SHORTLEAF PINE-BLUESTEM RESTORATION IN THE OUACHITA NATIONAL FOREST

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ABSTRACT.—The fire-dependent shortleaf pine-bluestem ecological community, once common in the Ouachita Mountains, had all but disappeared by 1970. This absence was due to the cutting of the original forests in the early part of the 20th century followed by effective fire suppression since the late 1930s. With the adoption of Forest Plan amendments in 1994, 1996, and 2002, and a Forest Plan revision in 2005, the Ouachita National Forest committed to restore the shortleaf pine-bluestem ecosystem on some 250,000 acres. Restoration treatments include thinning pine stands to a residual basal area of about 60 ft^2 per acre, felling most of the woody midstory stems, and prescribed burning at 3- to 4-year intervals. Achieving conditions similar to those depicted in historic photographs normally requires a thinning, a midstory reduction treatment, and three prescribed fires over about 10 years. Since 1994 some 52,992 acres have been thinned, 42,948 acres have received midstory reduction, and 143,233 acres have received one or more prescribed burns. Managers estimate that 18,653 acres are presently in a substantially restored condition. During this time the endangered red-cockaded woodpecker (*Picoides borealis* Vieillot) population has more than doubled, and populations of several other previously declining species of conservation concern have increased markedly.

PRE-EUROPEAN SETTLEMENT AND CURRENT ECOLOGICAL CONDITIONS

The Ouachita Mountains of west-central Arkansas and southeastern Oklahoma encompass 6.6 million acres, and together with the Boston Mountains and Ozark Plateaus to the north and east, form the Interior Highlands physiographic region (USDA Forest Service 1999). The Ouachitas are an eroded mountain system that originated in the late Paleozoic period some 280 million years ago through tectonic activity that folded and faulted the ocean sediments of the area from south to north, resulting in an unusual east-west orientation with broad long aspects facing south and north. Elevations range from 500 to 2,700 feet.

Travelers, settlers and scientists in this region during the 1800s and early 1900s described open pine (*Pinus echinata* Mill.) and hardwood forests with floristically rich understory vegetation of grasses and forbs (Nuttall 1999, Jansma and Jansma 1991, Palmer 1924, Little and Olmstead 1931, Cogburn 1976, McBride 1978) (Fig. 1). Elk (*Cervus elaphus* L.) and bison (*Bison bison* L.) once found suitable habitat in these open woodland communities (Smith and Neal 1991), and are enshrined in local names such as Buffalo Creek. Fires were common (Nuttall 1999, Featherstonhaugh 1844, Little and Olmstead 1931) and maintained the open condition (Foti and Glenn 1991). In a typical Ouachita Mountain area in Oklahoma, fires occurred at an average return interval of less than 10 years for most sites (Masters and others 1995). Tree densities then averaged 170 trees per acre and the average diameter was 11.4 inches (Kreiter 1995).

While the Ouachita Mountain landscapes of today are still dominated by forests, the composition and structure of these forests are much different. Many hundreds of thousands of acres of shortleaf pine-hardwood forests have been

Figure 1.—Historic conditions in the Ouachita National Forest circa 1920 (US Forest Service file photo).

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converted to loblolly pine (*Pinus taeda* L.) plantations on industry lands. The remaining second-growth stands of shortleaf pine and hardwood today on average have more trees and smaller trees than pre-European settlement stands. Today in the Oklahoma study area, for example, the average number of trees per acre ranges from 200 to 250, and their diameters average 9 inches (Kreiter 1995). Average fire return intervals now range from 40 to more than 1200 years (Masters and others 1995). Throughout the region understory vegetation is now dominated by woody species, and once-common grasses and forbs are scarce (Fenwood and others 1984, Masters 1991, Sparks 1996). Bison and elk have been extirpated. Other species such as Bachman's sparrow (*Aimophila aestivalis* Lichtenstein), brown-headed nuthatch (*Sitta pusilla* Latham), and northern bobwhite (*Colinus virginiana* L.) have been negatively affected by the loss of habitat (Jackson 1988), and the red-cockaded woodpecker (*Picoides borealis* Vieillot) has become endangered (Neal and Montague 1991).

