Whither Wildlife Without Fire?

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Introduction

Fire is a major ecosystem process that has been pervasive across the southern forest landscape on an evolutionary time scale (Watts and Hansen 1988). Wildlife evolved in response to frequent lightning-ignited burns that shaped the biota of the Southeast. Despite the dominant role that fire has played on an evolutionary scale, the use of prescribed fire as a forest wildlife management tool remains limited and must be expanded.

In this paper, our objective is to use case histories from the scientific literature, along with previously unpublished data, to describe why use of prescribed fire is critical for the effective management of numerous wildlife species in southern forests. In our view, some of the major wildlife management "problems" (i.e., many endangered and/or declining species) in the southern U.S. are rooted in habitat loss resulting from a lack of adequate (either sufficiently frequent and/or widespread) applications of prescribed fire.

Despite recent wildlife management successes and currently abundant populations of white-tailed deer (*Odocoileus virginianus*) and wild turkey (*Meleagris gallopavo*), there are many southern forest vertebrates (i.e., northern bobwhite [*Colinus virginianus*], red-cockaded woodpecker [*Picoides borealis*], Bachman's sparrow [*Aimophila aestivalis*], fox squirrel [*Sciurus niger*] and gopher tortoise [*Gopherus polyphemus*]) that are undergoing severe population declines as a result, in part, from fire being eliminated or greatly reduced across the southern forest landscape. To describe how fire impacts wildlife and what happens to wildlife when fire is eliminated from southern forest systems,

we present examples from research and field studies of threatened and endangered species, other species, and vertebrate communities. We use this information to build a case that points to a critical need for the continued and increased use of prescribed fire. Prescribed fire is an essential part of the management of southern pine forests, old fields and other native habitats throughout the South.

From the standpoint of wildlife management, we consider fire an essential, landscape-level factor in the context of: 1) ecosystem management; and 2) management strategies to maintain and, where appropriate, increase biodiversity of native vertebrates and the habitats they require.

Fire and Ecosystem Management

Any credible attempt at ecosystem management of upland pine forests in the South must include frequent (probably every one to five years, depending on soil conditions and management objectives) use of prescribed fire. In these habitats, it is critical to maintain stands with an open, park-like structure and an understory dominated by grasses and forbs.

An essential component of ecosystem management is the inclusion of actions that mimic natural ecosystem processes and/or disturbances. Fire is a classic example of such a disturbance process. Lightning-caused fire shaped the biota of southern forests throughout the millennia (Komarek 1964). Over time, human influences have fragmented southern forests to the point where it is impossible to rely on natural ignitions from lightning for specific management purposes. Therefore, prescribed fire (that is, burns purposefully ignited by humans in accordance with a predetermined range of conditions for specific management objectives) is the only practical way to mimic the lightning-ignited fires that once swept through vast regions of the South.

Fire and Wildlife

Wildlife biologists have maintained an evolutionary perspective about fire and wildlife since the science of game management was founded. For example, Leopold (1933) stated, "Fire has always been part and parcel of the evolutionary background of our present species in many regions." Nearly 70 years ago, in his pioneering work on the life history of the northern bobwhite, Stoddard (1931) concluded that this bird "... was undoubtedly evolved in an environment that was always subject to occasional burning ...." He generalized these conclusions to other plants and animals by stating, "... fire may well be the single most important factor in determining what animal and vegetable life will thrive in many areas." Furthermore, and perhaps most importantly, he noted, "when fire is eliminated, the animal life, adjusted through the ages to the open

pine forests, is evicted, along with the associated flora." Although many people thought these observations were heretical during the first half of this century, a large body of subsequent research has supported these basic natural history observations for many other ecological resources on continental and global scales (Pyne 1982, 1995).

Today, many southern forest wildlife species have a close affinity for habitat structure and resources that are maintained by frequent (every one to five years) fires (Table 1). Many of these wildlife species have been experiencing significant, long-term population declines, or are currently listed as rare, threatened or endangered, in part because fire has been eliminated from vast areas of the southern landscape (Table 1).

Table 1. Terrestrial vertebrates from southern pine forests and savannas that have affinities for habitats maintained by frequent fire.

