Barry has been a staff scientist at the U.S. Forest Service SRS Coweeta Hydrologic Laboratory for 19 years. He is a Research Ecologist and has spent much of his career focusing on natural and human-caused disturbances and their impacts on water quality. He is currently vice-chair of the Macon County Watershed Council and has served on several planning sub-committees of the Macon County Planning Board.
Panelist: *Larry Band*

lband@email.unc.edu
Larry is the Voit Gilmore Distinguished Professor of Geography and the Director of the Institute for the Environment at the University of North Carolina, Chapel Hill. He teaches courses in watershed hydrology, geomorphology, geographic information systems and environmental modeling. Larry's research is in the ecohydrology of watersheds, including the cycling of water, carbon and nutrients, the development and impacts of droughts and floods, and human/environment interactions. His current research is in watersheds in western North Carolina, the Triangle of North Carolina and Baltimore. He is a co-Principal Investigator on the Long Term Ecological Research Program at the Coweeta Hydrologic Laboratory.

Panelist: *Rick Wooten*
rick.wooten@ncdenr.gov
Rick is a senior geologist with the North Carolina Geologic Survey in Asheville, NC, and has been with the survey since 1990. From 1990-2003 Rick worked out of the Raleigh office on geologic mapping, the low-level radioactive waste repository project, and geohazards studies. Since moving to the Asheville office in 2003, he has worked primarily on landslide hazard mapping, other geologic hazards studies that include acid producing rock, mine collapse and subsidence, sinkholes and earthquakes. Rick has been the leader on the Landslide Hazard Mapping Project that got underway soon after Hurricanes Francis and Ivan moved through the region creating landslides that caused property damage and loss of life. Much of this work is being used by local planners in the region as a guide in the development of land use regulation.

Panelist: *Stacy Guffey*
stacyjguffey@yahoo.com
Stacy is Macon County's former Planning Director, currently works as a regional planning consultant. He has over a decade of experience in the field.

Panelist: *Jim Stokoe*
jim@landofsky.org.
Jim has held several positions with this four-county regional planning organization serving Buncombe, Henderson, Madison and Transylvania counties, NC for 30 years. He currently is semi-retired and co-manages the development of a regional "green infrastructure" plan for land conservation and development for his region. Jim's educational background is in geology and geophysics. He lives in Weaverville, NC.

Panelist: *D.J. Gerken*
djgerken@selcnc.org
DJ is a Senior Attorney with the Southern Environmental Law Cente focusing on public lands protection and growth in the mountain region. In addition to his legal education, DJ is trained as a planner. He is currently Board Chair of the Western North Carolina Alliance and Chair Elect of the Asheville Design Center.

Panelist: *Lewis Penland*
penlandgolf@earthlink.net
Lewis has been an active member of the Macon Planning Board for several years, and is the current Chair. Lewis has been instrumental in promoting landuse regulation in Macon County and seeking out qualified individuals to serve on various committees and sub-committees to develop ordinances for wise control of growth in the community. Current efforts include the development of a long range plan for Macon County and the town of Franklin.

Landslide hazard in the southern Appalachians: Hydrological and Ecological Controls

Larry Band[1], Taehee Hwang[1], T.C . Hales[2], Chelcy R. Ford[3], James M. Vose[3]
[1] University of North Carolina, Chapel Hill
[2] University of Cardiff
[3] U.S. Forest Service, Southern Research Station, Coweeta Hydrologic Laboratory

Over the past two decades there has been a significant population increase in the southern Appalachian Mountains with seasonal residents comprising much of the growth. The increase in second homes built on ridges and steep slopes is in contrast with traditional valley bottom development. Building residences on steep slopes and ridges requires cut and fill to develop flat areas for housing footprints and expansion of the road network, including access roads and private driveways. The effects of creating road networks that cross steep, landslide-prone Appalachian slopes are likely to increase the frequency and magnitude of floods and landslides, which in turn affects traditional valley bottom dwellings. Additional increases in hydrologic extremes with climate change, and change in land cover and forest composition will be superimposed on the altered landscape, with the potential of significantly increased hazards. Therefore, the potential effects of hillslope development on landslide hazards needs to be viewed within the framework of the long term geology, ecology, and hydrology of the southern Appalachians.

Landslide hazard mapping in Macon, Watauga and Buncombe Counties and investigations elsewhere in western North Carolina: Findings, observations and implications.

Richard M. Wooten, Rebecca S. Latham, Anne C. Witt, Kenneth A. Gillon, Thomas J. Douglas, Stephen J. Fuemmeler, Jennifer B. Bauer, John G. Nickerson
North Carolina Geological Survey

Landslide hazard maps are complete for Macon, Watauga and Buncombe Counties, and the Blue Ridge Parkway in North Carolina. This mapping and other landslide investigations in western North Carolina (WNC), have documented over 3,100 modern landslide locations and 2,900 mainly ancient, landslide deposits. These maps show areas of past, current and potential future landslide activity, and geologic units or structures that may pose hazards. Designed for use in a

Geographic Information System (GIS), the maps are a planning tool for the public, local governments, and emergency managers to help mitigate landslide hazards.

Initial findings and observations have emerged through these landslide hazard studies. Since 1916, four major storms or sequences of storms (1916, 1940, 1977 and 2004) have triggered landslides throughout WNC. Rainfall rate (intensity) and duration are critical factors in debris flow initiation. Peak rainfall amounts on the order of 25mm/hour for about 4 hours duration may trigger debris flows on unmodified slopes in WNC, especially when coupled with high antecedent moisture conditions. Storms with higher rainfall rates and duration than Hurricanes Frances and Ivan in 2004 have impacted the region in the past triggering significantly greater numbers of landslides than these two storms combined. Some structural-geomorphic domains may be more prone to landslide activity in certain weather events owing to orographic rainfall enhancement combined with geologic factors. Slow-moving slides or subsidence in poorly constructed embankments on steep slopes can mobilize into destructive debris flows during heavy rainfall events. Also, lower rainfall amounts can trigger debris flows in poorly constructed slopes in comparison to the rainfall amounts required for unmodified slopes to fail.

Major storm events that produce damaging floods and landslides will continue to affect WNC and the southern Appalachians. Global climate change may produce higher intensity, more frequent storms, and thereby trigger increased numbers of landslides. Use of the landslide hazard maps can help avoid and mitigate the impacts of landslides. These maps do not a substitute for site-specific investigations; however, they are readily useable at the parcel and parcel group level at a scale of 1:6,000 to show areas where detailed investigations are warranted prior to land disturbing activity.

