

Final Report to Joint Fire Science Program for #01C-3-3-01

Project Title: An integrated assessment of the historical role and contemporary uses of prescribed fire in southern Appalachian ecosystems

JFSP Project No.: 01C-3-3-01

Project Location: Coweeta Hydrologic Laboratory, Southern Research Station, USFS, Otto, NC – western North Carolina

Principal Investigators: Drs. James M. Vose, Katherine J. Elliott, Theodore L. Gragson, and W. Wallace Covington

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Brief Description of Project: The project objectives were to: 1) document and synthesize information on the historical and contemporary southern Appalachian fire regimes; and 2) evaluate the effects of prescribed fire on ecosystem structure and function along a moisture/productivity gradient from xeric, pine-hardwood to mesic, mixed-hardwood ecosystems in the southern Appalachian region.

Two of the three prescribed burn projects were ongoing (a xeric, pitch pine-hardwood and a dry, shortleaf pine-hardwood) and measurements were continued to evaluate long-term ecosystem responses as part of this JFSP project. The third project was added to understand and compare effects of fire on mesic, mixed-hardwood ecosystems in the southern Appalachians where information is lacking.

Status Report: We have completed our project, which is in its final year of the 3-year funding cycle. Objective 1: Two graduate students, under supervision of the university co-PIs (Northern Arizona University and University of Georgia) have completed their studies related to documenting the historical and contemporary southern Appalachian fire regimes. The NAU student (Ms. Nikki Cooley) has completed interviews with tribal elders of the Eastern Band of the Cherokee Nation; transcription of the interviews is complete; and a MS thesis was completed May, 2004. The UGA graduate student (Mr. William Jurgelski) has completed the collection of archived information from early 1990's USFS and NC State Forest Service records to synthesize information for the contemporary fire regimes; he has submitted a report (attached Jurgelski.doc), and a manuscript for publication is nearly complete.

Objective 2: To evaluate the effects of prescribed fire on mesic, mixed-hardwood forests, three sites were located (one in north Georgia and two in western North Carolina). Permanent plots were established and pre-burn and post-burn measurements (vegetation, soil and soil solution chemistry, carbon and nutrient pools, stream chemistry and sediments) were collected on all three sites. Two sites were burned in Feb-March 2004; one by the Tallulah Falls Ranger District, Chattahoochee National Forest (north GA) and one by the Wayah Ranger District, Nantahala National Forest (western NC). The third site in the Wine Spring watershed (western NC) was burned in March, 2003 by the Wayah Ranger District; post-treatment data have been collected for the first and second growing seasons after the fire, 2004-2005. Information from the ongoing projects has resulted in 3 refereed papers, 3 proceedings papers, and 1 thesis; 13 presentations at professional/scientific meetings; a Fire Ecology workshop hosted and organized by Coweeta Hydrologic Laboratory; and 4 other technology transfer efforts to National Forest Managers, The Nature Conservancy and the Eastern Band of the Cherokee Nation (see attached below).

Acomplishments and Project Results Summary:

Objective 1) was to document and synthesize information on the historical and contemporary southern Appalachian fire regimes. We addressed this objective by:

Appalachian Fire History

Three major initiatives were implemented to understand the historical role of fire. The first initiative examined southern Appalachian historical land management practices, specifically burning, of the Eastern Band of the Cherokee who have maintained this knowledge through oral practices also referred to as traditional ecological knowledge. Qualitative interviews were conducted with Cherokee tribal elders. The interview participants spoke at length about Cherokee burning practices. The transcribed interview data demonstrated the significance of oral history and revealed knowledge of the historical use of fire (Nicolette Cooley. 2004. MS Thesis, Northern Arizona University, Flagstaff, AZ).

