ABSTRACTS

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RESTORATION OF HIGH ELEVATION RED OAK WITH FIRE IN THE SOUTHERN BLUE RIDGE

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ABSTRACT

Prescribed fire is most often used to restore fire-adapted plant communities on xeric and mesic sites since these are the areas where frequent, low-intensity fires are most common. In southern Appalachian forests, these sites are typically found on south- and west-facing slopes and on ridges that historically supported varying pine and oak communities. The Southern Blue Ridge Fire Learning Network (SBRFLN) was created with the goal of restoring historical fire regimes across the southern Blue Ridge. The SBRFLN has targeted four plant communities for restoration. Three of the four forest communities are typical of relatively xeric sites. These include Shortleaf Pine-Oak, Pine-Oak-Heath, and Dry-Mesic Oak-Hickory. However, the fourth, High Elevation Red Oak (HERO), is unique in that it occurs at high elevations that are generally more cool and moist. This poster will present information on the extent of the HERO type in the southern Blue Ridge as well as the current composition and structure of stands being targeted for restoration. We will compare current stand structure to HERO restoration models developed by SBRFLN and others. We will also present preliminary results from several prescribed burns that have been performed in these stands and discuss fuel load changes and burn performance.

COMPARING THE IMPORTANCE VALUE OF OVERSTORY AND UNDERSTORY TREES IN OAK FORESTS

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ABSTRACT

In 2007, The Nature Conservancy began a long-term project at a site within the Brown County Hills of Indiana to manage dry-mesic oak forests. The understory of the oak forest is currently dominated by more mesic forest tree species. In the event of a canopy disturbance, there is little chance for oak and hickory saplings to compete with mesic forest species for canopy dominance. By comparing the importance value [IV = (relative basal area + relative density)/2] of tree species in the forest canopy (≥ 8 inch diameter at breast height [d.b.h.]) with the forest understory (4.5 ft tall - 8 inch d.b.h.) we can get a better idea of the severity of this problem. This monitoring will help determine if management activities are improving the IV of oak trees within the forest understory.

Baseline data were collected from fifty-three 0.1-acre monitoring plots in the summer of 2007. Oak species had an IV of 0.88 in the forest canopy compared to less than 0.04 in the understory. Data collected the first year following thinning and burning treatments in the fall/winter 2007 showed no increase in oak species' IV in the understory, but there was a 20.7 percent reduction in basal area and 6.25 percent reduction in canopy closure. The monitoring of the forest overstory vs. understory will repeat every 5 years plus 1 year following any management treatment and/or natural disturbance to determine if, over time, the IV of oaks in the understory increases. The long-term goal is to show whether forest management techniques used in the project can shift the dry/mesic forest understory from beech/maple dominance to oak/hickory.

THE EFFECTS OF SEASONALLY PRESCRIBED FIRE ON A DOLOMITE GLADE

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ABSTRACT

The diverse vegetation that dominates glade systems is dependent on fire for long-term sustainability; therefore, prescribed fires are an important management tool. However, fire management has focused on spring and dormant season burns, with spring burns favoring grasses and dormant season burns favoring forbs. Growing season fires are known to kill woody plants that are not fire adapted; however, the effects of growing season burns on species composition are not well documented. In an effort to determine optimum methods of glade management, we are studying the effects of prescribed fire during different seasons in a dolomite glade at Ha Ha Tonka State Park in Camden County, MO. Three sites have been established, each containing four treatments. Within each site, one treatment area is designated as an unburned control, and each of the remaining treatment areas will have fire applied during the spring, dormant, or growing season. Initial observations and application of fire were conducted from July to September of 2010 with subsequent applications scheduled for February and April of 2011. Final data collection and analysis will extend through September of 2011. Data will be comprised of both pre- and posttreatment observations, as well as observations timed to coincide with spring/early summer and late summer flowering periods. Quantification of the effects of seasonal burns will be accomplished through population studies conducted within and among plots. The results of this study should enable land managers to schedule burns in order to achieve a desired vegetation response. Baseline floristic assessment and initial postburn results were presented at the 4th Fire in Eastern Oak Forest Conference.

RESEARCHING EFFECTS OF PRESCRIBED FIRE IN HARDWOOD FORESTS

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ABSTRACT

The Upland Hardwood Ecology and Management Research Work Unit (RWU 4157) is a group of research teams located across the South, strategically placed to conduct research in physiographic sub-regions of the upland hardwood ecosystems including the southern Appalachian Mountains, the Cumberland Plateau, the Boston Mountains, and the Missouri Plateau. Our RWU is one of 16 maintained under the Southern Research Station by the U.S. Forest Service.

Our mission is to develop and disseminate knowledge and strategies for restoring, managing, sustaining, and enhancing the vegetation and wildlife of southern upland hardwood forests. Through experimental studies and modeling, our research program focuses on learning and predicting how upland hardwood-dominated forests and wildlife are affected by natural disturbances or silvicultural activities, and how plant and animal responses differ across environmental gradients such as elevation, moisture, and fertility.

One of our focal research areas is fire ecology and fire effects on hardwood forests and the wildlife communities they support. Understanding how fire affects upland hardwood forest communities will help land managers to develop scientifically-based methods to meet their management and restoration goals. Here we highlight some of our current studies on fire ecology.

FIRE ECOLOGY STUDIES

Historical Fire Frequency

We are using tree cores and fire scars to assess the frequency of fire in upland hardwood ecosystems prior to fire suppression efforts starting in the 1930s. For instance, in the Boston Mountains of Arkansas, we found that widespread fire occurred more often during drought years in the 1700s with fires likely achieving sizes unprecedented during the last century. Early transitional (1810-1830) settlement by Cherokees at population densities under 0.26 humans/km^2 was highly correlated ($r = 0.90$) with the number of fires per decade in the interior region of the Boston Mountains. Multiple regression analyses further implicated humans as well as short- and long-term climate variability such as forced by the El Niño/Southern Oscillation (ENSO) and Atlantic Multidecadal Oscillation (AMO). Understanding presettlement fire frequencies will help land managers in ecosystem restoration efforts.