The 2008 Mountain Landscapes Initiative

Stacy J. Guffey, Regional Planning Consultant, Franklin, NC

The Mountain Landscapes Initiative (MLI) was supported by a precedent-setting partnership between private-sector, government, and non-profit entities—may rank as one of the most ambitious land use planning initiatives in the southern Appalachian region. After a 3-month outreach effort that touched on the hopes and concerns of residents of the seven westernmost counties and the Eastern Band of Cherokee Indians, there was a weeklong master planning "charrette" at Western Carolina University and two satellite charrettes in mountain communities. Out of those workshops came a "toolbox" to guide responsible planning and development and a set of case studies for channeling growth in character with the environmental, economic, and cultural/historical realities of the mountain region. The effort was historic not only in its

ambitions, but also in its willingness to integrate all the components of sustainable growth, including the latest research on soil erosion, water quality, and slope development issues. The need for comprehensive planning, in fact, was the No. 1 recommendation in the "toolbox." As the "toolbox" becomes more widely distributed both online and in print, the principal partner in the MLI effort—The Community Foundation of Western North Carolina—intends to expand the conversation throughout western North Carolina, linking land use planning with environmental protection, economic development, farmland preservation, and other strategies for sustainability. We will explore how comprehensive planning should also incorporate mitigation measures for climate change and resource scarcity.

Linking Lands and Communities in the Land-of-Sky Region
Jim Stokoe, Land-of-Sky Regional Council

The *Linking Lands and Communities in the Land-of-Sky Region* project is guided by Land-of-Sky Regional Council in partnership with over 50 organizations and agencies working in Madison, Buncombe, Henderson, and/or Transylvania counties. The primary goal of the project is to create a Regional Conservation and Development Network, which will use a green infrastructure approach to identify the region's valuable ecological systems and resources, important working lands and recreation areas, cultural resources, and areas most suited for future growth and development. The completed plan will serve as a resource for decision-makers and developers to balance economic and environmental needs of our communities.

A series of region-wide assessments will form the basis for creating the regional network and plan, including:

- Water Resources
- Conservation and Recreation Lands
- Cultural Resources
- Agriculture (farmlands and forest lands)
- Wildlife Habitat and Biodiversity

The first four assessments above focus primarily upon ecosystem services provided by nature to human communities. The Wildlife Habitat Assessment is unique in that it will identify important lands and waters in region that are critical in maintaining healthy ecosystem function across the broader landscape. All of the lands represented by these assessments – as well as the services they provide—will be affected by climate change. The project managers hope to engage SAMAB conference participants in a discussion of how climate change may affect the economic, social and ecological landscape of our region – and how it may affect the competition among different land uses and the carrying capacity of our region for future human settlement.

Growth trends and policy choices in the mountains
DJ Gerken, Southern Environmental Law Center, Asheville NC

DJ will discuss recent growth patterns in the mountains, focusing on natural resources impacts and exposure to hazards like flooding and landslides. He will also address the state of planning in the mountains generally as compared to comparable regions in the state and the nation, policy proposals to prepare mountain communities for future growth, and recent efforts, like the Mountain Resources Act, to bring a regional perspective to planning efforts already underway in western North Carolina.

Macon County North Carolina Land Use Ordinance Development: A discussion of the experiences in developing local ordinances for the protection of water resources and public safety

Lewis Penland – Franklin, North Carolina

Over the past decade Macon County North Carolina has been working hard to develop and adopt land use ordinances. Several boards, committees, and sub-committees have been established toward this end, and much of the recent efforts are in response to rapid and unregulated population growth in Macon County and the region. As Chair of the Macon County Planning Board, the speaker is directly involved in preparation of citizen-based recommendations to the county commissioners for local erosion and sedimentation control, floodplain regulations, and development on steep slopes. Macon County's success in these areas is based on balancing practical regulations and property owners' concerns.

Session: Land Use Patterns and Change

November 18, 2009; 1:30-5:00 (Roan room)

Moderator:
Judy Francis, North Carolina Department of Environment and Natural Resources

Modeling the distribution of Tennessee's population growth through 2025: Projected land use change and implications for state wildlife action plan conservation priorities.

Joey Wisby[1], Conservation Information Manager
Collaborator: Sally Palmer[1,2], Director of Science
[1]The Nature Conservancy; 2021 21st Ave South, Suite C-400; Nashville, TN 37212
(615) 383-9909; jwisby@tnc.org
[2]spalmer@tnc.org

The Tennessee Chapter of The Nature Conservancy (TNC) has developed a statewide, fine-grained spatial model of future population growth through 2025 to better inform natural resource management and guide conservation investments. The Tennessee Advisory Commission on Intergovernmental Relations (TACIR) monitors the implementation of the 1998 Tennessee Growth Policy Act of 1998 and conducts public policy research, including on population growth. TNC utilized data published in the 2003 report "Population Projections for the State of Tennessee 2005 to 2025" completed by TACIR and the University of Tennessee Center for Business and Economic Research (CBER). This report derived detailed population growth projections for Tennessee's 389 municipalities and unincorporated portions of counties at 5-year intervals. Data from all Tennessee county growth management plans submitted under the 1998 Act was also utilized to capture future urban growth areas around municipalities and planned growth areas within unincorporated portions of counties.TNC then constructed a statewide development suitability model based on land cover type, topographic slope, FEMA flood ratings, protection status, and accessibility to existing urban centers. The development suitability model was then used to spatially allocate TACIR/CBER's projected population changes within the planned growth areas. Finally, TNC utilized the Tennessee State Wildlife Action Plan's (SWAP) relational database management system and geographic information system database in conjunction with the statewide growth model to identify the priority conservation areas facing the highest degree of threat from future land development. This spatially explicit analysis demonstrates which habitat types across Tennessee may be compromised by land cover changes and therefore less able to adapt given future climate change impacts. Results

from this study highlight the urgency of multi-agency, multi-jurisdictional cooperation to limit future habitat degradation due to potential infrastructure expansions and land cover conversion within the next two decades.

GIS modeling of exurban growth processes to guide environmental planning in Watauga County, NC

Christopher A. Badurek[1], Austin Chamberlain, Lloyd Edwards
Department of Geography and Planning, Appalachian State University, Boone, NC 28608
[1]badurekca@appstate.edu

Increasing population growth and resulting changes in land use in primarily rural areas are recognized as issues of significant importance to residents of western North Carolina. Previous studies have shown rapid growth in rural areas has been associated with decline in environmental quality as well as increased housing values that often price local residents out of the market. Since GIS analysis performed at an appropriate scale is difficult to provide with commonly used land use land cover (LULC) data sources, this study provides a GIS analysis of spatial density surfaces derived from land parcel data as a means of measuring exurban growth processes. In particular, two case studies demonstrating housing trends based on density surface analysis over a nearly 60-year time period (1950-2007) at two scales are presented: within a one-mile buffer area of the South Fork of the New River and across the extent of Watauga County. This housing density surface analysis is supplemented with additional data on land cover change derived from Landsat TM and ASTER remote sensing imagery spanning the last 10 years. Finally, land parcel density surfaces and land cover data are used to create a residential development and land cover change risk potential layer that highlights hotspots of growth that may have negative significant ecological, cultural (e.g., viewshed), or socioeconomic effects within the county. The land cover change risk map is discussed in relation to the environmental planning issues of mitigating potential land use conflicts, land conservation strategies, and increasing public participation in land use decision-making.