The second initiative examined the period of Cherokee initial sustained contact with European populations; establishment of the Cherokee political and economic alliance with the British; emergence of a Cherokee native state; and collapse of the traditional Cherokee system. This study has determined the location and size of Cherokee towns for select dates between 1685 and 1775 using historical cartography and colonial census records. Algorithms are being developed to rank land by the likelihood of disturbance as a function of distance, slope and terrain shape to derive measures of land disturbance relative to village location and size (Gragson, in preparation). These spatial models will be used to determine areas where Native American use of fire was most likely. The third initiative examined a diversity of state and federal records to determine patterns of cause, magnitude and recurrence of fire events for the southern Appalachian region. Archive data and information from 1880 to present included the 10th United States Census (1880), the first published study to focus specifically on forest fires in North Carolina authored by W.W. Ashe in 1895, J.S. Holmes 1909-12 surveys (Holmes 1910, 1911, 1912), and National Forest Service records (see attached: William Jurgelski 2003, unpublished report to Coweeta Hydrologic Laboratory, Otto, NC). Available information suggests that the period from 1880 to 1911 is one of comprehensive political reform that thoroughly transformed the southern Appalachian fire regime simultaneous to the extensive regional penetration of railroads and the dramatic rise in commercial forestry. An 80-year sequence (~1920-2000) consisting of approximately 15,000 fire events on state and federal lands have been compiled. This record is being analyzed to develop a comprehensive temporal and spatial description of fire for the region (see list below, Gragson, in preparation).

Objective 2) was to evaluate the effects of prescribed fire on ecosystem structure and function along a moisture/productivity gradient from xeric, pine-hardwood to mesic, mixed-hardwood ecosystems in the southern Appalachian region. We addressed this objective by:

Effects of prescribed fire on ecosystem structure and function

In the Conasauga River Watershed of eastern Tennessee and northern Georgia, we examined the effects of a single dormant season fire on carbon and nutrient cycling, water quality, and vegetation dynamics. The purpose of these burns was to restore shortleaf pine (*Pinus echinata* Miller)/mixed-oak forests with more diverse understories which include native bluestem grasses. Six sub-watersheds (similar in vegetation, soil type, stream size and location, and disturbance history) were located within the Conasauga River Watershed. Four of the sites were burned in March 2001, and two sites were designated as controls. Consistent with goals of the land managers, all the prescribed fires resulted in low-to-moderate intensity and low severity fires. We measured several key components to evaluate the effects of prescribed fire on ecosystem processes. These restoration fires did not have a significant effect on soil solution and stream chemistry or stream sediment (TSS) concentrations. Burning resulted in a total net loss of 55 kg ha⁻¹ nitrogen from the wood and litter layers, which should be easily replaced by future atmospheric deposition. We found a small reduction in soil CO₂ flux immediately following the burn but litterfall and net nitrogen mineralization were not significantly different from controls. We found no significant change in overstory, midstory, or ground flora species diversity after the

prescribed fire. Although fire reduced basal area of woody species in the midstory, prolific sprouting from hardwoods resulted in higher density of fire-sensitive species. Results from this study have been published in peer-reviewed journals (Hubbard et al. 2004, Elliott and Vose 2005a, 2005b).

Three sites in mesic, mixed-oak forests received prescribed burn treatments in March, 2003 and 2004. Fires were implemented by personnel from the Nantahala and Chattahoochee National Forests. In each case, the prescribed fires were moderate-to-low intensity and low severity understory burns. Ecosystem measurements (soil nutrients, vegetation composition and diversity, forest floor mass and nutrients, stream chemistry) were taken before and after the burn treatments. As a result, overstory mortality was < 2% in the mesic, mixed-hardwoods forest. In the understory, fire reduced basal area of woody species, but prolific sprouting from hardwoods resulted in higher density of fire-sensitive hardwoods such as *Acer rubrum*, *Oxydendrum arboretum*, and *Nyssa sylvatica*. On the mesic sites, *Quercus* density was significantly reduced, but it had high numbers of seedlings (stems <0.5 m height). We found little change in herbaceous layer percent cover or diversity on any of the mesic sites after prescribed fire. We hypothesized that the herbaceous layer was not significantly affected by these low-to moderate intensity fires because the burns occurred in the spring before emergence of herbaceous species and the low soil depth of heat penetration (<2.0 cm at 59 °C) did not result in damage to belowground rhizomes or buried seeds. Analyses of the effects of the prescribed fires are ongoing (preliminary results were presented at an International Conference in June, 2005; a Watershed workshop in September, 2005; Southern Appalachian Man and the Biosphere annual conference in November 2005; and a Fire in Eastern Oak Forests conference in November 2005). Manuscripts are in preparation (see list below Elliott, Vose, and Clinton; Elliott, Vose, and Hendrick; and Knoepp, Elliott, and Vose).