Species (scientific name)	Current status[a]
Gopher frog (*Rana capito*)	declining
Flatwoods salamander (*Ambystoma cingulatum*)	declining
Striped newt (*Notophthalmus perstriatus*)	declining
Gopher tortoise (*Gopherus polyphemus*)	threatened
Sand skink (*Neoseps reynoldsi*)	declining
Florida scrub lizard (*Sceloporus woodi*)	declining
Eastern indigo snake (*Drymarchon corais couperi*)	threatened
Audubon's crested caracara (*Polyborus plancus audubonii*)	threatened
Attwater's greater prairie-chicken (*Tympanuchus cupido attwateri*)	endangered
Northern bobwhite (*Colinus virginianus*)	declining
Mississippi sandhill crane (*Grus canadensis pulla*)	endangered
Red-cockaded woodpecker (*Picoides borealis*)	endangered
Florida scrub-jay (*Aphelocoma coerulescens*)	threatened
Bachman's sparrow (*Aimophila aestivalis*)	declining
Florida grasshopper sparrow (*Ammodramus savannarum floridanus*)	endangered
Henslow's sparrow (*Ammodramus henslowii*)	declining
Cape Sable seaside sparrow (*Ammodramus maritimus mirabilis*)	endangered
Sherman's fox squirrel (*Sciurus niger shermani*) (no longer game status in Florida)	declining

[a]Endangered and threatened status according to U.S. Fish and Wildlife Service listed vertebrate species index, January 31, 1998. Declining status determined from various sources.

Direct Versus Indirect Effects of Fire on Wildlife

Fire can affect wildlife populations directly (by killing individuals) and indirectly (by altering habitats). In general, indirect effects of fire on wildlife populations (especially with respect to habitat alteration) are far more significant than direct mortality (Leopold 1933: 346, Brennan and Hermann 1994). This concept, unfortunately, has not been embraced by the general public. Messages from Smokey Bear and Bambi have, in many ways, misguided the public about the effects of fire on wildlife.

Elimination of Fire: The NB66 Experiment

There are relatively few experimental studies that document what happens to wildlife populations and communities when fire is totally eliminated from a forest system. One classic experiment began at Tall Timbers Research Station in Tallahassee, Florida during 1966 and continues to the present. During 1966, a decision was made to eliminate prescribed fire from an 8.6-hectare (360 by 240 m) plot (named NB66 to signify "not burned since 1966") of mature old field upland pine forest 30 kilometers north of Tallahassee. During the first 15 years of fire exclusion, changes in vegetation and breeding bird abundance were dramatic (Engstrom et al. 1984).

Tree canopy cover on NB66 increased from 43 to 91 percent; groundcover (forbs and grasses) decreased from 85 to 21 percent. Most changes in forest structure were related to widespread encroachment of deciduous trees (e.g., oaks [*Quercus* spp.] and hickories [*Carya* spp.]). The breeding bird community shifted from one dominated by open habitat species (e.g., eastern kingbird [*Tyrannus tyrannus*], loggerhead shrike [*Lanius ludovicianus*], blue grosbeak [*Cyanocompsa cyanoides*] and Bachman's sparrow) to one dominated by species typically associated with mesic hardwood forests (e.g., yellow-billed cuckoo [*Cozzyzus americanus*], wood thrush [*Hylochila mustelina*], red-eyed vireo [*Vireo olivaceous*] and hooded warbler [*Wilsonia citrina*]). From 1966 to 1986, the average number of individual birds detected per census on NB66 decreased from 32 to 18 (a 44-percent decrease). Although total species richness remained about the same on NB66 (between 24 and 28 species), species composition changed dramatically over 20 years of fire exclusion (Landers and Crawford 1987).

With respect to small mammals, the hispid cotton rat (*Sigmidon hispidus*), cotton mouse (*Peromyscus gossipinus*) and eastern harvest mouse (*Reithrodontomys humulis*) were abundant at the beginning of the NB66 study, but disappeared from the plot by 1986. In contrast, the southern flying squirrel (*Glaucomys volans*) did not appear on NB66 until 1975 (10 years after fire exclusion), but subsequently underwent a significant increase in numbers (Landers and Crawford 1987).

