Burning for Birds: Concepts and Applications

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Abstract.—Prescribed fire is being used extensively for habitat management of non-game birds, although the area burned today is small relative to the amount of land that burned historically. Results of a non-scientific questionnaire of public and private land managers in the eastern U.S. revealed prescribed fire is being used to provide winter, breeding season, and migration habitat for at least 57 species of birds in 29 states. Increasingly sophisticated application of fire will be necessary to manage habitat for diverse bird species and other organisms. Contemporary training courses on the use of prescribed fire typically divide ecological effects of fire on animals into two categories: direct effects alter the animals' physical condition and indirect effects are mainly associated with changes in habitat. The envirogram, a conceptual tool developed by Andrewartha and Birch (1984) within their theory of the environment, can be used to diagram multiple direct and indirect effects of fire on bird species. Variables of prescribed fire (i.e., ignition pattern, season, frequency, etc.) can be matched within the envirogram to achieve the desired management objectives for individual species. We used a modified envirogram to examine how prescribed fire is used in intensive management for the northern bobwhite (*Colinus virginianus*) within the Red Hills of north Florida and south Georgia. A coarse-grained approach to management involving multiple species or an ecosystem may be more efficient and sustainable than emphasis on a single species.

Introduction

Extensive use of fire to manipulate vegetation by Indians disappeared from eastern North America centuries ago, and natural fires (e.g., lightning-started) have been reduced in the eastern United States by habitat fragmentation, fire suppression, and alteration of vegetation composition. Wildfires can be widespread during times of prolonged drought—nearly one-half million acres were burned in 2282 wildfires from 1 June to 22 July 1998 in Florida (Lewis 1998)—but these wildfires may behave very differently from natural fires because of long periods of fire suppression. It is probably not a coincidence that both the use of fire as a management tool (Pyne 1982) and populations of bird species that require habitat that is in early stages of vegetation succession (Askins 1999) declined in the 20th century. Current uses of prescribed fire can only be considered a limited stabilization or reversal of that trend.

Fire plays a critical role in ecosystem management as an ecological process in many vegetation types in the United States (Smith 2000). Fire has been long been recognized as an essential disturbance in some ecosystems, such as longleaf pine (*Pinus palustris*) woodlands, which require a relatively high fire frequency to suppress competing hardwoods and maintain an open forest structure that fosters pine regeneration. The endangered red-cockaded woodpecker (*Picoides borealis*) depends on pine forest structure and composition that are shaped by frequent fire. In other ecosystems, such as oak woodlands, savannahs, and barrens in the central hardwoods region (Anderson and others 1999; Yaussy 2000), acceptance of the role of fire continues to grow. The finer points of prescribed fire will play an increasingly important role in the success of natural resource management as wildlands are reduced and multiple management objectives increase.

Prescribed fire is pervasive in the growing emphasis of modeling vegetation manipulations on natural disturbances within the context of ecosystem management (White and others 1999; Engstrom and others 1999). According to a recent review, ecosystem management is "…management driven by goals, executed by policies, protocols, and practices, and made adaptable by monitoring and research based on our best understanding of the ecological interactions, and processes necessary to sustain ecosystem composition, structure, and function" (Christensen and others 1996). In this definition, sustainability of resources is a precondition of management for production. Maintenance of viable populations of animals (e.g., game or endangered species) is one of many natural resource goals that must be balanced within the ecosystem management framework by a broader "ecosystem composition, structure, and function." From this perspective, understanding the ecological relations of a single species is a critical element of ecosystem management within the constraints of ecosystem sustainability.

In this paper we (1) summarize the results of a survey to better understand the extent and nature of prescribed fire applications to non-game bird management; (2) examine the ecological basis for use of prescribed fire to manage bird populations; and (3) examine application of prescribed fire within the context of management for a single-species, the northern bobwhite (*Colinus virginianus*) within the Red Hills.

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Use of Prescribed Fire for Bird Management un the Eastern U.S.: Survey Results

In the statement of purpose of this symposium, it was stated "...with the exception of a few high-profile threatened or endangered species, the use of prescribed burning solely for nongame species or communities has been a rare occurrence." The dependence of some threatened and endangered bird species (e.g., red-cockaded woodpecker) on fire-maintained habitats is well-established (James and others 1997). To obtain a baseline evaluation of the current uses of prescribed fire in relation to populations and communities of birds in general, we surveyed 97 organizations that we thought to be prescribed fire practitioners. We distributed our survey electronically to contacts in the U.S. Fish and Wildlife Service, USDA Forest Service, National Park Service, state agencies (i.e., Forestry/Fire Protection, Wildlife, and Natural Heritage/Endangered Species programs), and The Nature Conservancy in 29 eastern states. Fifty-eight of a total of 60 responses stated that they burned property they manage, and, of these, 42 (72%) of the respondents stated that they burned specifically to provide habitat for birds (Brownlie and Engstrom 2001).