Fire and Fire Surrogate Study (FFS)

Scientists with RWU 4157 are participating in the wildlife component of the national collaborative Fire and Fire Surrogate Study (FFS). This long-term study is assessing how ecological components or processes may be changed or lost if fire surrogates, such as cuttings and mechanical fuel treatments, are used instead of fire or in combination with fire. Virtually no comparative data exist on how these treatments mimic ecological functions of fire, or how bird, reptile, amphibian, or small mammal communities respond to prescribed fire or fire surrogate treatments.

Regional Oak Study

Scientists within our RWU have partnered with the North Carolina Wildlife Resources Commission, the Stevenson Land Company, the Northern Research Station, and the Mark Twain National Forest in a regional study of how hardwood tree species respond to prescribed fire and other silvicultural treatments across a productivity gradient and across the Central Hardwood Region. We and our collaborators are also studying the response of herbaceous plants, seed banks, acorn viability, artificial northern red oak regeneration, fuels, bat, bird, reptile, amphibian, and small mammal communities to prescribed fire and other oak regeneration treatments. This regional oak study includes three independent, fully replicated study areas representing different physiographic areas of the Central Hardwood Region including the Southern Appalachian Mountains (NC), the Cumberland Plateau (TN), and the Ozark Highlands (MO). University collaborators with our regional oak study include the University of Tennessee, Alabama A&M University, North Carolina State University, and the University of Missouri.

Indiana Bats and Prescribed Fire

Scientists in our RWU are looking at the compatibility of prescribed fire in the Southern Appalachians with the conservation of the federally endangered Indiana bat. In cooperation with the Nantahala National Forest, Cherokee National Forest, and Great Smoky Mountains National Park, we are examining the effects of prescribed fire on snag population dynamics, Indiana bat roost tree availability in relation to fire history, and Indiana bat roost tree selection in relation to fire history and stand and landscape characteristics. This study will provide land managers with the information they need to manage Indiana bats and restore pine-oak habitats throughout the southern Appalachians.

Using Prescribed Fire to Restore Oak-Dominated Upland Hardwood and Hardwood-Mixed Pine Systems

Scientists are studying the use of regeneration and intermediate silviculture prescriptions coupled with fire to manage and restore upland hardwood systems. We have implemented a large-scale silvicultural assessment designed to examine the efficacy of stand-level prescriptions in reducing the potential impacts of gypsy moth infestations and oak decline on upland hardwood forests on the Daniel Boone National Forest, Kentucky. Early assessments showed a slight increase in tree vigor as determined by crown cover and position of residual trees in shelterwood with reserves, thinning, and oak woodland treatments. In a process to move a mixed-pine hardwood forest towards hardwood-dominated stands on the William B. Bankhead National Forest in Alabama, scientists found that following the initial thinning and burning treatments there was a 30 percent reduction in percent canopy cover, and light penetration through the canopies ranged from 5 to 25 percent pretreatment to 29 to 60 percent posttreatment. The cool, slow-moving burns had no discernable effect on the overstory trees. Avian and herpetofaunal population dynamics appear to be influenced more by the thinning than the fires.

Amphibians and Prescribed Fire in Longleaf Pine-Wiregrass Sandhills

Scientists are studying amphibian and reptile use of isolated sinkhole ponds in both regularly burned and long-unburned Florida longleaf pine-wiregrass sandhills. This study will help land managers assess how prescribed fire affects herpetofaunal populations in the long term.

Artificial Regeneration and Prescribed Fire

Scientists are studying how high quality seedlings of planted oak (*Quercus* spp.) and American chestnut (*Castanea dentate* [Marsh.] Borkh.) respond to prescribed burning. Preliminary results indicate that seedlings can withstand burning several years after planting if root collar diameters are relatively large when established.

Fire and Oak Decline

Scientists used LANDIS to model oak decline in the Boston Mountains of Arkansas 150 years into the future under two fire return intervals. The analysis delineated potential oak decline sites and established risk ratings for these areas. This is a further step toward precision management and planning.

SMALL MAMMAL OCCURRENCE IN OAK WOODLANDS AND RESTORED SAVANNAS

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ABSTRACT

Oak savannas are rare in the United States, and few quantitative data exist on how the small mammal community will respond to the restoration of this ecosystem. We present the baseline data for an ongoing savanna restoration research project at the Jasper-Pulaski State Fish and Wildlife Area in northwest Indiana. During the summer of 2009, we investigated the density, abundance, and microhabitat preferences of small mammal species in oak woodlands versus existing oak savannas to better predict if shifts in species composition would occur after the restoration process. We used one-way analysis of variance to compare abundance of each species to habitat type and multiple linear regressions to compare their abundance with microhabitat variables. Significant differences in species abundance were not observed between oak woodlands and oak savannas. White-footed mice were positively correlated with percent herbaceous cover and basal area of white oaks, but negatively correlated with percent cover of soft mast. Southern flying squirrels were trapped only in oak woodlands and were positively correlated with basal area of black oaks. Eastern chipmunks were positively correlated with percent herbaceous cover and negatively correlated with woody stem density. Red squirrels were only captured in oak woodlands and were positively correlated with soft mast and basal area of white and black oaks, but were negatively correlated with percent herbaceous cover. Our data suggest that oak woodlands converted to oak savannas will lose woodland obligate species, and microhabitat characteristics are better predictors of species occurrence than the macrohabitat.

VECTOR ANALYSIS OF RESPONSE OF ADVANCE REPRODUCTION TO REPEATED PRESCRIBED BURNING

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ABSTRACT

Advance reproduction is important to restore and maintain oak dominance. Response of oaks (*Quercus* spp.) and associated species to prescribed fire depends on a wide array of factors including site condition, fuel characteristics, fire frequency and intensity, and size or age of advance reproduction. It will be useful to quantify species response to fire for prescribing burning treatments that promote oaks while curbing their competitors. We used the 10-year Chilton Creek prescribed burning experiment data and vector analysis to simultaneously compare oak and associated species growth and resprouting ability, two important traits to determine future oak status. The species and size groups/classes identified based on the vector analysis can be directly applied to future prescribed burning practices.