Effects of Seasonal Fire Applications on Wildlife

Most applications of prescribed fire for wildlife management during the past 70 plus years have occurred during the latter part of winter (February or March). The tradition of late winter burning has stemmed from a number of ecological and cultural factors.

Ecological factors that stimulated use of dormant-season fire. Many upland pine forest stands throughout the South represent the "second forest" of this region. In the case of lands managed with intensive plantation forestry, these stands can be the third or fourth forests that have grown on a site. The original, highly pyrophillic groundcover vegetation (dominated by wiregrass [*Aristida* spp.] and 400+ associated species) in southern pine (primarily longleaf pine [*Pinus palustris*]) was lost when the original forests were cleared and planted to row crops prior to the Civil War. Old-field succession resulted in a dramatic change in species composition, especially in the groundcover vegetation. Today, most of the forest understory vegetation in this region is dominated by native ruderal species, such as broomsedge (*Andropogon* spp.), ragweed (*Ambrosia* spp.), blackberry (*Rubus* spp.) and many other forbs and shrubby plants that are relatively succulent (compared with wiregrass) and burn poorly during the peak growing season when lightning originally ignited most fires. Early wildlife managers, including Stoddard and his contemporaries, found the "old-field" vegetation that dominates vast areas of southern pine forests burns best during late winter, after the frosts had killed and dessicated most of the grasses and forbs.

Cultural factors that stimulated use of dormant-season fire. Late winter is a pleasant time to apply fire in the woods because temperatures are cool and frost-killed, old-field vegetation burns easily. Furthermore, most quail hunting seasons end by early March. The fact that quail and other desirable ground-nesting birds such as wild turkeys had not yet begun to nest during February or March was an added bonus for burning at this time of year. Conventional wisdom of the time dictated that fire during the nesting season would spell disaster for ground-nesting birds. Hence, a tradition of February and March fire emerged and became deeply ingrained in the culture of the Southeast.

Increased interest in lightning-season fire. During the past decade, much interest in applying prescribed fire during the lightning (or growing) season (May to August) has emerged (Robbins and Myers 1992). Again, the reasons for this are both ecological and cultural. Ecological reasons for applying lightning-season fire stem from natural history observations that wiregrass must be burned during this time of the year to flower and set viable seed (Robbins and Myers 1992). Furthermore, intensive lightning-season fires (as opposed to relatively cool winter fires) can be useful for generating extensive top kill (and

hence control) of invasive hardwoods (Robbins and Myers 1992). However, (Glitzenstein et al. 1995) showed that fire intensity was a more important factor than seasonality with respect to hardwood mortality.

Effects on ground-nesting birds. In a comprehensive review of seasonal fire effects, Robbins and Myers (1992: 57) stated no one really knows what the long-term effect [of lightning-season fire] would be on quail, turkey and other ground-nesting birds. Recently, scientists at Tall Timbers have undertaken a series of field experiments to examine the effects of dormant- versus lightning-season fire on wildlife. Over the short-term (three to four years), seasonal fire effects on birds are subtle and mostly insignificant at the population level for quail (Brennan et al. 1997, 1998, Carver et al. 1997), turkey (Sisson and Speake 1994) and many passerine birds in both the northern Florida and North Carolina Sandhills regions (Engstrom et al. 1996). Applications of lightning-season fire do not seem to "upset" breeding quail (Carver et al. 1997) or turkeys (Sisson and Speake 1994) from the standpoint of altering their movements. In fact, lightning season fires apparently provide patches of recently burned habitats that attract turkeys and quail, perhaps because arthropods are more available in these areas. Additionally, such fires may provide more open ground which results in increased access to food and easier travel. Further research on effects of lightning-season fire on demography, reproduction and survival of ground-nesting birds will be required to gain a long-term assessment of the tradeoffs between dormant- and lightning-season fire effects.

Effects on songbirds. Ongoing results from field experiments in Florida and North Carolina have yet to demonstrate differences with respect to avian populations on plots burned during the dormant versus lightning season (Engstrom et al. 1996) (Table 2). Potential, long-term effects of dormant- versus lightning-season fire applications will be assessed at the North Carolina Sandhills site over the next six to seven years.

Table 2. Average numbers of bird territories and nesting success on dormant- and lightning-season burned plots in the Sandhills region of North Carolina, 1996, 1997. For list of species, see Engstrom et al. (1996).