Fifty-seven bird species in 22 families (77% were nongame species) were identified by respondents as species that benefit from land management with prescribed fire. (See Brownlie and Engstrom 2001 for a complete list of species). Predictably, grassland birds, such as the emberizid sparrows, were well-represented and comprised 23% of the total; prescribed fire was also used for management of gamebirds, such as quail, dove, and ducks. Although our assessment of birds that are managed with fire is general, it indicates that prescribed fire is being used extensively for game and nongame birds, not just threatened and endangered species and that prescribed fire for management of avian habitat is being applied in a wide variety of vegetation types throughout the eastern United States. The diversity of habitats that are being burned for a diversity of bird species implies that many techniques of prescribed fire are being used.

Concepts

Ecology provides the scientific foundation of ecosystem management. One of the concepts critical to an ecological understanding of the relationship between birds and fire is plant succession. Christensen (1988) developed a model of succession that involved four phases: establishment, thinning, transition, and steady state. In establishment, seedlings grow rapidly. In the second phase, plants thin out during a period of intense inter- and intra-specific competition. The third phase involves gaps created in the canopy and initiation of small-scale recruitment. In the last phase, the plant community reaches a steady state in which establishment, thinning, and gap formation occur in a mosaic of patches. The scale and type of disturbances influence the size and nature of plant response to the patches. It is important to note that disturbance is implicit in natural plant community development. The stability of the "steady-state" is dependent on a variety of factors. Alteration of the disturbance regime or plant community composition (e.g., invasion of exotics) can disrupt community equilibrium and potentially shift the community into a new steady state (Wiens 1997).

Making theory relevant to managers is a substantial challenge to ecologists and requires a constant search for techniques that provide an interface between the two disciplines: science and management (Rodgers 1997). We use a simple conceptual technique, the envirogram (Andrewartha and Birch 1984), as such an interface to review some of the concepts that are essential for an ecological understanding of the relationship between fire and birds that is necessary for ecosystem management.

Effects of fire on animals are frequently classified as relatively short-term and direct (mortality or movement) or long-term and indirect via plant succession and alteration of vegetation structure (Smith 2000). This simple dichotomy is expanded within the envirogram (Figure 1; Andrewartha and Birch 1984). The envirogram is composed of three parts: the focal organism, the centrum (direct effects), and the web (indirect effects). The ability of the focal organism to survive and reproduce is influenced by four components of the centrum—resources, mates, predators, and malentities. The direct effects within the centrum are affected by environmental influences within the web that have increasingly less direct influence on the organism of interest. Fire plays multiple positive and negative roles within the centrum and the web for different organisms. For birds, fire can be within the centrum as a malentity, because it can kill an organism. At the same time, fire can be used to improve the structure of the habitat over a longer period.

In our envirogram, we match characteristics of prescribed fire with aspects of the environment that affect an animals' ability to survive and reproduce (Figure 1). Fire can be prescribed to increase or decrease its effect as a malentity by manipulating method of application and season. Season and severity can be altered to influence availability of food and nesting substrate. Area of burned acres on a landscape scale will play an important role in creating or eliminating habitat that will affect characteristics of the metapopulation of the species of interest. Patchiness of a burn locally may change the suitability of an area by altering shelter from predators and proximate sources of food.

James and others (1997) used the envirogram as a graphical technique to summarize the life history of the red-cockaded woodpecker. In their envirogram, fire

