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Fire in Southern Appalachians: Fuels, Stand Structure and Oaks

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Final Report

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JFSP #04-2-1-08

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Abstract

Managers responsible for maintaining the diversity and productivity of Southern Appalachian forests are increasingly turning to prescribed fire as an important management tool in oak dominated forests. The decision to use fire with increasing frequency and spatial extent is based, in part, on an emerging sense of the prehistoric significance of fire in this landscape and its potential to control the proliferation of fire-sensitive competitors in contemporary forests. While it is well documented that fire has been an important ecological force in Southern Appalachian forests for a very long time, there has been little research to demonstrate that prescribed fire effectively controls fire-sensitive competitors, promotes regeneration of desirable species, or maintains and promotes healthy forest stands. In the face of increased management burning there is a need to address these questions, and to quantify the role of existing and residual fuels in fire management following repeated fire of differing intervals.

Two studies were initiated in 1995 and 2002 in upland forests on the Cumberland Plateau of Kentucky to examine the effectiveness of prescribed fire to maintain oak dominance by altering stand structure and enhancing oak seedling establishment and development. We hypothesized that fire would: (1) reduce midstory stem density, and that these changes to stand structure and light availability would lead to improved performance of oak seedlings; and (2) control oak competitors. On ridgetop sites on the escarpment of the Cumberland Plateau, we measured stand structure and tree regeneration on 48 plots in 6 treatment areas over an 11-year period. Four units were burned 3-4 times and two units serve as fire-excluded references. On the topographically-dissected landscape of the Cumberland Plateau we recorded stand structure and multiple aspects of the tree regeneration process on 9 study sites (93 plots), with three sites burned four times, three sites burned twice, and three fire-excluded sites.

Prescribed fire reduced midstory stem density and basal area, and increased light availability which was transitory due to understory sprouting. Seedling population studies revealed that oaks and maple seedlings responded to stem kill by re-sprouting, with increased height and diameter. However, red maple seedlings grew more than oaks after burning. Burning reduced seedling density of potential competitor species, yet high fecundity of some species (e.g., red maple) and strong sprouting response of others (e.g., sassafras), suggests that multiple fires have provided neither the stand structural changes nor competition control that would lead to the development of more competitive oak advance reproduction. An oak mast event revealed a potentially positive role for fire in reducing the depth of the litter layer and enhancing oak seedling establishment and growth. Overall, our results suggest a modest role for prescribed fire in enhancing the establishment, growth and persistence of oak advance regeneration.

Purpose and Need

The use of fire in the management of forests in the Southern Appalachian Hardwood Forest Region has increased dramatically in the last decade for a number of reasons. There is an expectation among an increasing number of forest managers that restoring fire to upland hardwood forests will promote regeneration of oak species (*Quercus* spp.), many of which are currently threatened by a combination of drought, disease and poor rates of regeneration in the understory. Many believe that effective fire protection in the last half century has dramatically changed the direction of forest regeneration in upland oak sites (Abrams and Nowacki 1992), such that fire-sensitive species such as red maple (*Acer rubrum*) and eastern white pine (*Pinus strobus*) dominate the midstory in many oak forests, with a strong potential for reduction in community biodiversity throughout the region as these forests shift from oak to red maple dominated. Many researchers and managers contend that the use of prescribed fire in this region could be used to promote oak regeneration, and National Forest managers are increasingly using fire for this intended purpose, as well as for broader management objectives relating to fuels reduction and the creation of more open woodlands. Although a strong base of scientific research to support the use of fire to promote oak regeneration does *not* currently exist, the emergence of this new paradigm for forest management in upland oak forests has been adopted by managers within the National Forest and beyond, to other Federal, State and private land managers.

Fire, by reducing understory stem density of fire-sensitive species, may create lower density forest stands more similar to those present prior to Euro-American settlement, with possible benefits??? to the residual trees. This potential is another reason some forest managers recommend the use of prescribed fire on a landscape scale. However, this potential benefit has also not been well documented and further, the potential for negative impacts of fire on residual stems is a concern frequently articulated among forest managers less inclined toward the use of prescribed fire.