WOODLAND RESTORATION IN THE OZARK HIGHLANDS OF ARKANSAS

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ABSTRACT

Fire is one of the most important ecosystem disturbance processes in the Ozark-Ouachita Highlands. Conversely, the exclusion of landscape-scale fires from these ecosystems for the past several decades has changed the structure and species composition of the forest. Fire exclusion has allowed an increase of shade-tolerant, fire-intolerant tree species. The ecosystem restoration project on the Big Piney and Pleasant Hill Ranger Districts of the Ozark-St. Francis National Forest encompasses eight project areas designed to reduce hazardous fuels and increase forest health. Current restoration activities being implemented by the Forest Service include prescribed fire and commercial and noncommercial thinning. In order to assess changes in forest health over time, we monitored plant community structure and composition within the 102,120 acre ecosystem restoration project areas using 127 randomly placed macroplots. Data were collected during the summers of 2003-2006 (baseline) and 2007-2009 (remeasure). Data were stratified based on topographic position. Tree densities (stems per acre) decreased significantly in the north slope, south slope, and ridgetop communities. Overall tree density decreased as well. The majority of the decrease in stems per acre was from the midstory tree layer. Species richness in the ground layer increased in all communities, with a significant increase in the ridgetop community. Current restoration activities appear to be adequately producing the desired changes in forest structure. The continuation of prescribed fire is crucial to improving forest health and bringing the forest closer to desired ecological condition. In addition, continued monitoring can track progress toward desired condition and help guide forest management planning.

RESPONSE OF SEASONAL BIRD SPECIES DENSITIES TO HABITAT STRUCTURE AND FIRE HISTORY ALONG AN OPEN–FOREST GRADIENT

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ABSTRACT

Along an open-forest landscape gradient in northwest Indiana, we assessed associations of bird species with grasslands, savannas, woodlands, scrublands, and forests by relating fire frequency and vegetation characteristics to seasonal densities of 72 bird species distributed across the open–forest gradient. About one-third of the species did not exhibit statistically significant relationships with any combination of seven vegetation characteristics that included vegetation cover in five vertical strata (bare ground; vegetation 0.3-1 m height; vegetation 1-2 m height; living woody shrubs, sprouts, saplings, or small trees 2.5-10 cm diameter at breast height [d.b.h.]; and living trees >10 cm d.b.h.), dead tree density, and tree height. For 40 percent of the remaining species, models best predicting species density incorporated tree density. Therefore, management based solely on manipulating tree density may not be an adequate strategy for managing bird populations along this open–forest gradient. When fire frequency, measured over 15 years, was added to vegetation characteristics as a predictor of species density, it was incorporated into models for about one-quarter of species, suggesting that fire may modify habitat characteristics in ways that are important for birds but not captured by the structural habitat variables measured. Among those species, similar numbers had peaks in predicted density at low, intermediate, or high fire frequency. Given these avian compositional variations along the open-forest gradient, managers considering restoration of landscapes will face a fundamental challenge. What should the habitat composition of the restored landscape look like? We developed a model for evaluating the desirability for birds of different landscape habitat compositions by quantifying an important conservation tradeoff inherent in making restoration decisions, the tradeoff between the landscape's ability to promote avian species diversity and the landscape's use by threatened avian species. This quantification allowed us to evaluate the ability of different landscape compositions to achieve preferable tradeoff compromises, such as maximizing diversity for a given level of landscape use by threatened species. Managers can use such tradeoff results to evaluate which landscape compositions are associated with particular conservation and management priorities.

THE TRACE OF FIRE IN EASTERN NATIVE AMERICA

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ABSTRACT

Written in the rings of trees is a history of fire in Native America that tells of humans, drought, and their interactions. These fire histories in eastern Native America move through generations and territories from 1600 to 1850. These quantitative histories are based on thousands of fire scars found on oak and pine trees. Each fire scar has a date, location, and associated human population. Here we examine the connections between the occurrence of wildland fire in Native America and the people who lived there, the Algonquin, Cherokee, Chippewa, Osage, Menominee, and others. The documentation of fire history ranges from the ecosystems of Appalachia, the Great Lakes, the Southeast, and the Midwest. We found changes in fire frequency associated with Native American populations in Alabama, Arkansas, Kentucky, Michigan, Missouri, Tennessee, Oklahoma, Ontario, Pennsylvania, and Wisconsin. Many fire regimes in eastern Native America are found to have a temporal human "footprint", that is, an abrupt or rapid change in fire frequency not related to climate. The interactions of drought and human migrations and ignition are detected in the fire scar record. During years with large fires, severe drought is the predisposing factor, and human ignitions represent the inciting factor associated with the occurrence of widespread fires.

CLIMATE AND PHYSICAL CHEMISTRY IN EASTERN FIRE REGIMES

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ABSTRACT

Knowledge of the temporal-spatial variability in fire intervals is needed for understanding the changing effects of climate on fire regimes. This work focused on translating the physical chemistry of ecosystem processes and climate into fire regimes. This was achieved by using empirical, process, and multiple regression modeling to translate the laws and units of physical chemistry into the processes of ecosystem fire regimes. The Physical Chemistry Fire Frequency Model (PC2FM) is based on the Arrhenius equation and was calibrated with fire scar data, charcoal studies, and expert interval estimation. The model predicts the climate forcing of mean fire intervals (MFIcf) from temperature, precipitation, their interactions, and the partial pressure of oxygen. We used fire interval data from 166 sites in North America and elsewhere to calibrate the PC2FM. The PC2FM was calibrated with data from pre-Euro-American periods to reduce the effects of climate change, land use, fire suppression, and other nonclimatic factors affecting fire regimes. Details of the model's chemistry and statistics are presented. The model is applied to ecosystems at scales from 1 km^2 or larger, but can span multiple time periods and climate scenarios. Mean fire intervals are mapped for the historic period from approximately 1600 to 1820 using the PC2FM at regional scales in the eastern United States, at a broader scale in the United Sates, and at continental scales. Since the model does not directly include vegetation, natural or human ignitions, management, or topography, it only predicts fire regime characteristics that are influenced by climate.