The benefits associated with agricultural land: Results from the Farmland Values Project

Leah Greden Mathews, Department of Economics, UNC Asheville, Economics CPO 2110, One University Heights, Asheville, NC 28804
(828) 251-6551; lmathews@unca.edu

The recently completed Farmland Values Project collected information on the many benefits that people receive from farmland in four western North Carolina counties (Haywood, Henderson, Madison and Buncombe). This presentation will provide an overview of the results learned from the

1400+ residents and visitors who participated in our survey, focus group, and mapping exercise between 2006 and 2008. Farmland Values Project results provide baseline information about the values of various landscape amenities that may be impacted by climate change.

Wood waste for options for reuse and recycling at a green (EarthCraft) housing development that reduces energy needs

Phil Araman[1], Dan Hindman[2] and Matt Winn[1]
[1] U.S. Forest Service, Southern Research Station
[2]Department of Wood Science and Forest Products, Virginia Tech

Green building is the practice of increasing the efficiency with which buildings use resources (energy, water, and materials) while reducing building impacts on human health and the environment during the building's lifecycle, through better siting, design, construction, operation, maintenance, and removal. We are working with an EarthCraft certified "green" developer in Blacksburg, VA, to quantify the amount of oriented strand board (OSB), treated lumber, and spruce dimension lumber waste after home construction and determine potential uses for discarded material as an alternative to landfilling. Initial results indicate that 35 to 50 percent of the OSB waste material as well as 35 to 50 percent of the treated lumber waste can be recycled into useable solid-wood products. The remaining materials can be recycled for biofuels and mulch.

Exotic plant species and climate change in southern Appalachians

Kenneth Stolte[1], Sarah Marcinko[2] , Lindsay Majer[2] , and Gary Kauffman[3]
[1]U.S. Forest Service, Southern Research Station, Research Triangle Park, NC
[2]Equinox Environmental Consultation and Design, Inc., Asheville, NC
[3]U.S. Forest Service, National Forests in North Carolina, Asheville, NC

Five non-native invasive plant (NNIP) species were frequently found to move into forest interiors from adjacent rights-of-way (roads, railroads, power lines, etc. [ROW]) in three areas of the Pisgah and Nantahala National Forests in North Carolina. There were 139 documented NNIP occurrences in 73 stratified-random surveys in forest interiors—32 percent were herbs and grasses; 26 percent were trees; 23 percent were shrubs; and 19 percent were vines. Many NNIP species observed on ROWs were not found in adjacent forest interiors. Forest interiors in the Mount Rogers National Recreation Area and Linville Gorge Wilderness had 46 percent and 45 percent, respectively, of species found in ROW surveys. Conversely forest interiors in the Hot Springs area had 87 percent of the NNIP species found on adjacent ROWs. In general the NNIP species with greatest frequency along ROWs were also the most common species recorded in forest interiors. However, 31 percent of species observed in forest interiors were not found on adjacent ROWs.

The most frequently occurring species (N=number of sites) in forest interiors were *Microstegium vimineum* (*N*=24), *Lonicera japonica* (*N*=24), *Rosa multiflora* (*N*=19), *Ailanthus altissima* (*N*=18), and *Paulownia tomentosa* (*N*=18). No one NNIP species occurred in forest interiors in all three project areas. Most (60 percent) of the 20 NNIP species were found in only one area; however this may be due to 70 percent of all surveys (totaling about 50 miles) occurring in the Hot Springs area. On average, there were 1.7 NNIP species per forest interior sites. Many NNIP species were found below 2,500 feet, although multiflora rose, Japanese stiltgrass, and princesstree were all recorded above 3,000 feet. Japanese honeysuckle, however, was relatively consistent in its occurrence around 1,300 to 1,500 feet. Many species (37percent) were found along road beds in forest interiors. Site data indicated that NNIP abundance (cover or number of stems) was often related to specific biological and physical factors at forest interior sites. Abiotic factors included slope, aspect, elevation, topographic position, soil type, and distance to roads, water, gaps, and distance between ROWs and forest interior sites. The biotic factors commonly associated with high NNIP abundance were forest type, tree cover index, canopy density, and depth of duff and litter. NNIP tree species were more abundant on southern, drier slopes with a more open tree canopy, and often at drier topographic positions. Shrub, herb, and vine species were most successful on flatter, moister sites with more tree canopy coverage, and in wetter topographic positions.

In general the largest differences in abundances between NNIP tree species and NNIP vine, herb, and shrub species were landscape position, soil type related to soil moisture retention, aspect, slope, duff and litter depths, and forest community types. The abundance of NNIP tree species at drier sites suggests these species might be at higher risks of spreading into and within forest interiors as the climate in the Southeast mountains becomes warmer and drier.

Modeling transient response of Tennessee forests to climate change

Virginia H. Dale[1], M. Lynn Tharp[2] Donald G. Hodges[3], Karen O. Lannom[3]
[1] Environmental Sciences Division, Oak Ridge National Laboratory, Oak Ridge, TN
[2] CompSci Consulting, LLC, McRae, GA
[3] Department of Forestry, Wildlife and Fisheries, The University of Tennessee, Knoxville, TN

Most analyses of the effects of climate change on forests have been at large scales, ranging from the globe, to national, and occasionally, to key regions. Yet effects of climate change are likely to be driven by site-specific characteristics including soil depth, soil water holding capacity, and species sensitivity to drought and temperature. Because of uncertainty in climate changes and its effects, three climate change scenarios for 2030 and 2080 from three General Circulation Models (GCMs) were used to simulate a range of potential climate conditions for Tennessee forests. These climate

changes derive from the Intergovernmental Panel on Climate Change (IPCC) "A1B" storyline that assumes rapid global economic growth. The precipitation and temperature projections from the three GCMs for 2030 and 2080 were related to changes in five ecological provinces using the monthly record of temperature and precipitation from 1980 to 1997 for each 1 km cell across the state as aggregated into the provinces. The forest ecosystem model LINKAGES was used to simulate conditions for five ecological provinces from 1989 to 2300. Average output projects changes in tree diversity and species composition in all ecological provinces in Tennessee with the greatest changes in the Southern Mixed Forest province. Projected declines in total tree biomass are followed by biomass recovery as species replacement occurs in stands. The results suggest that biomass recovery following climate change is linked to dominant tree diversity in the southeastern forest of the US.