Finally, reduction of fuels accumulated during the last 60 fire-free years is another purpose articulated among managers for the use of prescribed fire. However, the benefits of prescribed fire for this purpose in the Southern Appalachian Hardwood Forest Region is likely highly variable spatially, and at any rate has been very poorly documented, with virtually no published data available (but with several studies in progress in the central hardwood region).

This research we conducted was designed in response to the growing need to document the effects and effectiveness of fire as a management tool for achieving specific objectives in the southern Appalachians. Knowledge of the historic and prehistoric presence of fire in upland oak forests and other anecdotal evidence are insufficient for establishing the potential of prescribed fire to maintain or restore oak communities, much less for elucidating the details of a fire regime that would accomplish that objective. The limited amount of research conducted to date presents confusing and sometimes contradictory results regarding effects of fire on stem density, species composition, fuel reduction and health of residual stems.

Study Description and Location

Study sites

Research under the proposed project will be conducted in collaboration with National Forest managers on the Morehead and Stanton Ranger Districts of the Daniel Boone National Forest (DBNF) (see letters of collaboration from DBNF personnel). The DBNF is located in the Cliff Section of the Cumberland Plateau in eastern Kentucky. In the Morehead District, study areas are ~1000-1200 acres (400-500 ha) with treatment areas within each of 3 study areas subdivided along ridge systems (~300-400 acres; 120-160 ha). These sites can be characterized as xeric to sub-xeric oak-hickory forests on the ridgetops, to mixed-mesophytic forest in the coves. In the Stanton Ranger District, treatment areas range from 70 to 140 acres (20-40 ha). These sites are limited to xeric and sub-xeric site qualities and vegetation type is typically oak-pine.

Experimental design

We are requesting new funds for two existing studies. A landscape-scale fire study was initiated in 2002 in collaboration with Forest Service managers in the DBNF, taking advantage of large-scale burning planned for the Morehead District. Previous JFSP funding supported identification of sites, pre-burn measurements, and post-burn measurements following burning in 2003 (frequent and infrequent burn sites) and 2004 (infrequent burn sites only). We will have accomplished these burns, data acquisition and data reduction by the time our funding ends in September 2004. Products from this work so far includes 3 presentations at the 2nd International Wildland Fire Conference in November 2003 and 2 presentations accepted for the Central Hardwood Forest Conference in March 2004 (see Arthur cv), as well as two MS theses (expected completion June and December 2004).

We propose to use new funding to leverage additional data collection from a long-term seedling population and stand structure study in the Stanton Ranger District, initiated in 1995 in collaboration with the DBNF on smaller burn units.

Large-scale study – In spring 2002 we established three study areas for large-scale burning. Within *each* study area, we identified three treatment sites: an unburned control, and two treatment sites with differing fire frequencies, "frequent" and "infrequent." By the time our JFSP funding for the current proposal has expired in September 2004 we expect to have accomplished the goals described in that proposal. The "infrequent" treatment sites will be burned approximately once every three years, starting in 2003.

The current proposal was designed as a long-term study, in the hopes of obtaining new funding. Thus, we designed a study that would allow us to examine frequent and infrequent burning intervals. We initially chose fire frequencies to coincide with the burning regime used by the landscape-scale burning experiments conducted by Sutherland et al. (www.fs.fed.us/ne/delaware/4153/4153.html) in order to support the development of a broader understanding of the role of fire in promoting oak regeneration in the region.

Table 1: Schedule for pre-treatment establishment of study sites and burning regime for "frequent" and "infrequent" burn sites.

Morehead Study - Burn History			
Year	**Control**	**Frequent burn**	**Infrequent burn**
2002	Pre-treatment msmts	Pre-treatment msmts	Pre-treatment msmts
2003		Spring burn	Spring burn
2004		Spring burn	No burn
2005		No burn	No burn
2006		Spring burn	No burn
2007		No burn	No burn
2008		Spring burn	No burn
2009		No burn	Spring burn

The responses of interest in this landscape-scale fire study within the timeframe of the proposed research are:

1. Effects of repeated burn treatments on stand structure and light regime.
2. Response of existing seedlings/saplings to light regime, measured on individual stems across the range of site quality, fire treatments, and fire effects.
3. Recruitment and dynamics of new seedlings measured across site quality, fire treatments and fire effects.
4. Effects of repeated frequent and infrequent burning on residual stem mortality, crown vigor and stand productivity.
5. Effects of repeated burning and frequency on fuel reduction and reaccumulation.