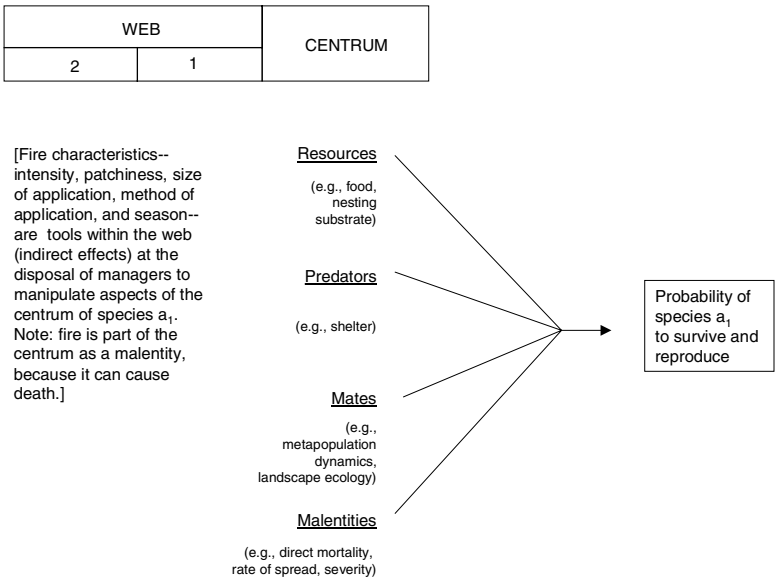

Figure 1.—Modification of a generalized Andrewartha and Birch (1984) envirogram to represent the various aspects of prescribed fire that indirectly and directly affect the ability of a bird species to survive and reproduce. Given the characteristics of an avian population of management interest prior to use of prescribed fire, a manager can match ecological characteristics of a bird species with the prescribed fire objectives.

played an indirect role in the amount of foraging habitat (a resource) through the effects on the abundance and distribution of hardwoods that compete with pines. They also hypothesized that fire might play a role in nutrient availability and population levels of cavity competitors. Their research indicated that frequency and season of fire were critical indirect influences on measures of productivity of the woodpecker, although they could not identify the exact causes of the relationship. We used the envirogram for another bird species that is managed intensively, the northern bobwhite.

Birds and Prescribed Fire in the Red Hills Landscape

The Red Hills physiographic region between Tallahassee, Florida, and Thomasville, Georgia, includes approximately 100 privately owned parcels in 310,000 acres of land that are managed for hunting (C. Ambrose pers. comm.). White-tailed deer (*Odocoileus virginianus*), mourning dove (*Zenaida macroura*), and ducks, primarily wood duck (*Aix sponsa*) and ring-necked duck (*Athya collaris*), are hunted, but northern bobwhite (*Colinus virginianus*) is the raison d'être for the hunting estates. Management for populations of bobwhite in the Red Hills plays a notable chapter in the development of prescribed fire as a management tool through the contributions of Herbert L. Stoddard, Ed and Roy Komarek, and Tall Timbers Research Station (Pyne 1982; Johnson and Hale, this volume).

Approximately 90 to 100 bird species are resident, breed, or overwinter throughout longleaf pine woodlands (Engstrom 1993). Depending on ground cover characteristics, approximately one third of the bird species, including the northern bobwhite, may nest and forage on or near the ground in longleaf pine woodlands (Engstrom 1993). These ground-nesting and ground-foraging species are presumably the species that are most directly affected by fire. Many of the bird species of the longleaf pine ecosystem are also common in old-field pinelands, which are structural analogues of longleaf pine woodlands (Engstrom et al. 1984), although a detailed comparison has never been made. Three species with affinities for open pine woodlands—the northern bobwhite, Bachman's sparrow (*Aimophila aestivalis*), and red-cockaded woodpecker—disappeared from an open oldfield pine woodland in northern Florida (NB66, a 22-acre study area on Tall Timbers Research Station) within 4 to 15 years after fire exclusion (Figure 2). This plot is now a closed canopy mixed hardwood-pine woodland with little ground-cover vegetation.

Based on evidence from existing remnant uncultivated tracts, pre-settlement upland vegetation on the hunting estates was likely an open-structured woodland dominated by longleaf pine with scattered species of other southern pines and fire-resistant hardwoods (e.g., *Quercus*, *Carya*) with a species-rich understory (Platt et al. 1988). Ground cover plant species richness in mesic longleaf pine woodlands at a 1000 m^2 scale is among the largest values reported in the temperate Western Hemisphere (Peet and Allard 1993). Some parts of the Red Hills, particularly in Florida, were converted to agriculture in the first half, and turned fallow in the latter half, of the 19th century (Paisley 1989). Agriculture eliminated much of the longleaf pine and some of the pyrogenic ground cover plants (e.g., wiregrass [*Aristida stricta*]) on many of these old-field sites. Loblolly (*P. taeda*) and shortleaf (*P. echinata*) pines frequently replaced longleaf as overstory dominants.