Session: Addressing Climate Change Issue in Appalachian Highlands from the Bottom Up

November 18, 2009; 8:30-4:30 (Pisgah room)

Session Moderators:
John Peine, USGS Southern Appalachian Field Station
Carolyn Wells, US Fish and Wildlife Service

Abstract:

What decisions are local natural resource management personnel facing with respect to accelerated climate change? Which natural resources are the most vulnerable? What uncertainties are precluding sound, defensible management decisions – including the development of adaptation and mitigation strategies? What are the "no regret" actions that we must take now, with the limited resources available, to ensure that the natural resources of our region are adequately buffered from the worst?
Agency field biologists and resource managers are facing increasingly complex and multidisciplinary challenges alongside of dwindling resources. Now is the time to address interdisciplinary science needs in risk assessment and mitigating strategies for vulnerable species and biological communities.

Structure of the discussion:

In the first panel, field-level personnel will profile examples of climate-sensitive natural resources unique or otherwise critical to the Southern Appalachian landscape, and their uncertainties with respect to how best to manage these resources in the face of accelerated climate change. A second panel of program managers will overview emerging regional initiatives and strategies (including monitoring, modeling, decision-support and risk assessment tools) and suggest how these programs could help address the specific issues presented in the first panel.

First PANEL– Field-level personnel profile examples of climate-sensitive natural resources unique or otherwise critical to the southern Appalachian landscape, and their uncertainties with respect to managing these resources in the face of accelerated climate change.

Panelists:
Chris Ulrey, Blue Ridge Parkway
Megan Sutton, The Nature Conservancy
Cleve Fox, U.S. Forest Service,
Jason Robinson, University of Tennessee
Nancy Finley, Great Smoky Mountains National Park

Second PANEL– Managers overview emerging regional initiatives and strategies (including monitoring, modeling, decision-support and risk assessment tools) and suggest how these programs could help address the specific issues presented in the morning panel.

Panelists:
Danny Lee, U.S. Forest Service, Southern Research Station
Dave Meriwether, U.S. Forest Service
Doug Burns, U. S. Geological Survey
Pete Murdoch, U.S. Geological Survey
Sherry Morgan, U.S. Fish and Wildlife Service
Thomas Minney, The Nature Conservancy
Mallory Martin, NC Wildlife Resources Commission
Y.Q. Wang, Rhode Island University
Jim Fox, National Environmental Modeling Center

Climate change adaptation planning in the U.S. Fish and Wildlife Service

Sherry Morgan[1] and Robert P.Ford[2]
[1]Assistant Regional Director, Migratory Birds and State Programs, U.S. Fish and Wildlife Service, 300 Westgate Center Drive, Hadley, MA 01035-9589
(413) 253-8610; Sherry_morgan@fws.gov
[2]Regional Climate Change Coordinator, U.S. Fish and Wildlife Service, The University of Memphis, South Campus, 950 Getwell, Bldg. 8, Memphis, TN 38111-0005
(901) 327-7631; Robert_p_ford@fws.gov

This presentation will describe climate change planning activities of the U.S. Fish and Wildlife Service (FWS), and will cover actions being taken in both the Southeast Region and Northeast Region of the Service. One of the major partnerships of the FWS in the Appalachian Region is the Appalachian Mountain Joint Venture (AMJV), a partnership of federal, regional and state agencies and organizations focused on the conservation of habitat for native migratory birds. The AMJV partnership is exploring opportunities to work collaboratively on climate change adaptation within the Appalachian Region. In addition, the FWS has developed a climate change strategic plan and five-year action plan. Key features of the strategic plan will be described. The Service has funding included in the President's 2010 budget to work with partners on climate change. The U.S. Geological Survey also

has funding for climate change work in 2010, and the discussions between the two Federal agencies to date have focused on delivering the science for climate change adaptation planning for fish and wildlife resources, working collaboratively with other partners across the landscape. The authors will also describe current thoughts within the FWS about adaptation planning.

A decision support system for monitoring, reporting and forecasting the ecological conditions of the Appalachian National Scenic Trail

Y.Q. Wang[1], Fred Dieffenbach[2], Rama Nemani[3], Ken Stolte[4], Glenn Holcomb[5]*
[1]Dept. of Natural Resources Science, University of Rhode Island, Kingston, RI 02881
[2]National Park Service, Northeast Temperate Network, Woodstock, VT 05091
[3]NASA Ames Research Center, Moffett Field, CA 94035
[4] U.S. Forest Service, Southern Research Station, Research Triangle Park, NC 27709
[5]U.S. Geological Survey, Northeast Region, Kearneysville, WV 25430
* On behalf of the project team and individual collaborators and participants

This presentation is to introduce a project that has been funded recently by NASA. The Ecological Forecasting Program is an element of the Applied Sciences Program within the Earth Science Division of the NASA Science Mission Directorate. This program collaborates with partner organizations to extend the application of NASA's research results to policy and management decision support tools. This project is to integrate NASA multisensor Earth observation data, the Terrestrial Observation and Prediction System (TOPS) modeling, and *in situ* measurements from A.T. MEGA-Transect partners to address identified national biological diversity priorities of Ecological Forecasting. The system will improve the decision-making system that exists between the Appalachian Trail Park Office, the Appalachian Trail Conservancy, the NPS Inventory and Monitoring (I&M) program, and the U.S. Forest Service, and will provide a means to convey meaningful information to the American public. The objectives are to: 1. Develop a comprehensive set of seamless indicator data layers consistent with the Appalachian Trail "Vital Signs"; 2. Establish a ground monitoring system to complement TOPS and integration of NASA data with *in situ* observations; 3. Assess historical and current ecosystem conditions and forecast trends by coupling TOPS with habitat models; and 4. Develop an Internet-based implementation and dissemination system for data visualization, sharing, and management to facilitate collaboration and promote public understanding of the A.T. environment. In particular the project will focus on the three primary Vital Signs (Phenology and Climate Change, Forest Health, and Landscape Dynamics) and four supplementary Vital Signs (Mountain Birds, Migratory Breeding Birds, Water Quality and Quantity, and Alpine and High Elevation Vegetation) that are most relevant and can be represented

well by NASA Earth observation data and the TOPS modeling capacities.

Communicating climate and climate change information for integrated decision support at the county and regional levels

Jim Fox, Director, UNC Asheville's National Environmental Modeling and Analysis Center, UNC Asheville (828) 301-2075; jfox@unca.edu
Collaborators: Greg Dobson, Jeff Hicks, Matt Hutchins, Karin Lichtenstein, Mark Phillips, Todd Pierce, Bridget O'Hara, and Susan Weatherford, UNC Asheville's National Environmental Modeling and Analysis Center

More climate and climate change information is now available than ever before and many groups are looking to use this information for decision making. However, much of this information is not easily accessed in formats that are clearly interpreted by the non-scientific community (e.g. local and regional decision makers, the general public). Decision makers need more than just raw data to make accurately informed decisions. By integrating trusted sources of climate information with other datasets (e.g. economic, environmental, cadastral, infrastructure, physical data), tools and techniques can be created that will enhance science communication and delivery. This leads to more informed decision making and a better understanding of data uncertainties.