Long-term seedling population and stand structure study – A portion of the funds requested in this proposal would be used to continue measurements of 720 seedlings in a seedling population study in the Stanton Ranger District of the DBNF and to follow long-term stand structure following repeated burning. Initiation of this study was supported by the DBNF (1995-2000) for prescribed fire treatments and monitoring, and by Southern Research Station's Bent Creek Experimental Forest (2000-2001) for establishment of the seedling study. Chestnut oak, scarlet oak and red maple seedlings are located on 2 study sites, each of which have three treatment areas, an unburned control, 3x burned (in 1995, 1999 and 2000), and 2x burned (in 1996 and 2000). This study design does not permit us to examine landscape-scale variability in the effects of fire on stand structure and light, but the maintenance of a long-term seedling population study will be very useful in guiding adaptive management of fire treatments called for in the DBNF Management Plan.

Detailed research approach

Characterization of the light environment following burn treatment

Within treatment sites, we established a plot network that allows us to sample and characterize variability in stand structure and light prior to, and created by, the burning, as well as the variability associated with site quality, enabling us to link seedling level investigations to stand structure across a range of sites. In each treatment site we established a sampling grid in a stratified random scheme, where we measure light and other site variables. These sampling points are also used as a means of locating existing seedling/sapling individuals and as sampling points for measuring new seedling recruitment (see next sections).

Light was measured using hemispherical photography and densiometers. Hemispherical photography and densiometers are particularly useful for characterizing light regimes because neither method depends on the highly variable instantaneous "spot" measurements associated with instruments that measure photosynthetically active radiation directly. We will measure light in $1m^2$ quadrats at each sampling point, and at two vertical locations within each quadrat, 1m and 2m. **need to add something about the densiometer/hemiphotos findings.**

Site variables will include both classification (categorical) variables and continuous variable related primarily to the moisture gradient.

Characterization of Stand Structure

At each sampling point structure and composition of forest trees and shrubs will be characterized using a combination of variable radius and fixed radius plots. Individuals will be mapped so that response to fire treatments can be determined in remeasurements and changes (e.g. mortality) correlated with the hemispherical photography as well as tagged seedling response seedling recruitment/development .

Seedling Response to Treatment

We are interested in the survival, growth and performance of seedlings and saplings in the advance regeneration pool, as well as seedlings recruited following treatment (see below). A seedling population study will be established by identifying and tagging seedlings/saplings in each of the 9 treatment sites. All seedlings will be marked with metal rings placed in a circle at a 4cm radius from the stem, tagged with a unique number, and mapped with reference the sampling grid points to facilitate location for annual measurements. Seedlings/saplings on burn treatment sites will be located in advance of burning, to permit us to follow their resprouting and subsequent performance after burning.

A subset of the seedlings per site will be randomly selected for a long-term (10-year) seedling population study in which we relate growth and survival to light environment, using hemispherical photography. In addition to quantifying the light environment above each seedling, we will also measure survival, height growth, basal stem diameter, and leaf area on an annual basis.

The remaining seedlings will be harvested at three different times during the long-term study as follows: first year, second year, and at 10 years (outside the timeframe of this proposal). These seedlings will be used for determination of leaf area, specific leaf mass, and C allocation above- and below-ground. In combination with measurement of the seedling light environment in the year of harvest, these data will be used to improve our understanding of the mechanisms by which seedlings of different species use resources differentially, and their relationship to plant growth.

Seedling recruitment study

To quantify recruitment following treatment, we will establish permanent plots (1 sq meter) in each treatment area using the grid locations described above. Within these plots, we will inventory all seedlings and saplings (up to 2 cm diameter). We will tag all oak and maple seedlings in these plots, measure diameter and height annually, and follow survival. Few studies have examined seedling recruitment into vegetation plots in tandem with tagging of seedlings for ongoing measurement. In addition, we will be able to couple recruitment with the light environment.