INFLUENCES OF TOPOGRAPHY AND FIRE ON EASTERN RED CEDAR (*JUNIPERUS VIRGINIANA*) DISTRIBUTION IN A PRAIRIE-FOREST TRANSITION ZONE

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ABSTRACT

Historic information indicates that eastern redcedar (*Juniperus virginiana* L.; ERC) was restricted to rocky bluffs and fire-protected areas throughout much of its range during the pre-Euro-American settlement period. As a consequence of settlement, dramatic changes occurred in land use, grazing, fire, and human populations, all of which coincided with a widespread increase in eastern redcedar's distribution and density. To more closely identify the relative importance of these factors, we initiated a study addressing ERC demographics and growth in a relatively intact post oak (*Quercus stellata* Wangenh.) woodland complex within the Wichita Mountains National Wildlife Refuge (WMNWR) located in southwestern Oklahoma. Tree density, ages, and site information were measured in 353 plots distributed throughout a 14,000 hectare area comprised of plains, riparian zones, and rugged mountains. Preliminary analysis suggests a positive correlation exists between tree age and local topographic roughness and rocky soil substrate. Overall, younger trees (<100 years old) dominated the age distribution refuge wide. Expansion appeared to occur more widely in moderately rough terrain compared to the extremes found in grasslands (gentle) and peaks (very rough). In areas with more open forest canopy conditions (e.g., savannas, open woodlands), ERC appears to exhibit nurse tree characteristics, whereby younger ERC more commonly establish at the bases of older oak trees. Older ERC trees (200-500+ years old) occupy increasingly topographically rougher terrain. We hypothesize that topography was historically an important barrier with respect to limiting fire spread and that a topographic roughness index (in addition to other variables) could be used to delineate the historic spatial distribution of ERC that existed during the past few centuries when frequent burning was well documented in these woodlands.

DENDROCHRONOLOGICAL DETERMINATON OF HISTORICAL FIRE OCCURENCE AND RECRUITMENT IN A SOUTHERN ILLINOIS OAK-HICKORY FOREST

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ABSTRACT

Throughout the central hardwoods, fire return interval dramatically increased during the period of Euro-American settlement. Fire was used as a tool for clearing land and improving forage for grazing. The Shoal Creek study site is located in Jackson County, Illinois, 8 km southwest of Murphysboro. Shoal Creek is situated at the northern extent of the Illinois Ozark Hills, classified as a Subsection of the Ozark Highlands Section. The region is unglaciated, and loess caps are 10 m deep on the ridgetops and 1-3 m deep on side slopes. Preliminary results suggest the site was frequently burned during postsettlement, with a mean fire interval (MFI) of 2.95 years from 1887 to 1946. Fire waned from the site in the 1930s, and the last major fire occurred in 1946. By this time, Shawnee National Forest had become established in southern Illinois, and fire suppression was the preferred management technique. Thirty-three fire scarred cross sections were opportunistically sampled from trees on a southwest aspect of a *Quercus-Carya* forest. Cross sections were sanded to 600 grit, and skeleton plots were used to determine signature years for cross-dating purposes. Year and seasonality of individual fire scars and approximate pith date were determined for each sample and were utilized in FHX2 fire history software. Recruitment history revealed that overstory *Quercus-Carya* species established under favorable conditions in the early 20th century. Timber was harvested from the site around 1900, and intense fires followed for the next 30 years. A small pulse of *Acer-Fagus* germinated as fire frequency decreased on-site during the 1930s, and a significant pulse established immediately after the last recorded fire in 1946. Superposed epoch analysis (SEA) determines the influence of immediate weather patterns and overall climate trends surrounding fire event years. SEA was run to compare fire event years at Shoal Creek with Palmer Drought Severity Index (PDSI) climate reconstructions. For the 95 percent confidence interval, there was not a significant association between fire and climate. In the central hardwoods, lightning is associated with rainstorms, and fires burn in both dry years and wet years, so the relationship between fire and climate is not strong. If rehabilitation of *Quercus-Carya* dominated forest stands is the management objective, the results of this study will aid in fire cycle planning of frequency and seasonality. Managers may consider the MFI for rehabilitation burns, and range of fire intervals for long-term maintenance burns. However, prescribed burns are not the only answer for managers. Fire must be used in accordance with silvicultural techniques that mimic natural disturbance regimes such as timber stand improvement (TSI) and shelterwood harvests which create large overstory gaps suitable for oak-hickory recruitment.

OAK-GRASSLAND RESTORATION AT LAND BETWEEN THE LAKES NATIONAL RECREATION AREA: PRELIMINARY RESULTS

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ABSTRACT

Two areas totaling 8,630 acres within the Land Between the Lakes National Recreation Area (LBL) were designated as oak-grassland demonstration restoration areas in 2004. Dormant and growing season prescribed fires along with several thinning operations occurred between 2006 and 2010. Prescribed fire frequency ranged from one to three ignitions within this time period. We conducted a comparison between the changes in basal area, canopy cover, and the occurrence or composition of understory herbaceous cover within areas treated by one fire with areas burned more than once, and areas that were both burned and thinned. Burned and thinned areas were also compared by thinning regime: cut-and-leave versus commercial thinning. Over the last 4 years, we have already seen that the vegetation management programs at LBL have affected forest structure and composition. Prescribed burning has had an effect on understory composition, and to a lesser degree, midstory composition. However, any structural changes accomplished by just the use of prescribed burning were limited to the most xeric sites. The combination of prescribed burning and thinning treatments had an effect on both species and structural composition across all canopy levels, with all sites types with herbaceous development increasing as well. Oak-grassland structure has yet to be completely developed within the two sites; however, several of the areas have developed a woodland structure. In conjunction with further prescribed burns, this combination should provide the higher light levels that are key to sustaining an understory dominated by herbaceous species.