Statement on deliverables:

We proposed three manuscripts on prescribed fire in southern Appalachian forest as part of the deliverables for this Joint Fire Science Program funding. We successfully produced 3 peer-review journal articles, 2 peer-review and 1 common proceedings, and a graduate thesis from our research (see attached publications). Three additional manuscripts on prescribed fires in mesic forests and 1 manuscript titled “Anthropological and historical evidence of Native American and Euro-American use of fire in the southern Appalachians” are planned for submission to peer-review journals in Winter-Spring 2006. As part of the technology transfer effort, we presented results at invited seminars and professional/scientific meetings, and hosted a fire ecology workshop to provide information on prescribed fire in southern Appalachians to a wide audience of users including scientists, natural resource managers, and fire managers from various state and federal agencies.

Deliverables to Joint Fire Science Program for funding years (2002-2005).

Papers published:

1. Clinton, Barton D., **James M. Vose**, Jennifer D. Knoepp, and **Katherine J. Elliott**. 2003. Stream nitrate response to different burning treatments in southern Appalachian forests. In: Pages 174-181 in K.E.M. Galley, R.C. Klinger, and N.G. Sugihara (eds.). Proceedings of the Fire Conference 2000: *The First National Congress on Fire Ecology, Prevention, and Management Proceedings*. Miscellaneous Publication No. 13, Tall Timbers Research Station, Tallahassee, FL.
2. **Vose, James M.** 2003. The role of fire in shaping the structure and function of forest ecosystems in the southern Appalachians. In: *Proceedings, Enhancing Southern Appalachian Forest Resources*, Hendersonville, NC. North Carolina State University, Forestry Education Outreach Program. 7 p.

3. Robert T. Hubbard, Barton D. Clinton, **James M. Vose**, Jennifer D. Knoepp, and **Katherine J. Elliott**. 2004. Nutrient and carbon pools and fluxes following stand restoration burning in oak/pine forest types in the Conasauga River Watershed. *Forest Ecology and Management* 190:311-321.
4. Cooley, Nicolette E. 2004. Understanding traditional knowledge for ecological restoration: A qualitative study with the Eastern Band of Cherokee. M.S. Thesis, Northern Arizona University, Flagstaff, AZ, 67 pp.
5. **Elliott, Katherine J., James M. Vose**, Barton D. Clinton, and Jennifer D. Knoepp. 2004. Effects of understory burning in a mesic mixed-oak forest in the southern Appalachians. Pages 272–283 in R.T. Engstrom, K.E.M. Galley and W.J. de Groot (eds.). *Proceedings of the 22nd Tall Timbers Fire Ecology Conference: Fire in Temperate, Boreal, and Montane Ecosystems*. Tall Timbers Research Station, Tallahassee, FL.
6. **Elliott, Katherine J. and James M. Vose**. 2005. Initial effects of prescribed fire on quality of soil solution and streamwater in the Southern Appalachian Mountains. *Southern Journal of Applied Forestry* 29:5-15.
7. **Elliott, Katherine J. and James M. Vose**. 2005. Effects of understory prescribed burning on shortleaf pine (*Pinus echinata* Mill.) /mixed-hardwood forests. *Journal of the Torrey Botanical Society* 132(2): 236-251.