Quantification of fuel loads before and after fire

We will use two methods to estimate fuel loadings, planar intercept transects (Brown 1974) and 30x30 cm forest floor blocks (citation). Forest floor blocks are used to remove quantitative samples of litter (Oi), fermentation (Oe) and humus (Oa) layers from the soil surface. Litter is separated in the field and weighed separately, as the leaf litter is frequently a key source of fuel for fires in this region (cite beth). Woody fuel loading is obtained by tallying fuels classes along a planar intercept transect before and after prescribed fire. Fuels are tallied into four diameter size classes, 1-hr timelag fuels (<1.4 in), 10-hr timelag fuels (1/4 to 1 in), 100-hr timelag fuels (1-3 in) and 100-hr timelag fuels, which includes everything greater than 3 in.

Ongoing seedling population study

We have an ongoing large, long-term seedling population study in place on the Stanton Ranger District. With funds from the JFSP we propose to continue measuring the survival, growth, and canopy openness above 720 seedlings of chestnut oak, scarlet oak and red maple, found within 6 treatment areas as described above. In tandem with permanent vegetation plots in which we monitor tree seedling composition and overstory vegetation (funded by US Forest Service Cost-share Agreement with DBNF), this study will help to answer the question of whether repeated burning on xeric oak sites promotes oak seedling establishment and growth. Preliminary data support our hypothesis that repeated burns (but not single burns) increase the canopy gap fraction and specific leaf mass, which we expect will result in increased growth of seedlings growing in microsites with greater photosynthetically active radiation.

Fire temperature and severity

We will measure fire temperatures using pyrometers consisting of temperature-sensitive paints on aluminum tags stapled to stakes (**height** and surface). In addition, we will measure scorch height on the 3 trees nearest to our grid locations. Recent work has demonstrated that….pyrometers. Initial research on these sites included efforts to incorporate measures of fire intensity; however, the landscape…

Statistical analysis

Data will be analyzed using a general analysis of covariance approach, with area and treatment as class variables. Covariates will include continuous variables such as initial seedling size, measures of light from the hemispherical photograph, measures of stand structure, measures of site such as land form index, terrain shape index, and transformed aspect. Categorical variables representing site may also be used as covariates. Interactions among several variables will also be examined. For most response variables, a linear model will be used. For individual seedling survival, however, a logistic model will be used.

Key Findings

We implemented single and repeated (3x) prescribed fires over a 6-yr period (2002-2007). Both pre- and post-burn, we quantified canopy cover and oak (*Quercus* spp.) seedling survival and growth compared to other woody seedlings deemed potential competitors, primarily red maple (*Acer rubrum* L.) and sassafras (*Sassafras albidum* (Nutt.) Nees.). Burning temporarily decreased canopy cover 3-10%, but cover rebounded the subsequent growing season. Repeated burning ultimately produced canopy cover about 6% lower than sites unburned and burned once, suggesting a cumulative effect on understory light. Red maple exhibited low survival (~ 40%) following single and repeated burns, but growth remained similar to unburned seedlings. Burning had little impact on sassafras survival and led to total height and basal diameters 2x greater than unburned seedlings. A single burn had no impact on the red oak group (*Erythrobalanus*) survival and increased height and basal diameters 25-30%, but this positive growth response was driven by seedlings on several plots which experienced high burn temperatures and consequently high overstory mortality. The white oak group (*Leucobalanus*), however, exhibited twice as high mortality compared to those unburned, with no change in growth parameters. Repeated burning negatively impacted survival and growth of both oak groups compared to unburned seedlings. With both burn regimes, oaks with smaller pre-burn basal diameters exhibited the lowest post-burn survival. Thus, despite the ability of prescribed burns to temporarily increase understory light and reduce red maple survival, neither single or repeated burns placed oaks in an improved competitive position. These findings result from a combination of highly variable yet interdependent factors including the 1) life history traits of oaks compared to their co-occurring competitors, 2) pre-burn stature of pre-existing oak seedlings, and 3) variability in fire temperature and effects on understory light.