Historic and present-day forests of the 1.78 million acre Ouachita National Forest (ONF) very much fit the descriptions above. The typical shortleaf pine-hardwood stand today ranges from 70-90 years old and comprises 90 to 100 ft^2 basal area of pine, and 30 ft^2 basal area of hardwoods per acre (Fig. 2). Of the hardwood basal area, two-thirds is in trees 3 to 9 inches in diameter (Guldin and others 1994). The condition of today's stands derives largely from two factors: the cutting of the original trees and more than 60 years of fire suppression. Large-scale exploitation of the original forests began in the early 1910s and was largely finished by 1940 (Smith 1986). Under U.S. Forest Service stewardship, the period of regeneration that followed the cutting was marked by a strict policy of fire suppression that continued well into the 1980s. The ecological upshot is that by about 1970, the shortleaf pine-bluestem woodland community had all but disappeared from the Ouachita Mountain landscapes (Foti and Glenn 1991).

PLANNING FOR RESTORATION

The ONF initiated large-scale restoration efforts for the shortleaf pine-bluestem ecosystem with the adoption in 1994 of a forest plan amendment to restore old-growth shortleaf pine stands on some 54,000 acres (USDA Forest Service 1994). In 1996 a forest plan amendment was adopted to restore another 120,000 acres of this ecosystem in west-central Arkansas to aid recovery of the endangered red-cockaded woodpecker (USDA Forest Service 1996). In 2002 still another forest plan amendment allocated 30,000 acres in McCurtain County, OK, for recovery of the red-cockaded woodpecker (USDA Forest Service 2002). Finally, a recently adopted revised forest plan (USDA Forest Service 2005) designated an additional 50,000 acres, unrelated to either old-growth forests or red-cockaded woodpecker recovery, to receive restoration treatments. Thus the total acreage allocated to shortleaf pine-bluestem ecosystem restoration is 254,000 acres, about 25 percent of the total pine-dominated acreage on the ONF and about 14 percent of the entire forest.

Figure 2.—Typical unrestored mature second-growth shortleaf pine-hardwood stand on the Ouachita NF today (photo by Joe Neal).

RESTORATION PRESCRIPTIONS

Restoration treatments vary somewhat between stands of native second-growth shortleaf pine and artificial plantations of loblolly pine. In the Ouachita Mountains the latter species was originally naturally distributed in narrow bands along larger stream corridors, mostly along the southern edge of the mountains. Since the late 1960s, however, the trend on private industrial forest lands has been to replace the shortleaf pine forests on upland sites with loblolly pine plantations, thus increasing loblolly pine's acreage far in excess of its original extent. Some of these formerly private lands have been acquired for the National Forest system by purchase or exchange. Each of the areas now dedicated to restoration of the shortleaf pine-bluestem ecosystem contains some loblolly pine plantation acreage.

Native Second-Growth Shortleaf Pine

For typical second-growth shortleaf pine stands, the restoration prescription requires thinning to a residual basal area of about 60 ft^2 per acre, felling most of the woody midstory stems in a treatment known within the agency as wildlife stand improvement (WSI), followed by prescribed burning at 3- to 4-year intervals. Overstory hardwoods, mainly oaks (*Quercus* spp.) and hickories (*Carya* spp.), are retained as individuals or clumps within pine stands, and as entire stands throughout the landscape. Flowering trees and fruiting shrubs such as dogwood (*Cornus florida* L.), serviceberry (*Amelanchier arborea* (Michx. f.) Fern.), and wild plum (*Prunus* spp.) are retained during midstory reduction treatments. Implementation of these treatments will result in substantially restored conditions in about a decade (Fig. 3).

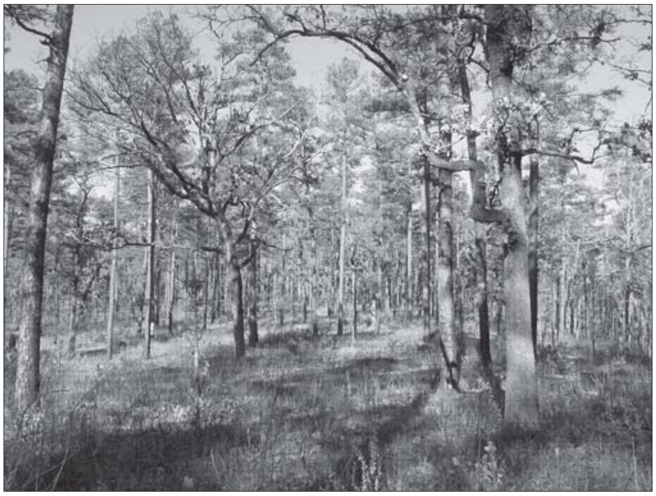

Figure 3.—Restored shortleaf pine-bluestem community on the Ouachita NF (photo by James M. Guldin).