A four-step process was created to guide the transfer of climate information into knowledge. The process included 1) integration of data and information, 2) creating visualizations, 3) telling the story, and 4) group decision making. Data integration occurred at county and regional scales in order to facilitate local decision making to such groups as city and county councils, emergency and first responders, and community planners. Specific tools created to help guide this transfer of knowledge and better interpret climate and climate change information included the use of GIS and other geospatial visualization technologies, web-based interactive technologies, and open source solutions. These tools helped address such issues as hazard mitigation, land use and future growth planning, and forest health. This presentation will highlight examples of tools and techniques developed which addressed the integration of climate and climate change information for integrated decision support across the western North Carolina region.

The work described here involved a multi-disciplinary collaboration between the University of North Carolina at Asheville's (UNCA) National Environmental Modeling and Analysis Center (NEMAC), the Renaissance Computing Institute at UNCA, the U.S. Forest Service, the National Weather Service, the National Climatic Data Center, and other local businesses. NEMAC focuses on unique collaborations involving the academic, public, and private sectors.

Session: Water Supply and Stress

November 19, 2009; 8:30-11:00 (Roan room)

Session Moderator:
Judy Francis, North Carolina Department of Environment and Natural Resources

PANEL – Climate change and trout in southern Appalachia: Biology to policy

The sustainability of native trout populations in southern Appalachia is one of the many challenges presented by climate change. Biologists continue to assess the current and future impacts of a warming climate on coldwater habitats, ecosystem functions, and species survivability. Agencies must determine appropriate management actions that anticipate expected changes and species impacts. Decision makers must understand ways to address the problem through promulgation and implementation of effective policy. Sportsmen must provide support and advocacy for both scientists and like-minded policy makers. Clearly this is an issue that must be addressed on multiple fronts. Partnerships, sharing of information and collaborations will be critical to protect trout and their habitat throughout the region.

This panel will include a discussion of current and expected habitat conditions and management strategies for trout in southern Appalachia from the perspective of both state and federal agency researchers who are involved in assessing the impacts of climate change. Other panelists will discuss the activities of non-profit organizations in educating their membership, providing technical expertise, and various advocacy strategies at the local, state, and federal levels. Information regarding the status of federal and state climate change policy will also be provided, as well as potential funding opportunities for wildlife resource managers to address the many challenges associated with this issue.

Moderator: *Judy Francis, AICP*
Judy.Francis@ncdenr.gov
Judy has over 25 years of planning experience working for local, state, and federal land management entities in Florida, Colorado, and North Carolina. She currently is the Western Field Officer for the Office of Conservation & Community Affairs in the NC Department of Environment & Natural Resources and facilitates public / private conservation partnerships. She has been an avid fly fisher for over 20 years.

Panelist: *Nathanial Gillespie*
NGillespie@tu.org
Nat Gillespie is the director of the Eastern Lands Protection Program of Trout Unlimited (TU), where he works to develop partnerships with land trusts and TU chapters and programs to help protect lands that benefit trout habitat and water quality, and to restore the ecological integrity of streams and watersheds on protected lands. He is focused on the Chesapeake Bay watershed, western North Carolina, and New York state.

Panelist: *Doug Besler*
doug.besler@ncwildlife.org
Doug has worked for the NC Wildlife Resources Commission for over 13 years and currently serves as the Mountain Region Supervisor of the Department of Inland Fisheries. He is involved in numerous projects with the goal of protecting and sustaining native trout populations in western North Carolina.

Panelist: *Fred Harris*
fahadh92@hotmail.com
Fred began working for North Carolina Wildlife Resources Commission in 1972 as a District Fisheries Biologist. During his 36-year career with the commission Fred worked as a Fisheries Research Coordinator, Fisheries Program Manager, Chief of Fisheries, and Deputy Director. He retired in 2008. He is a life member of the American Fisheries Society and served as the Society's president in 2003.

Panelist: *Sheryl Bryan*
sbryan@fs.fed.us
Sheryl has been a Fisheries and Wildlife Biologist for the U.S. FOREST SERVICE in North Carolina for over 20 years and is based in Asheville. She also has experience with wildfire planning and impacts on endangered trout and salmon in Oregon. Her primary interest is native trout habitat protection and restoration, mitigation of land management effects, and public access to natural resources.

Panelist: *Capt. Michael "Squeak" Smith*
squeaksmith@earthlink.net
A self-proclaimed fly fishing "addict," Squeak began his fishing adventures at age 3 and has been an advocate for trout ever since. He has provided leadership for many habitat restoration initiatives, hydropower relicensings, and public education efforts in western North Carolina. He has been a leader in Trout Unlimited since 1986, serving in numerous roles including the Southeastern Regional Vice-President, and a six-year member of the Board of Directors. He was recently selected as one of "The Ten" most influential members in the history of Trout Unlimited.

Panelist: *Richard Mode*
grmode@earthlink.net
Richard has been a leader for a number of environmental organizations including a founding member of Trout Unlimited Table Rock Chapter, a Board member for over 18 years of the North Carolina Wildlife Federation, and an Affiliate representative to the National Wildlife Federation for over 8 years. He is the recipient of numerous awards including the 2007 Budweiser/National Fish & Wildlife Foundation Conservationist of the Year. He currently serves as the National Wildlife Federation Outreach Coordinator in North Carolina for Climate Change and travels frequently to Washington, DC to lobby for climate change legislation.

Session: Water Supply and Stress

November 19, 2009; 11:00-12:00 (Roan room)

Session Moderator:
Alice Cohen, U.S. Forest Service, National Forests in North Carolina

Impacts of climate change on watershed hydrology and water supply stress in the southern Appalachians region

Ge Sun[1] and Steve McNulty
Southern Global Change Program, U.S. Forest Service, Southern Research Station, Raleigh, NC
[1]Ge_Sun@ncsu.edu

The forested Appalachian ecoregion is well known for its high biodiversity and ecological significance due to its rich water resources and warm climate. The region is the headwaters of a few major rivers that provide quality water to several large metropolitan areas in the southeastern U.S. Traditionally, the region has a very low water supply stress due to high precipitation but low water withdrawal for human use. However, future warming and an increase in rainfall variability may cause water quantity and quality concerns in this water rich ecoregion. This paper presents basic scenarios of possible response of watershed hydrologic processes and water supply stress to climate change. First, water supply in the region is highly dependent on surface water that may have increasingly high inter-annual and intra-annual variability under a changing climate. Second, the hydrology in the region is energy limited, so an increase in air temperature is likely to increase water loss through evapotranspiration, which in turn will reduce streamflow, especially during the dry seasons (i.e., Spring and Fall). Third, extreme hydrological events such as floods and droughts are expected to become more frequent under a changing climate, and finally, a rise of intense storm events is likely to increase the probability of soil erosion and landslides in this mountainous region. Land use change and population growth will stress the water resources in the Appalachians regardless of how climate will change in the future. This paper will explore how integrated watershed ecosystem management could be used to address these water resource issues caused by climate change and other stressors.