Establishment of new seedlings after fire treatments was typically greater than on fire-excluded sites. Throughout the study three species or species groups, *Acer* spp., yellow-poplar (*Liriodendron tulipifera* L.) and sassafras, comprised the majority of annual recruitment and each followed a different response pattern to fire frequency or in the absence of fire. The recruitment of *Acer* spp. may be more driven by available seed source rather than fire-treatment. Yellow-poplar recruitment after a single prescribed fire displayed a high density of recruitment, probably a seed bank release, but yellow-poplar recruitment decreased significantly following repeated fires. Multiple prescribed fires resulted in lower overall densities of yellow-poplar and *Acer* spp. at the end of the study, whereas 1x-burn led to elevated densities of these species over time. If prescribed fire is to be used as a management tool for reducing seedling populations of these particular species, multiple fires should be implemented rather than a single fire. Sassafras repeatedly responded positively to each fire treatment in high numbers. It is doubtful that prescribing additional fires at the same time of year would have any effect on sassafras colonization. However, if sassafras is deemed an undesirable oak competitor, additional investigation into the control of this root-suckering species may be warranted, perhaps prescribing fire during the growing season.

White and chestnut oak seedlings originating from seed and establishing in burn treatments displayed more vigorous growth, on average, than seedlings established in fire-excluded treatments. In addition, seedling survival in burn treatments was greater than in the relatively closed canopy of the fire-excluded treatments. Prescribed fires can result in tree mortality and reduced density and basal area of trees, and consume a significant portion of the leaf litter layer. Both of these effects had positive effects on oak seedlings establishing and developing in recently burned stands. Evidence from this study suggests that oak seedlings established and growing on recently burned sites may be more competitive than oak seedlings developing under nearly closed canopy stands if and when a future stand release event occurs.

Contrary to our first hypothesis, litter fuel loads did not differ among landscape positions, and duff depths were greater on subxeric sites compared with submesic sites. This suggests that the drier conditions of these sites, compared with submesic sites, coupled with dominance by oaks and other species with decay-resistant foliage, supersedes the effects of downslope movement of leaves, leading to greater accumulation of partially decomposed organic material on subxeric sites. We also hypothesized that a single fire would reduce litter and small woody fuels, and that fuel reductions would vary by landscape position with greater reduction of fuels on subxeric sites. Significant reduction in fuels occurred for litter across all landscape positions, whereas a decrease in duff depth was significant only on intermediate and subxeric landscape positions. Coupled with increased variability in litter mass, this may suggest potential for increased soil erosion after prescribed burning. A decline in total fuels also was statistically significant on intermediate and subxeric landscape positions. Finally, we hypothesized that fuel loads after autumn leaf fall following prescribed burning would be similar to pre-burn fuel loads. We found that post–leaf fall litter mass returned to near pre-burn levels, suggesting that the fires did not have a lasting impact on fuel loading. Our study suggests that, beyond an increase in fuel discontinuity, a single late-winter, early spring prescribed fire of low to moderate intensity will do little to alter the future wildfire risk in stands similar to those studied here.

Management Implications

Using prescribed fire in southern Appalachian deciduous forest ecosystems where oaks are dominant or prominent in order to maintain oak in those ecosystems will require more study to determine how or even if fire can be used effectively to favor oaks. The prescription in the current study involved both single and multiple early spring prescribed fires. The mechanisms by which fire might differentially benefit oaks, given their life history characteristics, over other species need further investigation and the reality of using prescribed fire to consistently provide those mechanisms in a timely and sufficient manner must be addressed. The most obvious of these mechanisms are alteration of stand structure and resource availability, competition control resulting from differential tolerance to fire, and alteration of forest floor characteristics that might enhance oak seedling establishment. To date, only one burning-vegetation treatment prescription appears promising (*see* Brose below).

The best available information regarding oak regeneration suggests that the presence of competitive oak regeneration sources—large oak advance reproduction and/or oak stump-sprout potential---prior to significant overstory removal is the most important prerequisite for successful regeneration of oak. Various tools exist to sample stands that are candidates for regeneration to determine the adequacy of oak regeneration sources to meet stand level objectives. Studies also show that when oak regeneration sources are adequate, there are a variety of overstory removal options available to release it.