When stand regeneration is desired, advantage can be taken of shortleaf pine's ability to resprout following fire, a habit noted early on by Mattoon (1915). The repeated prescribed burning should serve to provide advanced regeneration of shortleaf pine through resprouting of existing seedlings as well as recruitment of new seedlings over time. Thus, when a decision is made to regenerate these stands, foresters should be able to rely on release of adequate numbers of seedlings from the advance-growth seedling bank, rather than simply upon seedfall and germination of new seedlings, which can be uncertain in shortleaf pine. Reproduction cutting methods utilizing either irregular seedtree (seedtree with reserves) or irregular shelterwood (shelterwood with reserves) methods will be employed to naturally regenerate these stands. Nominal rotation lengths are 160 years for old-growth restoration units, 120 years in areas managed for red-cockaded woodpecker recovery, and 70 years for the remainder.

Loblolly Pine Plantations

Restoration treatments for loblolly pine plantations include thinning to a residual basal area of about 60 ft^2 of basal area to encourage development of the desired understory grasses and forbs, and prescribed burning at 3- to 4-year intervals to maintain the understory vegetation and discourage loblolly pine reproduction. The loblolly pines will be carried to ages and sizes that are economically efficient. The stands will then be clearcut and replanted with native shortleaf pines, which will then be managed as described above.

The Role for Timber Sales

The ability to sell valuable wood products is at the very heart of restoration efforts regardless of whether the stand currently consists of native second-growth shortleaf pines or planted loblolly pines. All commercial thinning or regeneration cutting is accomplished through the use of timber sales that are advertised and sold to the highest bidder. Further, under authority of the Knutson-Vandenberg Act of 1933 and the National Forest Management Act of 1976, portions of the proceeds from these timber sales are retained to pay for most of the follow-up midstory reduction and prescribed burning needed to restore the stands. The upshot is this: timber purchasers are willing to pay a substantial price for the privilege of cutting and removing trees under the Forest Service restoration prescription, helping us achieve desired conditions across many landscapes. The use of sale proceeds to pay for midstory reduction and prescribed burning reduces the need to rely upon scarce federal appropriated dollars for these treatments, and results in the ability to restore much larger areas than would be possible through expenditure of appropriated dollars alone. In this ecological context, timber sales are a means to an end rather than an end unto themselves.

ENVIRONMENTAL EFFECTS OF RESTORATION

While understanding the essential need for restoration in order to recover the endangered red-cockaded woodpecker (Fig.4), and sensing the ecological correctness of restoring an ecosystem that was once widespread but had practically vanished, Forest Service planners and land managers acknowledged that there were unanswered questions about the environmental effects of restoration activities. Studies designed to answer many of these questions were undertaken in cooperation with Oklahoma State University, the University of Arkansas, and the Southern Research Station of the Forest Service. These studies were based on a completely randomized experimental design with three to four replications depending on the study. All studies included treatments of 1) thinning, WSI and burning with measurements taken 1, 2, and 3 years after the burn; and 2) an untreated control. Some of the studies also included a thinning, WSI, and no burn treatment. The experimental units were all typical mature second-growth stands of mostly shortleaf pines ranging in age from 70 to 90 years, and averaging about 40 acres in size.