THE EFFECTS OF PRESCRIBED BURNING ON THE BLACK KINGSNAKE: GOING BEYOND THE DEMOGRAPHIC DATA

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ABSTRACT

Species responses to habitat alteration are most frequently studied by estimating changes in population numbers. However, subtle changes in the habitat may cause indirect effects that go unnoticed in the short term yet can cause adverse population effects in the long term. Although demographics may be informative to reveal how snakes respond directly to habitat alterations, understanding how landscape changes may alter prey abundances, preferred microhabitat availability and use, predation intensity, and foraging strategy would assist biologists in knowing more of the collective effects caused by landscape alterations. The objective of this project was to determine how the black kingsnake (*Lampropeltis getula nigra*) is affected by changes to the landscape that are caused by prescribed burning. In the summer of 2010, I began this project at Land Between The Lakes National Recreational Area in southwestern Kentucky. I set up four study plots (each 800 m x 800 m; 64 ha) within the Franklin Creek Area burn unit (~960 ha in total size) and four study plots of equal size in an adjacent unburned habitat with similar topography. The Franklin Creek Area was burned in April 2007 and again in September 2010. Drift fences with funnel and pitfall traps were erected in the center of each plot, and an array of coverboards were placed throughout each plot. During the summer of 2010, a total of 848 reptiles, amphibians, and small mammals were captured, marked, and released. Reptile species richness and diversity indices (DI) were lower in burned plots (13 species, DI = 2.03) than in control plots (17 species, DI = 2.37). Biophysical copper models were deployed in each plot to measure the potential body temperatures a black kingsnake could achieve. Mean temperatures in burned plots were consistently warmer than in control plots and more frequently exceeded the critical thermal maximum of black kingsnakes (42 °C) suggesting that habitat in burned plots may become too warm for black kingsnakes, thus limiting the amount of time that they could be active (foraging for food or searching for a mate). Available habitat was measured within all plots prior to the second burn, and burn plots were characterized by fewer understory trees and higher ground temperatures. Burned plots also had higher air temperatures, a lower percentage of leaf litter, and shallower depths of leaf litter than control plots. The preferred body temperature (T_{pref}) was also measured for four captured kingsnakes in a thermal gradient arena, and mean T_{pref} was determined to be 28.2 ± 1.6 °C. Of these captured kingsnakes, one was large enough to have a radio-transmitter surgically implanted, and I am currently tracking this individual within a burned plot. This project is currently in the second of three field seasons.

MULTIPLE BURNS PAVE THE WAY FOR IMPROVED OAK-HICKORY REGENERATION IN CANOPY GAPS IN SOUTHERN OHIO FORESTS

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ABSTRACT

In 1995, we began a study of prescribed fire as a tool to sustain mixed-oak forests. We hypothesized that repeated fires would reduce stand density "from below", favoring the development of oak-hickory advance regeneration relative to the shade-tolerant species (e.g., red maple) that dominated the understory. Our study consisted of four 60 acre stands burned two to five times from 1996 to 2005, and two unburned stands, located in the Vinton Furnace Experimental Forest, OH. We collected overstory and regeneration data on a total of fifty-four 0.3 acre plots located across the full range of upland topographic moisture conditions in the six stands. Though fire reduced the density of 1-4" d.b.h. (diameter at breast height) saplings (-74 percent) and 4-10" d.b.h. midstory trees (-30 percent) on these permanent plots by 2008, canopy cover remained high (>85 percent), and the relative abundance of oak-hickory advance regeneration was not significantly greater in burned vs. unburned plots. In 2003, canopy gaps formed in these same stands during a regional white oak decline. In 2008, we quantified understory structure and tree regeneration in 52 canopy gaps (separate from the permanent plots); 28 gaps were in three stands burned three to five times and 24 gaps were in three unburned stands. Gaps were formed from the death of one to nine canopy trees (mean = 4). The understory structure of burned gaps was much more open than unburned gaps, which had a dense layer of saplings and midstory trees. Burned stands had significantly more oak-hickory advance regeneration in gaps (range 3,725 to 5,590 stems/ac) than did unburned stands (607 to 2,308 stems/ac); and oak-hickory dominated the larger advance regeneration layer (stems 1ft tall to 1 inch d.b.h.) in burned gaps. Sassafras advance regeneration was also more abundant in burned gaps while shade tolerant species and all other intolerant species were equally abundant in burned and unburned gaps. While fire alone did not clearly benefit oak-hickory regeneration in closed canopy forests, canopy gaps that formed after multiple burns became dominated by large oak-hickory regeneration. Our results suggest that, given enough time, repeated fires can increase the probability that oak and hickory will retain dominance after a canopy disturbance.

ASSOCIATION OF FIRE SEASON, FIRE FRONT, AND FIRE TEMPERATURE ON THE MORTALITY OF EARLY SUCCESSIONAL PERSIMMON AND SWEETGUM TREES

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ABSTRACT

Land managers commonly treat grasslands with prescribed fire to decrease encroachment of woody vegetation and to maintain grassland biodiversity. The focus of our study was to assess the mortality of two early successional invaders, sweetgum and persimmon, in response to various fire regimes. We compared: (1) tree mortality between spring dormant-season (March-April) and fall growing-season (October) fires; and (2) the relationship between fire intensity and tree mortality. To examine these objectives, we sampled tree mortality from four burns between the fall of 2007 and the spring of 2009 at Big Oaks National Wildlife Refuge in southeastern Indiana. Our results suggested that the fire season, fire front, and fire temperature were all positively associated with mortality of these two early successional trees in a species-specific manner.