Benthic macroinvertebrates response to imperviousness: Rapid bioassessment findings in the southern Appalachians

Jon Calabria[1] , Carter Cone[1], Jeff Bruton[2], Rockie English[3]
[1] North Carolina State University Water Quality Group, c/o 100 Frederick Law Olmsted Way, Asheville, NC 28806
jcalabr@g.clemson.edu

[2] *North Carolina Department of Environment and Natural Resources*
[3] *Clemson University*

Although it is not surprising that increased watershed imperviousness degrades biotic integrity, our investigations reveal increased imperviousness is likely a limiting factor for benthic macroinvertebrate communities. As climate change occurs in the southern Appalachians, modified flow regimes in urbanizing areas may significantly impact biotic integrity. Climate change may also influence seasonal trends. These changing variables will have a direct effect on the benthic macroinvertebrate habitat. This baseline study investigated benthic macroinvertebrates from small headwater catchments (n=179) and analyzed the abundance and composition using the Hilsenhoff Family Benthic Index (FBI) to determine pollution tolerance of organisms. A curve number for each catchment was calculated using the TR-55 Curve Number (CN) Methodology from USDA. The CN is a surrogate for the catchment imperviousness, relying on the hydrologic soil unit and land use. Our investigation suggests a strong correlation of FBI values by CN ($r^2=.74$, $p<.0001$), suggesting increased imperviousness can degrade benthic macroinvertebrate communities. Based on these findings, interventions such as stream and watershed enhancement and restoration in less impervious watersheds may yield higher success rates (as measured by biotic integrity) as we combat the habitat variability resulting from climate change.

Session: Resource Restoration and Management

November 19, 2009; 8:30-12:00 (Pisgah room)

Session Moderator:
Michelle Aldridge, U.S. Forest Service, National Forests in North Carolina

North American forest trees, climate change, and genetic peril: A forest health monitoring project

Kevin M. Potter[1], William W. Hargrove[2] and Frank H. Koch[1]
[1]Department of Forestry and Environmental Resources, North Carolina State University, Research Triangle Park, NC 27709
[2]U.S. Forest Service, Eastern Forest Environmental Threat Assessment Center, Southern Research Station, Asheville, NC 28804

The Forest Health Monitoring Program of the U.S. Forest Service is sponsoring an assessment of the risk posed by climate change to the genetic integrity of North American forest tree species. It has three central objectives: 1) Forecast the future location and quality of habitat for at least 100 North American tree species under two climate change models. 2) Predict the risk of extirpation for existing populations. 3) Assess the overall susceptibility of species and their populations to genetic degradation and extirpation. We will illustrate this project with examples of Southern Appalachian forest tree species at varying degrees of risk from climate change.

To meet the first objective, we are using the Multivariate Spatio-Temporal Clustering (MSTC) technique to predict the future location and quality of habitat for forest tree species under the Hadley model and Parallel Climate Model (PCM) in 2050 and 2100.
For the second objective, we are measuring the straight-line Minimum Required Migration (MRM) distance from the existing locations of each species to the nearest favorable future habitat. The greater this distance, the less likely the species will be able to reach the nearest refuge, and the more likely it will become locally extinct.

For the third objective, we are working with other forest geneticists and ecologists to assess the risk of genetic degradation for each species, synthesizing existing knowledge about the biology and genetic diversity of each species with results from the first two parts of this project.

The results of this work should be valuable for scientists and policymakers attempting to determine which forest tree species and populations should be

targeted for monitoring efforts, conservation actions, and molecular marker studies. The results also should be useful for land-use planners and conservation organizations identifying locations that could be preserved as important future habitat for at-risk tree species.

Response of southern Appalachian tree species to climate change: Should we intervene?

Laura E. DeWald[1] and Stephanie Q. Grant
[1]Biology Department, Western Carolina University, Cullowhee, NC 28723
(828) 227-2478; ldewald@wcu.edu

There is ample historical evidence that geographic ranges of North American tree species have naturally shifted in response to changing climates. However, these shifts were associated with longer time scales than species are facing with the current rate of climate change. In addition, habitat fragmentation has made it unlikely that large-scale shifts can occur without human intervention. In these cases, "assisted migration" might be the appropriate mitigation strategy. However, this strategy is not without risk and there are many examples of long-term negative consequences associated with human-mediated movement of plant species and genetic material. Another alternative is to let adaptation to the changing climate occur through natural selective processes. For this strategy to be successful, plant populations have to adapt relatively rapidly. There is increasing evidence from a variety of species that this is already occurring. However, examples of rapid or contemporary evolution occurring in long-lived organisms such as trees are rare. This presentation will summarize and compare different management strategies that can be used to assist southern Appalachian tree species in successfully responding to climate change. In addition, we will provide an example of rapid genetic change in North Carolina populations of northern red oak (*Quercus rubra*) that may serve as a model to help managers predict tree species' responses and develop management strategies to improve resilience of southern Appalachian forests to climate change.

Present and future near-ground microclimates across Great Smoky Mountains National Park: Forecasts from the GSMNP Temperature Network

Jason Fridley, Syracuse University
107 College Place, Department of Biology, Syracuse, NY 13244
(315) 443-3098; fridley@syr.edu

In the topographically complex, heavily forested landscapes that typify the southern Appalachians, the microclimates that most organisms experience are determined by both atmospheric conditions and landscape properties. Understanding how such microclimates will shift in a warmer atmosphere is crucial to predicting the fate of the region's ecosystems, but little is currently understood about how regional climate predictions translate to understory conditions across a wide range of topographic positions. In 2005,

a 170-sensor temperature network was deployed in GSMNP to create high-resolution (30-m) landscape models of near-ground temperature regimes in relation to topography, vegetation, and edaphic conditions.

The models reveal that understory temperatures of different landscape positions are often decoupled from regional air mass properties. In particular, wetter locations such as coves and high elevation sites tend to exhibit modulated microclimates that respond only weakly to annual, seasonal, and interannual climate fluctuations. Drier and more exposed locations such as ridgelines tend to have more variable microclimates that fluctuate with ambient weather systems. This has important implications for predicting the impact of regional climate change on southern Appalachian ecosystems. For example, in the absence of large changes in regional precipitation, high elevation forests may be less sensitive to regional climate change than is commonly assumed. Indeed, if, in contrast, drier, low-elevation sites warm in parallel with expected atmospheric warming, habitat diversity in the southern Appalachians may actually increase and include boreal, temperate, and tropical elements. In this presentation I will describe the GSMNP temperature network; present results of landscape models that show how topography, vegetation, and soils drive near-ground temperature regimes; and show preliminary predictions of how GSMNP microclimates may change over the coming century.