Biological and Physical Environmental Effects

Birds

Wilson and others (1995) studied the effects of restoration on populations of breeding birds. They found populations of 10 species significantly greater in the treatments than the untreated controls, indicating beneficial treatment effects. Among these species are the eastern wood-peewee (*Contopus virens* L.), a declining neotropical migrant, and the brown-headed nuthatch, a non-migratory species of conservation concern. Two neotropical migrant species of concern, the ovenbird (*Seiurus aurocapillus* L.) and black-and-white warbler (*Mniotilta varia* L.) had significantly lower numbers in the treatments than the controls, indicating adverse effects. Some 27 species showed higher but non-

Figure 4.—The red-cockaded woodpecker on a shortleaf pine, Ouachita NF (photo by Joe Neal).

significant population numbers in the treatments than in the controls, suggesting the possibility of beneficial treatment effects. Among this group are the neotropical migrants Kentucky warbler (*Oporornis formosus* Wilson), ruby-throated hummingbird (*Archilocus colubris* L.), great-crested flycatcher (*Myiarchus crinitus* L.), yellow-breasted chat (*Icteria virens* L.), common yellowthroat (*Geothlypis trichas* L.), white-eyed vireo (*Vireo griseus* Boddaert), yellow-throated vireo (*V. flavifrons* Vieillot), blue-gray gnatcatcher (*Polioptila caerulea* L.), and prairie warbler (*Dendroica discolor* Vieillot). Other species of conservation concern in this group were the red-cockaded woodpecker, Bachman's sparrow, northern bobwhite, wild turkey (*Meleagris gallopavo* L.), and red-headed woodpecker (*Melanerpes erythrocephalus* L.). Some 10 species had non-significantly lower population numbers in treated stands, suggesting the possibility of adverse effects. Species of conservation concern in this group include the neotropical migrants scarlet tanager (*Piranga olivacea* Gmelin), Acadian flycatcher (*Empidonax virescen* Vieillot), and whip-poor-will (*Caprimulgus vociferous* Wilson). However, in a follow-up songbird study Masters and others (2002) found that the rate of occurrence of the Acadian flycatcher increased in the second and third year post-burn treatments as compared to the untreated control. In a subsequent study of northern bobwhites in the restoration area, Cram and others (2002) detected population increases ranging from 5-fold to 19-fold in treated stands as compared to untreated controls, confirming the beneficial effects of treatments on this important game bird.

In yet another study focused on habitat quality for early successional songbirds, Jennelle (2000) concluded that pre-commercial thinning and burning in stands of young trees, and commercial thinning and burning in stands of mature trees, provided suitable foraging and nesting habitat for several such species of conservation concern, including the prairie warbler, yellow-breasted chat, and common yellowthroat. Of special importance was the presence of hardwoods in the shrub layers of both treatments.

In response to restoration efforts and an aggressive translocation program, the red-cockaded woodpecker population has increased from about 32 adult birds and 13 active territories in 1990, to some 88 adults and 37 active territories in 2006 (Figs. 5 and 6). Further, 40 or more young have been fledged in five of the last six breeding seasons (Fig. 6).

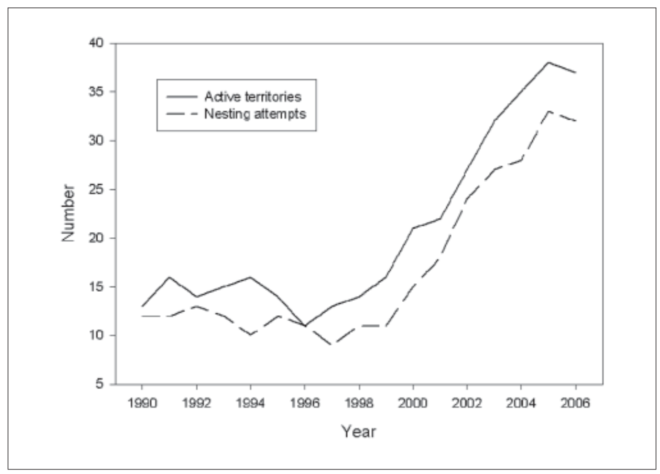

Figure 5.—Changes in number of red-cockaded woodpecker territories and nesting attempts, 1990-2006, Ouachita NF.