		Type of fire application			
		Dormant season		Lightning season	
Location	Year	Number of territories	Percentage nest success	Number of territories	Percentage nest success
Sandhills Gamelands	1996	26.5	66.0	29.0	62.5
	1997	20.0	53.0	23.0	58.5
Fort Bragg	1996	37.5	75.0	30.5	67.5
	1997	30.0	63.5	26.5	71.5
Averages		28.5	64.7	27.3	65.0

Can Herbicides Substitute for Fire?

In the simplest sense, fires oxidize vegetation. However, fire provides myriad other ecosystem services such as releasing nutrients, scarification of seeds for germination, and fertilization from ash and carbon. Fires reduce understory litter, which results in more sunlight on the ground and, thus, opportunities for many grasses and forbs to thrive where soil temperature and moisture conditions are changed in their favor. Like fire, herbicides also eliminate vegetation. However, many of the other ecosystem services provided by fire are lacking from herbicide applications.

Use of herbicides for silvicultural applications (primarily to control competing vegetation and to favor planted pine) has greatly increased during the past several decades. One outgrowth of the dramatic increase in herbicides for forest management, especially in the South, is that these chemicals are being perceived as an adequate substitute for prescribed fire. The rationale is that they eliminate undesirable and/or competing vegetation, *just like fire.* People often argue that the only difference between herbicides and fire is herbicides take a little longer than fire to work. However, this view is naive and shortsighted, given the other ecosystem services provided by fire. Still, herbicides remain popular, and their use will continue to increase. Factors such as smoke management (Ottmar et al. 1996) have also caused herbicides to become an attractive alternative to fire for forest management objectives.

In our view, the direct substitution of herbicides for prescribed fire in the context of wildlife management is ill-informed and perhaps even dangerous when it comes to endangered species management. For example, in mixed-pine forests of eastcentral Mississippi which are occupied by the endangered red-cockaded woodpecker, the use of herbicides to reduce invasive hardwoods (with applications of fire approximately every five to seven years) resulted in only limited habitat improvement for the woodpecker. In contrast, frequent (about every two to three years) applications of prescribed fire (following hardwood midstory removal via logging) resulted in improved habitat for the woodpecker, as well as a positive population response from more than 12 other species of terrestrial vertebrates (Brennan et al. 1995). Recent work by Burger et al. (in press) provides substantial evidence that a suite of regionally declining grassland birds benefit from an enhanced fire regime associated with red-cockaded woodpecker habitat management.

Herbicides can be used for managing wildlife habitats. Compounds that selectively eliminate invasive, woody species, while maintaining pines and native legumes, have the potential for long-term (10 to 15 years) control in situations where managers struggle to control invasive hardwoods. However, we believe the greatest benefits to be derived from herbicides for managing wildlife

habitats in southern pine forests occur when such chemicals are used in conjunction *with* prescribed fire, rather than *instead of* fire.

Fire and Management for Natural Diversity

Management for biological diversity, especially in the context of ecosystem management, has emerged as a dominant resource management theme during the last five years. There are numerous ways that management for "diversity" can be co-opted and twisted to meet virtually any management objective. For example, a weedy field dominated by 15 exotic, invasive species of plants is more diverse than a patch of natural forest that contains only 10 species. Clearly, the concept of diversity does not always equate to one of desirability. Hence, any consideration of diversity must be addressed in the context of desired future conditions, native versus exotic species and, ultimately, improved land use and stewardship.

Management for Game Versus Management for Diversity

Although contemporary application of prescribed burns generally is accepted in the context of game management today (especially for quail and wild turkey), the fire agenda reaches far beyond traditional game habitat management. Today, prescribed fire professionals seem to be split into two camps: those with an agenda related to game management, and those with an agenda related to biodiversity objectives. Although dialogue between these two groups has been limited, enhanced communication may produce significant benefits. For example, frequent applications of prescribed fire for quail management has resulted in the maintenance of significant populations of red-cockaded woodpeckers on private lands in Florida and Georgia (Landers et al. 1989). On some public lands in Mississippi, use of fire for red-cockaded woodpecker habitat management resulted in improved habitat conditions for bobwhite (Brennan et al. 1995). Conversely, frequent burning for quail results in high-quality habitat for dozens of threatened and endangered species (Landers et al. 1989, Block et al. 1995). The point here is that while management goals may differ, resource and ecological managers must cooperate to obtain the greatest, positive impacts from applications of fire and understand how nontarget resources are affected (Landers et al. 1989, Hunter 1990).