Relationship to other research and Future research needs

The Shelterwood-Burn prescription (Brose) show promise, at least on parts of the multiple environmental gradients where these ecosystems occur. The primary operative mechanism in this prescription is reduction in oak competitors. Another non-fire based prescription (Loftis) involves using herbicides to alter stand structure and light regimes to provide the conditions necessary to develop large oak advance reproduction prior to significant overstory removal. More research comparing burning and other treatments across regions, and environmental gradients within regions, needs to be conducted to determine which prescriptions work to maintain oak and where on the landscape they work. The focus of the research and its design should be such that mechanisms can be closely examined that are related to oak life history characteristics and well those characteristics of other species. Such a study is underway in southern upland forests with study locations in North Carolina, Tennessee, and Missouri involving scientists in the Southern and Northern Research Stations.

Deliverables

Publications in peer-review journals

Alexander, H.D and M.A. Arthur. 2009. Foliar morphology and chemistry of upland oaks red maple, and sassafras seedlings in response to single and repeated prescribed fire. Canadian Journal of Forest Research 39: 740-754

Alexander, H.D., M.A. Arthur, D.L. Loftis, S.R. Green. 2008. Survival and growth of upland oak and co-occurring competitor seedlings following single and repeated prescribed fires. Forest Ecology and Management 256:1021-1030.

Loucks, E., M.A. Arthur, J.E. Lyons and D.L. Loftis. 2008. Characterization of fuel before and after a single prescribed fire in an Appalachian hardwood forest. Southern Journal of Applied Forestry 32: 80-88.

Blankenship, B.A. and M.A. Arthur. 2006. Stand structure over nine years in burned and fire-excluded oak stands on the Cumberland Plateau, Kentucky. Forest Ecology and Management 225:134-145
.

Chiang, J., M.A. Arthur and B.A. Blankenship. 2005. The effect of prescribed fire on gap fraction in an oak forest on the Cumberland Plateau. Journal of the Torrey Botanical Society 132: 432-441.

Papers in preparation, to be submitted in 2009:

Green, S.R., M.A. Arthur, and B.A. Blankenship. The effects of periodic prescribed fire on oak (*Quercus* spp.) and red maple (*Acer rubrum* L.) seedlings on xeric ridgetops in eastern Kentucky. Target journal: *Forest Ecology and Management*
.

Royse, J., M.A. Arthur, D.L. Loftis. Hardwood tree seedling recruitment in response to prescribed fire in a central Appalachian forest. Target journal: *Forest Ecology and Management.*

Royse, J., M.A. Arthur, D.L. Loftis. Establishment and growth of oak (*Q. alba* and *Q. prinus)* seedlings in burned and unburned forests on the Cumberland Plateau. Target journal: *Southern Journal of Applied Forestry.*

Presentations at scientific meetings

Alexander*, H.D., M.A. Arthur, D.L. Loftis, and S.R. Green. 2008. Response of upland oak and co-occurring competitor seedlings following single and repeated prescribed fires. Fire and Eastern Oaks Conference in Carbondale, IL, May 20-22, 2008.

Alexander*, H.D. and M.A. Arthur. 2008. Interspecific differences in stemflow chemistry and N mineralization among red maple and upland oaks. Ecological Society of America, August 2008, Milwaukee, WI.

Royse*, J., M.A. Arthur, D.L. Loftis. 2008. Prescribed fire and oak seedling development in an Appalachian forest. Fire and Eastern Oaks Conference in Carbondale, IL, May 20-22, 2008.

Alexander*, H. D. and Arthur, M. A. 2007. Interspecific differences in N mineralization rates and stemflow chemistry among red maple and upland oaks. Ecological Society of America, San Jose, CA.

Alexander*, H. D., Arthur, M., Loftis, D., and S. Green. 2007. Landscape-level assessment of prescribed fire effects on oak regeneration. 2nd Fire Behavior and Fuels Conference-The Fire Environment-Innovation, Management, and Policy, Destin, FL.