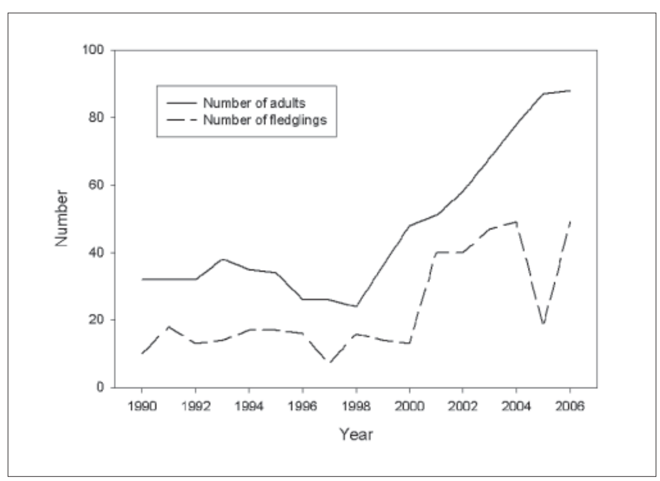

Figure 6.—Changes in number of red-cockaded woodpecker adults and fledglings, 1990-2006, Ouachita NF.

Mammals

Masters and others (1998) found that populations of small mammals in treated stands increased in abundance and diversity; no species was adversely affected. Total community abundance, richness, and diversity were lowest in untreated controls. The authors concluded that restoration efforts may be particularly beneficial to the white-footed mouse (*Peromyscus leucopus* Rafinesque), golden mouse (*Ochrotomys nuttalli* Harlan), and fulvous harvest mouse (*Reithrodontomys fulvescens* Allen), species that may have historically depended on pine-grassland habitats. In a study to determine the effects of restoration on the production of forage for white-tailed deer (*Odocoileus virginianus* Zimmermann), Masters and others (1996) found that preferred deer forage in treated stands was 6 to 7 times greater than untreated controls. Another mammal study currently underway is investigating habitat quality for the eastern spotted skunk (*Spilogale putorius* L.) in shortleaf pine-bluestem landscapes (Leismeister, unpublished data). Restored areas apparently are among the few places in Arkansas where this species of conservation concern can be regularly found.

Other Taxa

Thill and others (2004) studied the effects of restoration on populations of amphibians and reptiles, butterfly fauna and nectar sources, and moth fauna. In most years amphibian relative abundance, richness and diversity were comparable to or higher in restoration treatments than in untreated controls. Overall, values for reptile relative abundance, richness, and diversity were greater in the restoration treatments than in the controls, though the differences were generally not statistically significant. Numbers of adult butterflies were lowest in the untreated controls, highest in the treated stands the first year after burning, and intermediate in the second and third years after burningpresumably due to available nectar sources, which exhibited treatment effects nearly identical to numbers of adult butterflies. A butterfly species of conservation concern, the Diana fritillary (*Speyeria diana* Cramer), was significantly more abundant in treated stands. The moth fauna study yielded different results. For late summer and autumn, moth numbers showed a response similar to butterflies with higher relative numbers in the treatments than in the controls. However, the pattern in spring was reversed, with higher relative numbers of moths in the controls. Additional work is necessary to explain these differing seasonal responses.

Vegetation

Sparks and others (1998) identified more than 150 herbaceous species in their prescribed-burn study stands that were generally absent from untreated controls. Among these were some 40 species of native legumes whose nitrogen-fixing activities augment soil fertility, and whose foliage and seeds provide an important source of food for wildlife. Species richness increased in restored stands after both late growing-season and late dormant-season prescribed fires, and was lowest in unburned stands. Overall, herbaceous species richness, diversity, and total forb and legume abundance increased in treated stands as opposed to untreated controls. A key finding in the study is that season of burn influenced the numbers of fewer than 10 percent of the herbaceous species, and none were excluded by season of burning (Sparks and others 1998). It appears that none of the herbaceous species in the Ouachitas depend exclusively on summer burning to maintain their presence in these restored stands.

Soil and Foliar Nutrients

Liechty and others (2005) compared soil chemistry and foliar nutrients of treated stands with untreated controls. Mineralizable N, total N, C, Ca, and pH of surface soils were higher in treated stands than in the untreated controls. Foliar concentrations of N, P, and K were significantly higher in treated stands for at least a year after burning, though only K concentrations remained higher for the entire 3-year post-burn period. The authors concluded that surface soil fertility and productivity had improved in treated stands.