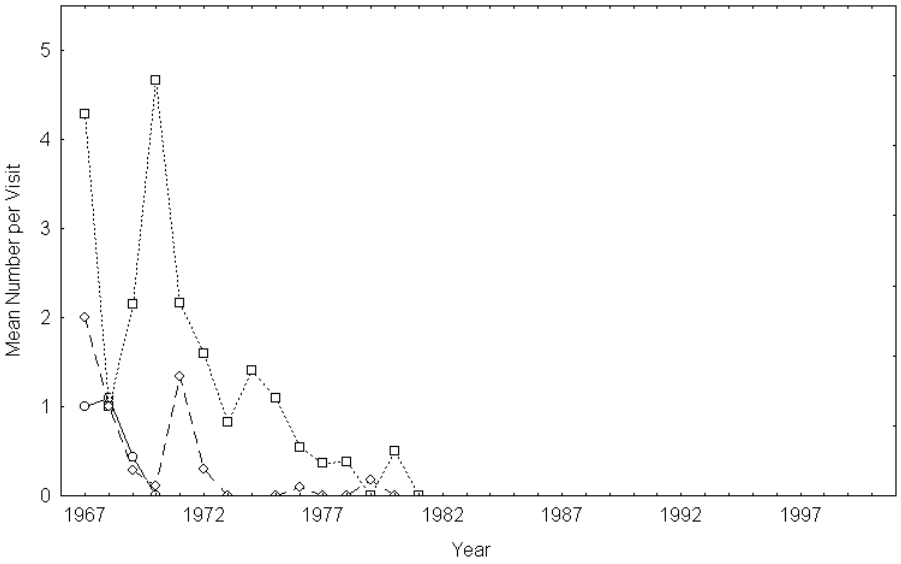

Figure 2.—Changes in abundance of northern bobwhite (dotted), red-cockaded woodpecker (dashed), and Bachman's sparrow (solid) in an oldfield pine woodland over a 15-year period in response to fire exclusion (adapted from Engstrom et al. 1984).

Typical historical fire behavior within longleaf pine woodlands is believed to have been frequent (1 to 3 year fire intervals) and low intensity that rarely killed mature trees (Myers 1990). These fires reduced aboveground herbaceous vegetation biomass to ash and killed or topkilled most hardwood stems. Grasses and forbs readily resprout after these low intensity fires. The season of natural fires, based on lightning-started fires, is strikingly different from the seasonal application of prescribed fire for management of northern bobwhite populations on the hunting estates (Figure 3). Prescribed fires on the hunting estates are typically initiated immediately after the end of quail hunting season in late-February , March, or early April, whereas lightning-started fires occurred most frequently in May or June (Komarek 1968; Brennan and others 1995). The choice of season for prescribed fire in the Red Hills is based on the desire to avoid burning during the hunting season, minimize loss of quail nests to fire, take advantage of dry vegetation and relatively cooler, drier weather, and prepare for timber management activities. Many of the prescribed fires in the Red Hills are small to intermediate scale (10 to 200 acres) although sometimes as much as 1000 acres may be burned on a single land ownership in a day. Landscape patterns of Red Hills prescribed fire is typically controlled by using roads or plowed lanes as firebreaks. Fires are mostly conducted during the daytime (especially in Florida) under low humidity, and light wind conditions, but nighttime fire is permitted in Georgia. These occasional nighttime fires often result in patchy low-severity burns. Flanking, backing, and head fires are used depending on the objectives of the managers. Ignition is typically with a drip torch along roads from a truck or ATV (all-terrain vehicle). Fire permits are required and are issued on a daily basis by state (Florida and Georgia) forestry departments.