Royse*, J.P.; Arthur, M.A.; Loftis, D.L. 2007. Prescribed fires affect seedling establishment and survival in a central Appalachian forest. 2nd fire behavior and fuels conference: the fire environment-innovations, management, and policy. Destin, Fl.

Alexander, D., Arthur, M.A., Loftis, D.L. and S.R. Green. 2006. Overstory and seedling response to repeated fires in Eastern Kentucky. Conference Proceedings, Fire in Eastern Oak Forests: Delivering Science to Land Managers. November 15-17, 2005. Columbius, Ohio. USDA Forest Service. Northern Research STtion. General Technical Report NRS-P-1.

Green*, S., M.A. Arthur, B.A. Blankenship** and D.L.Loftis. 2004. The effects of periodic prescribed fire on the growth and survival of red maple (*Acer rubrum*) and oak (*Quercus* spp.) seedlings on xeric ridge tops in eastern Kentucky. Central Hardwood Forest Conference.

Loucks*, E., M.A. Arthur. 2004. Evaluating bole damage and crown decline after prescribed fires in an Appalachian hardwood forest on the Cumberland Plateau, Kentucky. Central Hardwood Forest Conference.

M.S. and Ph.D. Theses/Dissertations

Alexander, Heather D. 2008. Upland oak and red maple: Community and ecosystem effects in the presence and absence of fire. University of Kentucky PhD Dissertation, pp.127.

Royse, Jacob. 2008. Establishment and development of hardwood seedling in response to prescribed fire in a central Appalachian forest. University of Kentucky MS Thesis, pp. 67.

Green, S.R. 2005. The effects of prescribed fire on stand structure, canopy cover and seedling populations in oak dominated forests on the Cumberland Plateau, KY. University of Kentucky Thesis, pp.52.

Science delivery and application

Develop and maintain project website: http://www.fs.fed.us/r8/boone/fire/fsa/

Attend Daniel Boone National Forest (DBNF) Management Team Meetings/ Provide summaries of research activities and site visits to DBNF:

Presentation to the Daniel Boone National Forest Review Team Meeting, July 2008.
Planning meeting with DBNF forest personnel: February 29, 2008.
Presentation of research results to DBNF Leadership Team, May 30, 2007.
Meeting with DBNF personnel, January 13, 2006.
Field trip and research summary to DBNF personnel, January 28, 2004.

Regional Fire Research Conference:

Co-organized with Daniel Boone National Forest a workshop for land managers and researchers in the region: *The Science of Prescribed Fire on the Cumberland Plateau,* August 11-13, 2008, Natural Bridge State Park, Slade, Kentucky.

Core member, Cumberland River Fire Learning Network (FLN). Participation as a core member in the FLN entailed four 3-day workshops and numerous 1-day meetings, from January 2007-December 2008. http://www.fs.fed.us/r8/boone/fire/fln.shtml.

Other science delivery activities:

Kentucky Prescribed Fire Council, Keynote address, Frankfort, KY. June 2008.

“Fire ecology in upland oak ecosystems”. Presentation for USFS NASP training, June 2008, Asheville, NC.

Fire and oak ecosystems on the Cumberland Plateau. Training presentation for Rx-310, *Introduction to Fire Effects* class, December 5, 2007, London, KY.

Seminar presentation, “Fire and Upland Oak Ecosystems on the Cumberland Plateau,” Women and Minority Artists and Scholars Lecture Series, Virginia Tech, Department of Forestry. November 2007.

“Fire ecology and management in the Cumberlands.” Presentation to the *Scientific Foundations of Conservation Planning in the Cumberland Plateau and Mountains* conference, Knoxville, TN, November 13-14, 2007.

“Prescribed fire and oak regeneration”, Presentation to Oak Regeneration and management, Professional Forestry Worskhop, October 3-4, 2007, Lexington, KY.

Seminar presentation, “Toward an Ecological Understanding of Fire on the Cumberland Plateau”, Alabama A&M University, Normal, Alabama, January 2006.

Seminar presentation, “Toward an Ecological Understanding of Fire on the Cumberland Plateau,” Centre College, Centre, KY, March 2006.