Tree Growth

Over 4 years of a study comparing tree growth in restored and untreated controls, Guldin and others (2005) found no significant differences in tree growth between treatments and controls. However, growth in both treated and untreated stands was substantially less than that predicted by a regional shortleaf pine growth model (Lynch and others 1999); observed growth was 70 percent less than predicted by the model in treated stands, and 50 percent less than predicted in the controls (Guldin and others 2005). This unexpected outcome is possibly due to generally drier-than-normal weather conditions during the tree growth study. At any rate, the lower than expected tree growth rates were not due to treatment effects.

ECONOMIC EFFECTS

Before considering the economic effects of restoration treatments, it should be understood that there is no law requiring that National Forest lands be managed for profit. In fact, there is specific language in the National Forest Management Act of 1976 directing that managers should not select treatments based on a “greatest return” criterion. Nevertheless, it is useful to describe economic effects in terms of opportunities foregone so as to private landowners an idea of costs and returns should they be interested in applying these restoration prescriptions.

Huebschmann (2000) used an input-output model to estimate the economic effects of shortleaf pine-bluestem restoration for red-cockaded woodpecker recovery over a 100-year simulation period for a 155,000-acre study area in

Scott County, AR. He compared present net value (PNV) for the area if managed under the restoration prescription with a 120-year rotation and low tree density, to what its PNV might be under a more traditional management prescription with a 70-year rotation and heavier stocking. He estimated that after 100 years the PNV for the restored area would be $111 million less than the PNV for the area had it been managed in a more traditional manner. This value translates into an opportunity cost of about $9.25 per year for each acre of pine in the study area. Most of this opportunity cost is attributable to the fact that old pine trees, of which there are many more on the landscape under a long-rotation restoration prescription, do not grow as fast as younger trees. The economic model was based on present average stumpage value for pines, and thus overestimates the economic costs if the future value of large old trees is significantly greater, which is a distinct possibility. At this point, there is no reason to believe that an area managed under a restoration prescription would produce any dramatically different economic value than an area under traditional management provided that the rotation lengths are the same.

RESTORATION PROGRESS AND FUTURE CHALLENGES

From the work that began in the late 1970s as a treatment applied to a few acres surrounding red-cockaded woodpecker cavity tree clusters, the restoration efforts today have burgeoned to encompass landscapes at a scale of hundreds of thousands of acres. Since the adoption of the first formal shortleaf pine-bluestem restoration decision document in 1994, the Ouachita National Forest has thinned 52,992 acres, conducted mid-story reduction treatments on 42,948 acres, and applied prescribed burning at least once on some 143,233 acres within restoration areas. Managers estimate that 18,653 acres are currently in a substantially restored condition.

Because of the scale of the undertaking, however, there are significant challenges to achieving restoration objectives. Ultimately, almost 85,000 acres will likely have to be burned annually in order to maintain desired conditions in the restoration areas. State smoke management plans currently being implemented in Arkansas and under development in Oklahoma may limit the acreage that can be ignited in a single burn, and/or limit the total acreage that can be burned in a single day. Furthermore, the forest's work force is aging, with fewer individuals able to meet the physical fitness requirements each year for prescribed burning. These changes could make it more difficult to burn sufficient acreage each year. Though herbicides have been used only sparingly to date, their use might have to be increased substantially if prescribed burning capability erodes. Further, prescribed burning which has historically been done only by Forest Service employees might have to be done by outside contractors.

SUMMARY

This conservation effort, which had its first stirrings as a concern for an endangered species on a few scattered parcels of land, has grown with public support to encompass a commitment to restore a quarter million acres—a pace and a scale scarcely imaginable 15 years ago. It proceeds by utilizing elements of landscape ecology and restoration ecology supported by local research results published, for the most part, in peer-refereed scientific journals. It promises to substantially restore an ecosystem that was once widespread but is now rare. It offers the opportunity to develop self-sustaining populations of an endangered species and several other species of conservation concern that are presently underrepresented on the landscape. At the same time, the work maintains all of the traditional human uses of the land from logging and firewood gathering to hunting, hiking, and camping. This work enjoys the support of the conservation and lumber manufacturing communities, in addition to the general public. It integrates all of the conservation laws that govern management of National Forest lands. Finally, we and others think it restores an aesthetic beauty to the land not seen in many decades. As a result, we believe this work serves as an example of ecosystem renewal and as a showcase for appropriate management of National Forest lands.

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