High intensity fires associated with head fires, and spring dormant season fires had the greatest impact on the mortality of persimmon trees. However, fall growing season fires of either high intensity or long duration had the greatest impact on sweetgum trees. Full mortality of these trees was difficult to achieve due to prolific root and collar sprouting occurring shortly after the fires.

POSTFIRE SUSCEPTIBILITY OF HABITATS TO INVASION BY SEED OF ORIENTAL BITTERSWEET

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ABSTRACT

Prescribed fires are a common management tool in forested ecosystems. These fires help to maintain forest structure as well as species biodiversity. Fires also create disturbance which could allow for invasion of exotic species. Oriental bittersweet (*Celastrus orbiculatus*) is an exotic liana (woody vine) that is aggressively moving its way west from the eastern United States. This species is a major invader of forests and can disrupt natural succession. We set out to investigate if habitats that have been burned provide more conducive conditions for bittersweet germination than those that have not. We examined six different habitat types including sand prairie, moraine prairie, oak savanna, oak-hickory forest, beech-maple forest, and oak forest. In each habitat type we had replicated 6 x 6 m plots that were divided into four different treatments: high fire intensity, low fire intensity, litter removed, and a control. We burned these plots in either the spring (prairies and oak savannas) or fall (oak-hickory, beech-maple, and oak forest) dormant seasons. After the burns (April), we introduced 25 seeds of oriental bittersweet to each of the four treatments within the plot and monitored their germination and height monthly throughout the growing season (May-September). When examining the maximum number of seedlings per sampling period over the 2 years, the forested habitat plots (beech-maple and oak forest) had significantly greater percent germination than the open plots (prairie, savanna); however this comparison is confounded with year of sowing and differences in weather between years. Plots on moraine soils had greater overall percent germination than those on sandy soils. In the prairie and savanna habitats, the control had the highest percent germination, while the litter removed had the lowest. The high and low intensity fire treatments were not significantly different from the control nor the litter removed plot. In the oak and beech-maple forest habitats, the germination percentage in the control treatment was significantly lower than the low and high fire treatments. The litter removed treatment was not significantly different from the control or the two burn treatments. Thus, in some habitat types, fire could make the plant community more susceptible to invasion, while in others, it does not. This result is largely a function of how exposed the seeds become in the habitat in the absence of litter. In more open habitats (prairie and savanna) these seeds are exposed to more sun and do not germinate well, while in the forested plots, having less litter is conducive to germination since the canopy of the forest protects the seeds from excessive sun and heat. These results will assist land managers in making decisions when burning in forested areas with high amounts of oriental bittersweet.

DETERMINING LUMBER VALUE CHANGES IN FIRE INJURED OAK TREES

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ABSTRACT

Prescribed fire is used for a variety of management tasks in woodlands with only limited information on how it affects lumber product values. We analyzed how fire related injuries affect lumber volume and grade in red oaks (*Quercus coccinea* and *Q. velutina*) harvested from two sites in southern Missouri. Trees (n=58) with varying degrees of external damage (scar size), time since fire, and log size were harvested and milled into dimensional lumber. Lumber grade and scale changes due to fire related injuries were tracked on individual boards (n=423; 4160 board feet). To estimate lumber product value losses, grade and scale changes were compared to an expected grade and scale as if no fire injuries were present. Preliminary analysis indicates tree size, scar size, and time since fire to be important predictors in decreased lumber product values, and minimal value loss occurs within the first 10 years after fire-caused injuries occur. Current field sampling has occurred on mid-quality woodland sites where lumber product quality is typically low. Future field sampling (approximately 30 additional trees) and analysis will target higher quality sites.

ESTIMATING FUEL CONSUMPTION DURING PRESCRIBED FIRES IN ARKANSAS

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ABSTRACT

While prescribed fire is essential to maintaining numerous plant communities (especially those dominated by oak and pine), fine particles produced as smoke can impair human health and reduce visibility in scenic areas. As a result of these concerns, the Arkansas Voluntary Smoke Management Guidelines were established by the Arkansas Forestry Commission to mitigate the impact of smoke from prescribed fire on people's health and to ensure adherence to air quality regulations. These guidelines use standard fire behavior and fuel models developed elsewhere in the United States. The accuracy of these models for determining fuel loading and consumption in Arkansas, however, is unknown. We established 120 modified Brown's transects in 15 burn units and three community types on the Mena, Oden, and Poteau Ranger Districts of the Ouachita National Forest in Arkansas to determine fuel loads before and after prescribed fires. The three community types were pine-oak (*Pinus echinata-Quercus* spp.) forest, oak forest, and pine woodland. In addition to the ordinary Brown's methodology of measuring litter and duff depth and tallying woody fuels, we also clipped attached vegetation and collected 1 and 10 hour fuels in adjacent quadrats before and after the prescribed fires. This enabled us to estimate the live fuel component not sampled by Brown's transects and test the accuracy of ordinary Brown's transects in terms of woody fuel consumption. We used localized bulk density values to convert inches of litter and duff into tons per acre. We then used FFI (Fire Ecology Assessment Tool-Firemon Integrated) software to quantify fuel consumption on 7 of the 15 prescribed fires. Preliminary analyses showed that the fuel consumption occurring in the Ouachita Mountains was consistent with expected values based on standard fire behavior and fuel models (Table 1), and that fuel consumption in restored woodlands was significantly less than that in closed canopy forests (Fig. 1).

Table 1.—Comparison of fuel consumption values predicted by standard fire behavior fuel models and Brown's transect data collected on dormant season prescribed fires on the Ouachita National Forest in Arkansas, 2010 and 2011

Community Type	Standard Fuel Model	Actual Brown's Transect Data*
	tons/acre	tons/acre
Pine-oak forest	3.0–4.4	3.0–5.4
Oak forest	0.8–2.5	2.0–3.8
Pine woodland	1.5–5.9	0–1.9

* Includes Brown's transect data only (N = 32, 14, and 9 for pine-oak forest, oak forest, and pine woodland, respectively).