In preparation:

8. **Elliott, Katherine J., James M. Vose**, and Barton D. Clinton. Vegetation response to prescribed fire in mesic, mixed-oak forests in the southern Appalachians. Will be submitted to Canadian Journal of Forest Research (Refereed).
9. Knoepp, Jennifer D., **Katherine J. Elliott**, and **James M. Vose**. Prescribed fire in mesic, mixed-oak forests in the southern Appalachians: effects on soil and soil solution nutrients, and stream water quality. Will be submitted to Southern Journal of Applied Forestry (Refereed).
10. **Elliott, Katherine J., James M. Vose**, and Ronald L. Hendrick. Long-term vegetation response to stand-replacement fire in pine-hardwood forests of the southern Appalachians. Will be submitted to International Journal on Wildland Fire (Refereed).
11. **Gragson, Theodore L.**, and William Jurgelski. Anthropological and historical evidence of Native American and Euro-American use of fire in the southern Appalachians.

Technology Transfer:

Fire Ecology Workshop 2005 -- we conducted a formal workshop to transfer scientific knowledge and discuss management implications with a larger sphere of natural resource managers and user groups. “Fire Ecology”, a workshop to provide forest managers current information on the effects of fire in southern Appalachian ecosystems was hosted and organized by Coweeta Hydrologic Laboratory, Otto, NC, May 24-25, 2005. Participants included representatives from The Nature Conservancy, National Park Service, Environmental Protection Agency, NC Division of Forestry, Little Tennessee Land Trust, US Fish & Wildlife Service, US Forest Service, and North Carolina Wildlife Resources Commission.

Fire Workshop presentation titles and authors: * highlights the presentation of results from this JFSP project.

- “Fire history and forest succession in yellow pine stands of the Appalachian Mountains”. By Charles W. Lafon, Assoc. Professor, Department of Geography, Texas A&M University. Co-authors H.D. Grissino-Mayer, G. Wight, S.R. Aldrich, S.Q. Croy, E.K. Sutherland, J.A. Hoss.
- “Anthropological and historical evidence of Native American and Euro-American use of fire in the southern Appalachians”. By Bill Jurgelski and **Theodore L. Gragson**, Department of Anthropology, University of Georgia.

- * “Management implications of historic fire regimes in the southern Appalachians”. By **James M. Vose**, Coweeta Hydrologic Laboratory, Southern Research Station, USDA Forest Service.
- * “Prescribed burning in the southern Appalachians: soil nutrients and water quality responses”. By Jennifer D. Knoepp, Coweeta Hydrologic Laboratory, Southern Research Station, USDA Forest Service.
- * “Prescribed fire effects on forest floor and woody debris”. By Barton D. Clinton, Coweeta Hydrologic Laboratory, Southern Research Station, USDA Forest Service.
- “Prescribed fire on xeric sites in the Appalachians for restoration of Table Mountain and pitch pines”. By Thomas Waldrop, Southern Research Station, USDA Forest Service.
- *“Prescribed fire effects on mesic forest vegetation”. By **Katherine J. Elliott**, Coweeta Hydrologic Laboratory, Southern Research Station, USDA Forest Service.
- “Prescribed Fire Effects on Air Resources – the Science of Smoke, Smoke Management and Regulatory Issues” By Bill Jackson, Air Quality Specialist, USFS – National Forest in North Carolina.
- “Effects of prescribed fire and fire surrogates for fuel reduction on birds and herpetofauna in the southern Appalachians”. By Catherine Greenberg, Southern Research Station, USDA Forest Service.
- “Prescribed fire effects on game species in the southern Appalachians” Craig Harper, Assoc. Professor, Department of Forestry, Wildlife, and Fisheries, University of Tennessee.
- “Prescribed fire effects on birds and small mammals”. By Chris Moorman, Assoc. Professor, Department of Forestry and Environmental Resources, North Carolina State University.
- “Fire Use in the southern Appalachians”. By Dan Olsen, Assistant Director for Fire, National Fire Plan, Region 8, USDA Forest Service.
- Fire Workshop Practitioner’s Session “Challenges for Future of Fire Use in the Southern Appalachians: “What do we need to know?” Moderator – Tom Speaks, Forest Supervisor, Cherokee National Forest, Tennessee

Other Presentations (Professional meetings and invited seminars):