Potential for climate adaptation within elevation and latitude gradients in the southern Appalachians

Hugh Irwin
Conservation Planner/Program Director, Southern Appalachian Forest Coalition, 46 Haywood Street, Suite 323, Asheville, NC 28801
(828) 252-9223; FAX (828) 252-9074; hugh@safc.org; www.safc.org

The importance of landscape corridors has been widely recognized in conservation biology. Corridors provide routes for genetic interchange and permit animal and plant movements for adaptation. Corridors can also help mitigate local extirpations and contribute to the recovery of populations. Climate change will make landscape connectivity even more important as species are forced to adapt to changing climate conditions. Climate adaptation is often visualized and modeled occurring over a latitude gradient with sensitive species finding suitable habitat in more northern latitudes as climate pressure eliminates habitat in more southern latitudes. However, the elevation gradient in mountainous regions such as the Southern Appalachians provides potential for species adaptation in some areas and for some species over much shorter geographic ranges. As climate change is incorporated into conservation planning, it is important to anticipate how well the elevation gradient within existing conservation lands is capable of accommodating species adaptation and movements. It is also important to identify corridors across both latitude

and elevation gradients that can provide escape routes for species under climate change.

A methodology will be presented for creating a GIS based latitude-elevation gradient for evaluating changes in species habitat under climate change. This latitude-elevation model will also be used to illustrate corridor design to assure suitable latitude-elevation gradients between established landscape conservation areas.

Habitat quality, niche breath, temporal stochasticity, and the persistence of populations in heterogeneous landscapes

Scott M. Pearson[1] and Jennifer M. Fraterrigo[2]
[1]Department of Natural Sciences, Mars Hill College, Mars Hill, NC 28754
(828) 689-1402; spearson@mhc.edu
[2]Department of Natural Resources and Environmental Sciences, University of Illinois, Urbana, IL 61801

Spatial heterogeneity in habitat quality creates variation in demographic performance among subpopulations of native species, and this heterogeneity will affect species' responses to climate change. We explore the effects of within-patch heterogeneity on population persistence in a simulation model and use the model to examine the effects of year-to-year climatic variation. Spatial heterogeneity, niche breadth, and temporal stochasticity in the environment are widely recognized as important drivers of population structure, yet few studies have examined the combined influence of these factors. Simulated populations had life history traits resembling perennial forest herbaceous plants, and simulated landscapes were based on forests of southern Appalachian Mountains. Habitat quality varied continuously within and among habitat patches using realistic patterns based on topographic gradients. Temporal stochasticity in survival was implemented to simulate interannual climatic variation, and levels of stochasticity were varied to reflect different frequencies of extreme events. The effects of habitat fragmentation, spatial variation in habitat quality, and niche breadth resulted in differential demographic performance among habitat patches of similar size and shape. These effects overshadowed influences of temporal stochasticity on population persistence. The results suggest that populations of forest perennials may be more sensitive to habitat fragmentation and variation to habitat quality than to temporal stochasticity due to climate. However, specialist species will be more sensitive than generalist to temporal stochasticity.

Employing LiDAR data for vegetation management on Roan Mountain

Christopher W. Fusting[1], Gary Kauffman[2], Neil Thomas[3]
[1]cfusting@gmail.com
[2]gkauffman@fs.fed.us
[3]rdi@resourcedata.net

The North Carolina LiDAR data set has the potential to answer a variety of ecological questions. In this study, management efforts on Roan Mountain

were concerned with three classes of vegetation: grassy balds, shrubs, and the canopy. Analysis of the LiDAR point distribution suggested the resolution was highest at 20 ft^2. The maximum LiDAR height for each grid cell was derived from bare earth and return 1 LiDAR points. The resulting digital elevation model (DEM) was subtracted from the resulting digital surface model (DSM) to derive a vegetation height layer. A field investigation was conducted to determine the height break points that defined the different vegetation classes. The vegetation height layer was classified into the three vegetative classes according to the data gathered during the field investigation.

The resulting vegetation class model was evaluated for accuracy using the data gathered during the field investigation. The model correctly identified canopy, shrub, and grassy bald edges throughout the study area for which ground truth data was available. The model also identified vegetation isolated within the grassy bald, and correctly identified it as shrub or canopy. The limitations of the model were based its resolution. Vegetation filling a 20 ft^2 grid cell was extracted and classified reliably, while smaller vegetation was identified only part of the time.

SAMAB Cooperative Executive Committee Members, Alternates, Coordinating Office Staff and SAMAB Foundation

Officers of the Board of Directors

Executive Committee Chair

Rick Durbrow
Program Analyst
U.S. EPA – Region IV
61 Forsyth St. SW
Atlanta, GA 30303-3490
Phone: 404-562-8286
Email: durbrow.rick@epamail.epa.gov

Executive Committee Vice-Chair

Gary Peeples
Outreach and Education
U.S. Fish & Wildlife Service
160 Zillicoa St.
Asheville, NC 28801
Phone: 828-258-3939, ext. 234
Email: gary_peeples@fws.gov

Executive Committee Vice-Chair

Possibility

Executive Committee Members

Dennis Barnett, Chief
Environmental Resources Branch
U.S. Army Corps of Engineers
South Atlantic Division
60 Forsyth Street SW, Room 9M15
Atlanta, GA 30303-8801
Phone: 404-562-5225
Email: dennis.w.barnett@usace.army.mil

Kevin Brown
TN State Conservationist
USDA – NRCS
675 U.S. Courthouse
801 Broadway
Nashville, TN 37203
Phone: 615-277-2531
Email: kevin.brown@tn.usda.gov

Brian Cole, State Supervisor – Ecological Services
U.S. Fish and Wildlife Service
160 Zillicoa Street
Asheville, NC 28801
Phone: 828-258-3939, Ext. 223
Email: brian_cole@fws.gov

Nancy Finley, Chief of Resource Management and Science
Great Smoky Mountains National Park
107 Park Headquarters Road
Gatlinburg, TN 37738
Phone: 865-436-1245
Email: nancy_finley@nps.gov

Dan Forster, Director
Wildlife Resources Division
GA Department of Natural Resources
2070 U.S. Hwy. 278, SE
Social Circle, GA 30025
Phone: 770-918-6400
Email: dan_forster@dnr.state.ga.us

Phil Francis, Superintendent
Blue Ridge Parkway
National Park Service
199 Hemphill Knob Road
Asheville, NC 28803
Phone: 828-271-4718
Email: phil_francis@nps.gov

Dee Freeman, Secretary
NC Dept. of Environ. & Natural Resources
1601 Mail Service Center
Raleigh, NC 27699-1601
Phone: 919-715-4102
Email: dee.freeman@ncdenr.gov

Scott Gain, Director
USGS Tennessee Water Science Center
640 Grassmere Park, Suite 100
Nashville, Tennessee 37211
Phone: 615- 837-4700
Email: wsgain@usgs.gov

Nancy Herbert, Assist. Station Director
USFS Southern Research Station
200 W.T. Weaver Blvd.
Asheville, NC 28804
Phone: 828-257-4306
Email: nherbert@fs.fed.us