Future Landscapes of the South: Pockets of Fire in an Unburned Landscape

Trends in prescribed burns: State perspectives. Data from the past decade show that applications of prescribed fire have remained more or less stable across six southern states (Figure 1). However, the total amount of land managed with prescribed fire remains relatively small, compared with the total land

base in the Southeast. For example, only Georgia and Florida have had years where more than a million acres (about 2.6 percent of the land area in each state) were burned by prescription. In states such as Mississippi or the Carolinas, only about 0.3 percent of the total land area is burned annually. Furthermore, approximately 35 to 60 percent of these applications of prescribed fire were for hazard reduction or silvicultural objectives rather than for wildlife habitat management.

Implications of current trends. Because relatively little land is currently managed with prescribed fire in the Southeast, we need more use of fire on the landscape scale. What we will probably see during the next few decades is more use of fire on public lands and a continuing reduction in fire use on private lands. For example, the USDA Forest Service has made increasing applications of prescribed fire one of their highest management priorities at the national level. In contrast, some large industrial forestland owners have reduced or eliminated the use of fire, based on the belief that herbicides are much more appropriate than fire for maximizing tree growth and economic returns. The nonindustrial private landowner is caught somewhere in the middle of this continuum. Several states (most notably Alabama, Florida and Georgia) have implemented "right-to-burn" legislation designed to protect the private landowner from liability when they apply fire responsibly and within permitted prescription parameters. However, there are few incentives and many disincentives for use of fire by small, nonindustrial private landowners, who are often discouraged from using fire because of smoke management concerns (National Research Council 1976, Ottmar et al. 1996) and other liability issues. Additionally, a proposed reduction in allowable sizes of particulate matter (U.S. Environmental Protection Agency 1997) could result in a major resource policy conflict between the Clean Air Act and the Endangered Species Act if allowances are not made for prescribed fire.

Thus, when taken as a whole, we predict that the southern landscape of the foreseeable future will continue to evolve in the following direction. There will be pockets of public land that will be subjected to relatively frequent applications of fire. These lands will be distributed throughout a broader matrix of private lands (both industrial and nonindustrial) that will increasingly be fire excluded. From the standpoint of wildlife populations and communities, the frequently burned public lands will most likely serve as limited refugia for species that require open, park-like upland pine habitats. It remains to be seen whether the frequently burned patches of public lands will be sufficient to provide the area required to keep species with such habitat requirements from declining or becoming extinct. In any event, this broad-scale land use experiment has begun and will continue well into the next century. We hope managers and researchers will learn from this experiment as it develops.