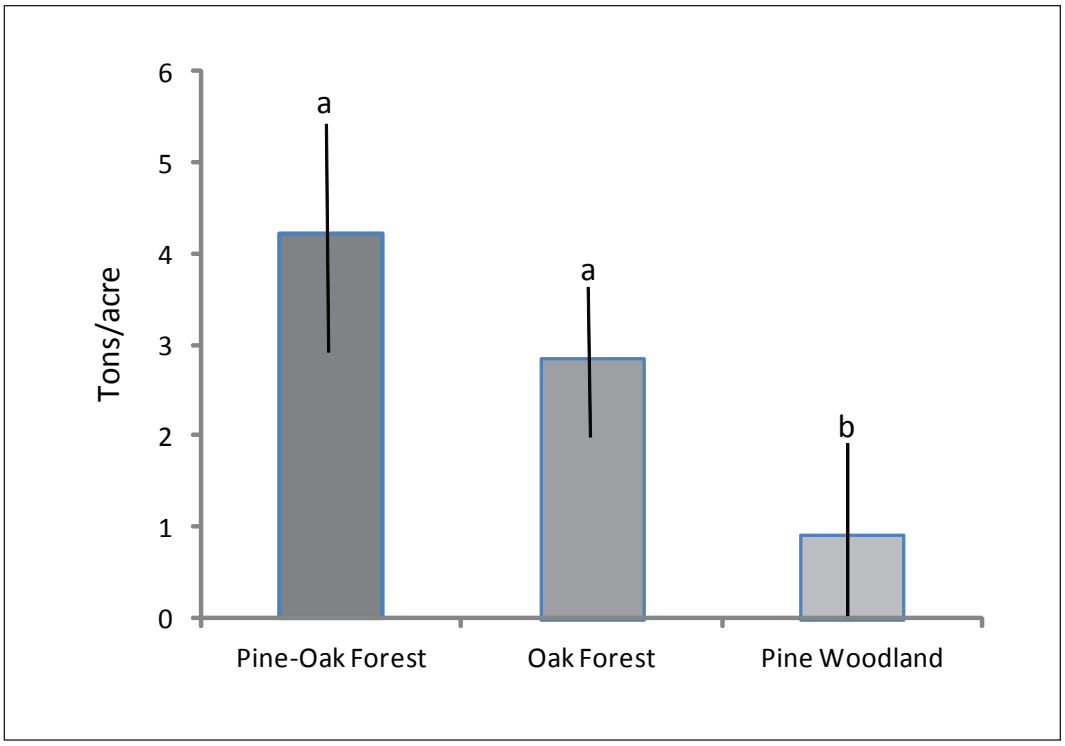

Figure 1.—Overall fuel consumption in pine-oak forest, oak forest, and pine woodland using only Brown's transect data on the Ouachita National Forest in Arkansas, 2010 and 2011. Different letters indicate a significant difference ($p \leq 0.05$, mean ±2se) among forest types.

FIRE EFFECTS ON THE RESPROUTING AND TOTAL NONSTRUCTURAL CARBOHYDRATES OF THE HIGHLY INVASIVE ORIENTAL BITTERSWEET

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ABSTRACT

An important evolutionary strategy for surviving fire is the ability to resprout. Resprouting ability is determined by resistance to burning, the location of meristems, and storage of special chemical reserves for regrowth. Total nonstructural carbohydrates (TNC) in the roots can be an important source of readily available reserves for rapid resprouting. Oriental bittersweet (*Celastrus orbiculatus*) is a highly invasive liana that is migrating westward across the central portion of North America. This aggressive liana can girdle trees, reach and cover forest canopies, increase tree susceptibility to ice damage, and alter successional trajectories. While it is known that this species can vigorously root sprout after a fire or from cutting, no quantitative study on this prolific resprouter has been done. We are conducting a replicated experiment on sand and moraine soil substrates to examine the effects of burning, cutting, and the combination of the two on resprouting and regrowth of Oriental bittersweet. We initiated eight experimental blocks with control, burn, cut, and cut and burn treatments in the spring and fall. Extreme weather prevented us from conducting growing season treatments (which were moved to the fall dormant season), so we added an additional cutting treatment in early July. Oriental bittersweet density and cover were measured in four 1 m^2 subplots in each treatment plot (10 × 10 m) with a pretreatment inventory done in July 2009 and a posttreatment remeasurement done in July 2010. Stems were classified into six size categories: seedlings; <2.5 mm in diameter; 2.5-5.0 mm; 5.1-10 mm; 10.1-15 mm; and >15 mm. We also collected three root segments of Oriental bittersweet from each plot in March, May, and July for TNC analysis. We used the differences in Oriental bittersweet cover, stem counts, and diameters as our response variables for the preliminary comparisons between 2009 and 2010. We found that burning and cutting plus burning reduced bittersweet cover more than just cutting and no treatment, but the reduction was less on the richer morainal soils than on sand. We found that the cut and burn treatment had significantly greater numbers of resprouts compared to the cut treatment ($F_{2,1} = 2.1$, $P = 0.1$). In addition, the number of resprouts increased with size class ($F_{4,1} = 9.8$, $P < 0.001$). When we examined the percentage of plants that were killed in each size class we found, as expected, that the largest size class had the most survival overall. The spring cut and burn had the most killed stems, but also had the highest number of resprouts. Seasonally, TNC declined from a peak in March to moderate levels in May and then increased by July. Cutting bittersweet in early July resulted in a 75 percent reduction in TNC compared to dormant TNC levels. Our results have important implications for developing effective strategies for controlling and eliminating Oriental bittersweet.