1. **Elliott, Katherine J.** and **James M. Vose**. Vegetation response to prescribed fire across a moisture/productivity gradient in the southern Appalachians. Fire in Eastern Oak Forests: Delivering Science to Land Managers, Columbus, OH, November 5-17, 2005.
2. **Elliott, Katherine J.**, Stephanie Laseter, **James M. Vose**, Ge Sun, and Steve McNulty. 2005. Fire effects on stream sediment and nitrate concentrations across geographical regions in the southeastern US: mountains, Piedmont, and Coastal Plain. Southern Appalachian Man and the Biosphere 16th Annual Conference, Cherokee, NC, November 1-3, 2005.
3. **Elliott, Katherine J.**, Stephanie Laseter, **James M. Vose**, Ge Sun, and Steve McNulty. 2005. Effects of prescribed fire on quality of soil solution and streamwater in the southeastern US. Forest Service Watershed Research, Grandby, CO, September 13-15, 2005.
4. **Elliott, Katherine J.** and **James M. Vose**. 2005. Effects of prescribed fire on vegetation across a moisture/productivity gradient in the southern Appalachians. 5th International Conference on Forest Vegetation Management, Corvallis, OR, June 20-24, 2005.
5. **Elliott, Katherine J.** 2004. Effects of prescribed fire on vegetation dynamics in the southern Appalachians. Clemson University, Clemson, SC. Oct 29, 2004. Invited seminar.
6. **Elliott, Katherine J.** 2004. Ecosystem effects of prescribed fire in southern Appalachian forests. NE Research Station, Morgantown, WV, Nov. 3, 2004. Invited seminar.
7. **Elliott, Katherine J.** 2004. Prescribed fire as a silvicultural tool in the southern Appalachians. West Virginia University, Morgantown, WV, Nov. 4, 2004. 3-hr lecture to Stand Dynamics graduate course.

8. **Elliott, Katherine J** and **James M. Vose**. 2004. The historical role and contemporary uses of fire in southern Appalachian ecosystems. Southern Research Station, All Scientist Meeting, Atlanta, GA. March 2-4, 2004.
9. **Katherine J. Elliott, James M. Vose, Theodore L. Gragson**, Nicolette Cooley, Thom Alcoze, Sally Oran, and William Jurgelski. 2003. The historical role and contemporary uses of fire in southern Appalachian ecosystems. The 2nd International Wildland Fire Ecology and Fire Management Congress, November 16-20, 2003, Orlando, FL.
10. **James M. Vose**. 2003. Fire in the mountains: using fire to restore forest ecosystem structure and function in the southern Appalachians. Invited presentation at Symposium on 'Enhancing the Southern Appalachian Forest Resource'. Hendersonville, NC, Oct. 2, 2003.
11. **Elliott, Katherine J**. 2002. Stand restoration burning in oak/pine ecosystems in the Southern Appalachian Mountains. Virginia Polytechnic Institute and State University, Blacksburg, Virginia, Nov 12, 2002. Invited Seminar.
12. **Elliott, Katherine J., James M. Vose**, and Barton D. Clinton. 2002. Vegetation responses to stand restoration burning in oak/pine forest types in the Conasauga River Watershed of western Georgia and eastern Tennessee (abstract). Ecological Society of America 87th Annual Meeting, p. 346, Tucson, AZ, August 4-9 2002.
13. Cooley, Nikki. 2002. Understanding traditional knowledge for ecological restoration: a qualitative interview study with Cherokee and Appalachian elders (abstract). Ecological Society of America 87th Annual Meeting, p. 103, Tucson, AZ, August 4-9 2002.

Other Technology Transfer:

1. The Nature Conservancy, field trip to the Conasauga prescribed burns, Oct 6, 2005 by **James M. Vose** and **Katherine J. Elliott**.
2. Blue Ridge Ranger District, field trip of the Conasauga prescribed burns, May 28, 2003 by **Katherine J. Elliott**.
3. Poster presentation at Restoration meeting in Hawaii, Dec 2002 by Nikki Cooley.
4. Oral presentation to International Tribal Councils meeting June 17, 2003 by Nikki Cooley.
5. Oral presentation to Eastern Band of the Cherokee Nation, July 29, 2003 by Nikki Cooley.