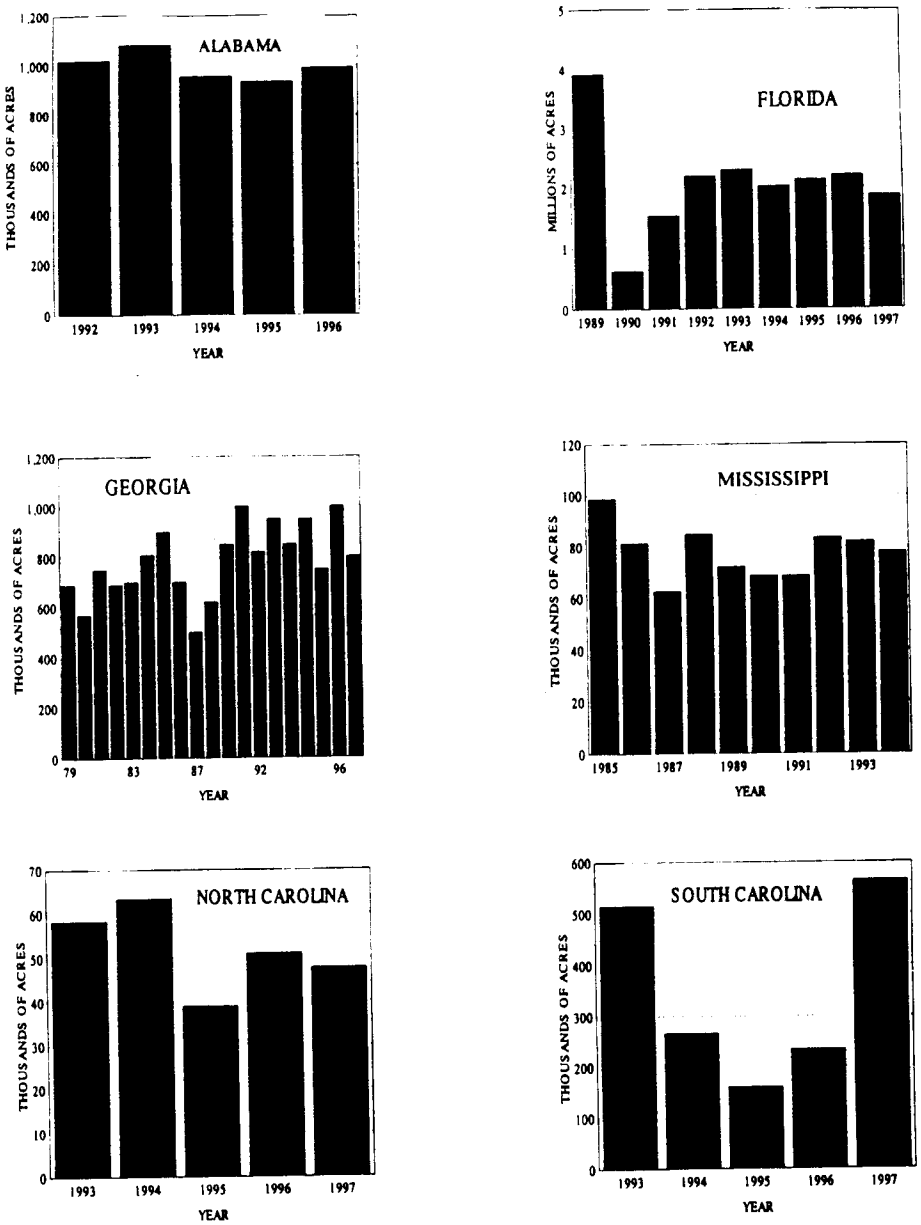

Figure 1. Acres of prescribed burns in six southeastern states during recent years. Data provided by Alabama Forestry Commission; Florida Division of Forestry; Georgia Forestry Commission; Mississippi Forestry Commission; North Carolina Department of Environment, Health, and Natural Resources; and South Carolina Forestry Commission.

Whither Wildlife Without Fire?

To modify a biblical perspective (with apologies to Ruth 1:16), it is safe to say that "Whither fire goest, wildlife will go ...." Drastically reducing fire on the southern landscape has resulted in the decline and loss of many wildlife species that we not only find highly desirable, but are also central to our natural heritage. We are presently witnessing broad-scale declines in many species that require open, park-like pine forests because frequent fire and the forest structure maintained by frequent fire are being lost.

There is no substitute for fire as a forest management tool for wildlife. Herbicides and mechanical methods of removing vegetation are poor or marginal substitutes for fire, although these methods may be useful when applied in conjunction with fire. Results emerging from seasonal fire experiments suggest that effects of dormant- versus lightning-season fire applications are relatively subtle, especially when compared with fire suppression. Although initially counterintuitive, it can be argued logically that fire is not a disturbance, *per se,* but rather a necessary process for the proper management of southern forests for wildlife. The elimination of fire is actually more of a disturbance (and hence, a real catastrophe) than the actual effects of the fire itself (Landers et al. 1989).

Acknowledgments

We thank the following people and agencies for the support required to collect the information presented in this paper: Kate Ireland, Leigh Perkins and Walter Sedgwick—Red Hills Plantation Owners; Brian Millsap—Florida Game and Fresh Water Fish Commission, Nongame Wildlife Program; Alan Shultz and Erich Hoffman—Fort Bragg Army Base; and Terry Sharpe—North Carolina Wildlife Resources Commission. We also thank Ann Bruce for compiling prescribed fire data from various southern states.

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