Marisue Hilliard, Forest Supervisor
USFS National Forests in North Carolina
160 Zillicoa Street
Asheville, NC 28801
Phone: 828-257-4268
Email: mhilliard@fs.fed.us

Glenn Holcomb
Program Manager
USGS Northeast Area
11649 Leetown Road
Kearneysville, WV 25430
Phone: 304-724-4526
Email: gholcomb@usgs.gov

Tom Hunter, Executive Director
Appalachian Regional Commission
1666 Connecticut Avenue, NW
Washington, DC 20235
Phone: 202-884-7700
Email: thunter@arc.gov

Hank Jarboe
U.S. Army Corps of Engineers
Lakes and Rivers Division
P.O. Box 1159
Cincinnati, OH 45201-1159
Phone: 513-684-6050
Email: hank.jarboe@usace.army.mil

Sonya Jones, Regional Program Officer
USGS Southeast Area
Spalding Woods Office Park, Suite 160
3850 Holcomb Bridge Road
Norcross, GA 30092
Phone: (770) 409-7700
E-mail: sajones@usgs.gov

John Myers
Environmental Policy & Regulatory Outlook
Tennessee Valley Authority
1101 Market St., LP5U
Chattanooga, TN 37402
Phone: 423-751-8855
Email: jwmyers@tva.gov

Patricia D. Parr, Natural Resources Manager
Oak Ridge National Laboratory
P.O. Box 2008
Bethel Valley Road (for express mail)
Oak Ridge, TN 37831-6340
Phone: 865-576-8123
Email: parrpd@ornl.gov

Paul Sloan, Deputy Commissioner
Tennessee Dept. of Environment & Conservation
1st Floor, L & C Annex
401 Church Street
Nashville, TN 37243-1534
Phone: 615-532-0102
Email: paul.sloan@ tn.gov

Tom Speaks
USFS Cherokee National Forest
2800 N. Ocoee St.
Cleveland, TN 37312
Phone: 423-476-9700
Email: tspeaks@fs.fed.us

Alternates

Ray Albright
National Park Service
Southern Appalachian CESU
University of Tennessee
274 Ellington Plant Sciences
Knoxville, TN 37996
Phone: 865-974-7126
Email: ralbrigh@utk.edu

Cory Berish, Chief
Policy, Planning and Evaluation Branch
U.S. EPA – Region IV
61 Forsyth St. SW
Atlanta, GA 30303-3490
Phone: 404-562-8276
FAX: 404-562-8269
Email: berish.cory@epamail.epa.gov

Barry Clinton
USFS Southern Research Station
Coweeta Hydrological Lab
3160 Coweeta Lab Road
Otto, NC 28763
Phone: 828-524-2128 x 124
Email: bclinton@fs.fed.us

Dale Ditmanson, Superintendent
Great Smoky Mountains National Park
107 Park Headquarters Road
Gatlinburg, TN 37738
Phone: 865-436-1201
Email: dale_ditmanson@nps.gov

Judy Francis
Western Field Office
NC Dept. of Environ. & Natural Resources
2090 U.S. Highway 70 West
Swannanoa, NC 28778-8211
Phone: 828-296-4523
Email: judy.francis@ncdenr.gov

Zoe Hoyle
USFS Southern Research Station
200 W.T. Weaver Blvd.
Asheville, NC 28804
Phone: 828-257-4388
Email: zhoyle@fs.fed.us

David Hughes
Appalachian Regional Commission
Program Operations Division
1666 Connecticut Avenue, NW
Washington, DC 20235
Phone: 202-884-7740
Email: dhughes@arc.gov

Gary Jacobs
Environmental Sciences Division
Oak Ridge National Laboratory
P.O. Box 2008
Oak Ridge, TN 37831-6037
Phone: 865-574-7374
Email: jacobsgk@ornl.gov

Monika Mayr, Deputy Superintendent
NPS Blue Ridge Parkway
199 Hemphill Knob Road
Asheville, NC 28803
Phone: 828-271-4779, ext. 201
Email: monika_mayr@nps.gov

Wes Nettleton
USFS Southern Region
Forest Health Protection
1720 Peachtree Road, NW
Atlanta, Georgia 30367
Phone: 404-347-2719
Email: wnettleton@fs.fed.us

John Peine
USGS-BRD
University of Tennessee
311 UT Conference Center Bldg.
Knoxville, TN 37996
Phone: 865-974-4056
Email: jpeine@utk.edu

Terrance Rudolph
Area Conservationist
USDA – NRCS
9737 Cogdill Rd., Suite 152C
Knoxville, TN 37932-3381
Phone: 865-671-3830, ext. 105
Email: terrance.rudolph (at) tn.usda.gov

Monica Schwalbach
USFS National Forests in North Carolina
160 Zillicoa St.
Asheville, NC 28804
Phone: 828-257-4268
Email: mschwalbach@fs.fed.us

Terry Seyden, Public Affairs Officer
USFS National Forests in North Carolina
160 Zillicoa Street
Asheville, NC 28804
Phone: 828-257-4202
Email**:** terryseyden@fs.fed.us

Michael Spencer
Georgia Department of Natural Resources
2070 U.S. Highway 278, SE
Social Circle, GA 30025
Phone: 770-918-6406
Email: michael_spencer@dnr.state.ga.us

Michael Walsh, Division Commander
South Atlantic Division
US Army Corps of Engineers
60 Forsyth St., SW
Atlanta, GA 30303
Phone: 404-562-5006
Email: michael.j.walsh.col@usace.army.mil

Affiliate Members

Russell Townsend
Tribal Historic Preservation Officer
Eastern Band of Cherokee Indians
2877 Governor's Island Road
Bryson City, NC 28713
Phone: 828-488-0237
Email: russtown@nc-cherokee.com

Charles Feldhake
USDA Agricultural Research Service
1224 Airport Road
Beaver, WV 25813
Phone: 304-256-2858
E-mail: charlie.feldhake@ars.usda.gov

SAMAB Coordinating Office

Alex Comfort, Executive Director
Cradle of Forestry Interpretive Association
66 S. Broad St.
Brevard, NC 28804
828-883-5713
E-mail: alexcfaia@citcom.net

Julie Dennis, Administrative Assistant
Cradle of Forestry Interpretive Association
66 S. Broad St.
Brevard, NC 28804
828-883-5713
E-mail: cfaia@citcom.net

Adam DeWitte, Assistant Dir. of Education
Cradle of Forestry Interpretive Association
66 S. Broad St.
Brevard, NC 28804
828-883-5713
E-mail: adamcfaia@citcom.net

Crystal Reece, Comptroller
Cradle of Forestry Interpretive Association
66 S. Broad St.
Brevard, NC 28804
828-883-5713
E-mail: cfaia@citcom.net

SAMAB Foundation Board of Directors

Charles C. Van Sickle, Chair
19 Nottingham Drive
Candler, NC 28715
Phone: 828-665-2422
Email: cvans1@juno.com