CHANGES IN FOREST UNDERSTORY ASSOCIATED WITH REDCEDAR ENCROACHMENT IN FIRE SUPPRESSED *QUERCUS STELLATA* FORESTS

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ABSTRACT

Fire suppression in oak woodlands of Oklahoma, Missouri, and Arkansas often leads to the establishment of a redcedar (*Juniperus virginiana*) midstory that alters species richness and understory productivity. In a *Quercus stellata* dominated forest in northern Oklahoma, we compared vegetation in forest gaps, forests without redcedar, at the inner and outer edge of redcedar canopies, and near trunks (200 plots total). Species richness (11 to 6 spp. m^{-2}) and cover (53.3 to 12.7 percent) declined with proximity to redcedar trunks. Regression analysis indicated that richness ($R^2 = 0.08$) and cover ($R^2 = 0.18$) were best explained by redcedar litter mass. Partial canonical correspondence analysis revealed two strong canonical axes, one related to litter/light and the other to cover of *Quercus* spp. versus redcedar. Tree seedlings and woody vines dominated near redcedar. Forbs, graminoids, and *Quercus* spp. seedlings were more common in areas without redcedar. Our study indicates that litter is the main determinant of understory vegetation declines associated with midstory redcedar encroachment in these fire-suppressed forests. Decreases in herbaceous litter loads, which historically contributed to the accumulation of fuel beds, will have a positive feedback effect on midstory encroachment. Declines in recruitment of *Quercus* spp. that were related to increasing abundance of redcedar and consequent increases in litter loads eventually may lead to changes in overstory composition.

FROM SPRING EPHEMERALS TO LIGHT TO FUNGI: PLANT DYNAMICS IN AN OZARK OAK/HICKORY-FOREST/WOODLAND COMMUNITY MANAGED FOR WILDLIFE THROUGH PRESCRIBED BURNS

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ABSTRACT

This research examines the effects of prescribed fire on community structure and function in Ozark forests. The research aim is to inform decisions about future monitoring and management strategies for forests in southwest Missouri managed for wildlife, and more generally, to understand how heterogeneity in light through a canopy affects community and ecosystem function. Eighteen circular 0.1-ha plots have been established across three "treatments/habitats" at the Drury-Mincy Conservation Area (DMCA) in Taney County, MO. In addition, belt transects and 100 m^2 areas have been sampled in conjunction with circular plot sampling. Burning was prescribed on approximately 70 percent of closed forest at DMCA in 1999 with the goal of reestablishing open woodlands, with subsequent burns in 2001, 2003, 2008, and 2010. Prior to this, the closed forest areas had not burned in over 50 years. Small areas of DMCA have been burned since the early 1980s and are sampled as "reference sites", while areas unburned for over 50 years are sampled as "control sites". All prescribed burns have been conducted in March and April on the same forest areas. Fire is clearly opening the canopy and resulting in greater heterogeneity in photosynthetically active radiation reaching the forest floor. However, after 12 years, recently burned forests do not have significant oak regeneration, and plant community structure and function are still more typical of a closed forest than open woodland. We will present data on physiology of oak and hickory saplings, herbivory on oak saplings, soil respiration, leaf litter inputs, fungal abundance, overstory production, light penetration to understory, spring ephemeral diversity, and overall understory, midstory, and overstory plant species richness and cover. Finally, we will summarize interactions towards the goal of increasing our ability to predict plant and animal population dynamics and anticipate and minimize habitat degradation and pest species invasions in Ozark forests.

PRESCRIBED BURNING IN AN UPLAND OAK FOREST REDUCED LITTER N, SOIL ORGANIC C, AND GRAM NEGATIVE BACTERIA

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ABSTRACT

Prescribed burning is a management technique used for reducing fuel loads, preventing exotic species invasion, and maintaining wildlife habitat. In upland oak (*Quercus* spp.) forests, prescribed burning prevents the process known as mesophication where the dominant canopy species shift from fire tolerant oaks to fire intolerant tree species. Recently, it has become increasingly important to manage forests from an ecosystem service perspective, especially for soil carbon storage. However, little data exists that explores the relationship between prescribed burning at different frequencies and forest soil properties. We assessed the effect of prescribed burning at 0, 2.5, and 5 fires per decade (FPD) on litter, soil, and the soil microbial community in an upland oak forest in central Oklahoma. Results indicated burn treatments had 26 percent lower litter total nitrogen, resulting in a higher C:N ratio ($P = 0.0017$ and $P = 0.0039$ respectively). The litter lignin:N ratio was lower under 0 FPD when compared to 2.5 FPD but was no different from 5 FPD ($P = 0.019$). Areas burned at 5 FPD had 2.5 times less soil organic matter (SOM) and 2.7 times less soil organic carbon (SOC) than other treatments ($P = 0.0383$). Carbon storage dropped from 36.0 Mg ha^{-1} at 0 FPD to 15.7 Mg ha^{-1} at 5 FPD. Differences in SOM and SOC were associated with increased soil bulk density ($P = 0.0039$). Phospholipid fatty acid analysis (PLFA) indicated that gram-negative bacteria were significantly less abundant under 5 FPD ($P = 0.0378$). Differences in litter chemistry could cause heterogeneity in ecosystem functioning between forest areas with different fire histories, yet changes in litter chemistry did not reflect the differences that occurred in soil chemistry. Differences between the response of litter and soil to fire show an uncoupled nutrient cycling relationship between these two pools. Less litter N may limit the availability of N in soil pools after repeated burning over time as reflected by the C:N and lignin:N ratios. However, nitrogen limitation may not be as dramatic under 5 FPD due to lower amounts of recalcitrant lignin in litter. The reduction in SOM and SOC could affect soil properties like cation exchange capacity and porosity, affecting the availability of nutrients and water in the soil. Shifts in the microbial community could occur because of the reduction of SOC or changes in other nutrients not measured in this study. Our sampling occurred long enough after burning (1.5 years) to indicate that shifts in the soil microbial community were due to the soil environment rather than the burning itself. It is unknown how this change in the soil microbial community will effect nutrient cycling, but it is evident that prescribed burning can alter the soil microbial community at a broad taxonomic level. The differences found in SOM, SOC, and gram-negative bacteria illustrate how burning at a high frequency may be destructive to SOM and SOC, while maintaining an intermediate burn frequency maintains a soil environment like that of an unburned forest.