Prescribed fire is used extensively to manage habitat to produce high populations of northern bobwhite in the Red Hills landscape in southern Georgia and northern Florida. A modified envirogram reveals how fire directly and indirectly influences northern bobwhite fitness (Figure 4). This envirogram only includes factors that are associated with fire. For example, the effects of fire on mate availability are unclear and therefore left blank. Resources in the centrum of the bobwhite envirogram that are influenced by fire are mainly foods: seeds, leaves and insects. Soil disturbance (harrowing) in food plots and agricultural fields and fire are used to manage the composition and structure of vegetation. Soil disturbance creates suitable substrate for weedy plant species that provide the preferred foods of quail. Woody species tend to suppress grasses (Wilson 1998). Fire frequently kills hardwood saplings or aboveground stems that would radically alter the structure and composition of the ground cover plant community, particularly the grasses. Fire frequency, severity, and season affect vegetation composition and age, which are important for herbaceous insects that are food for young bobwhite quail. Various hawks (e.g., *Accipiter* and *Buteo*) are predators of bobwhite and the bobwhite requires brush for escape cover. Patchiness of burn, although difficult to obtain predictably, could provide essential cover. The season for fire also might have a strong affect on visibility of quail to hawk predators. Eliminating cover by fire during hawk migration in the spring, when numbers of hawks are at their peak, could increase predation by hawks. On the other hand, delaying burning until later in the spring to minimize predation by migratory hawks creates the potential of increasing the loss of bobwhite nests directly to fire. The relative importance of loss of some adults to predation to loss of nests to fire to bobwhite fitness should inform management on the preferred season of fire.

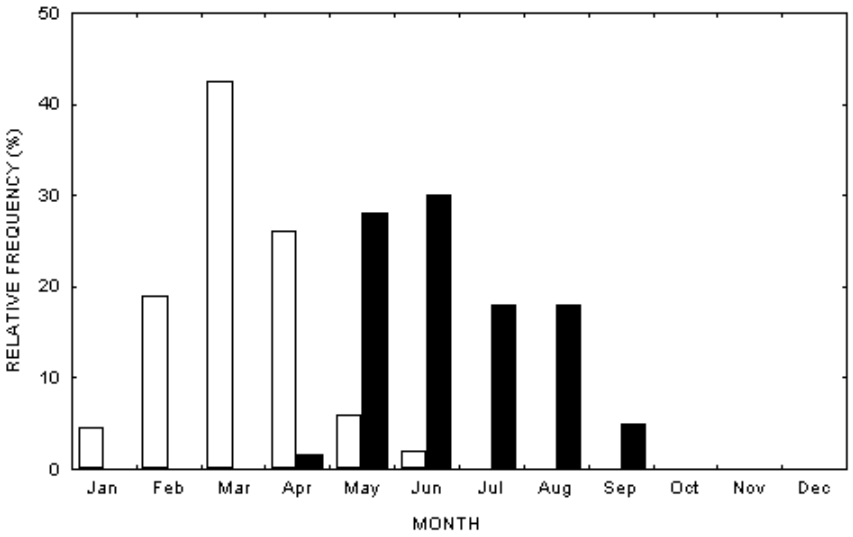

Figure 3.—Frequencies of fires started by lightning (solid bars) and prescribed fires initiated for northern bobwhite management (open bars) in the Red Hills region of north Florida and south Georgia (adapted from Brennan and others 1995 with permission).

Examination of this envirogram reveal some potential difficulties in the long-term use of fire within the framework of short-term maximization of bobwhite numbers, particularly in the interaction between soil disturbance, vegetation composition, and fire. Soil disturbance—depending on its scale and intensity—may cause the loss of native, pyrogenic grasses and forbs, particularly wiregrass in the Red Hills. Creation of food plots, small agricultural fields, and harrowing have the simultaneous effects of generating preferred foods of the bobwhite and eliminating the ground cover plant species that are best adapted to carry fire. The grasses and forbs that replace the pyrogenic species apparently are less able to compete with invasive hardwoods. The scale and severity of soil disturbance are likely to be influential in ground cover plant species recovery.

The tradeoffs between intensive management for the bobwhite and pyrogenic ground cover emerge in the direct and indirect effects of the environment on bobwhite fitness (Figure 4) and can also be seen within the framework of coarse and fine filters (Agee 1999). Management for short-term increases in bobwhite numbers (fine filter) through soil disturbance alters the ground cover composition that best supports prescribed fire. Impairing the competitive balance between grasses and woody plants through harrowing or plowing will ultimately limit the effectiveness of prescribed fire as the principal form of disturbance within the ecosystem. A coarse-filter approach in which the natural ground cover composition is left undisturbed (e.g., retention of wiregrass) and, to a lesser extent, the season of fire is shifted to the growing season within the Red Hills may be necessary to prevent ecosystem instability and potentially loss of ecosystem composition and function.

Conclusions

Use of prescribed fire has been challenged for reasons of public health and safety. Challenges have also emerged for ecological reasons, because fire has positive or negative effects on different species (e.g., long-distance migratory songbirds vs. red-cockaded woodpecker or rare butterflies vs. grassland birds). These potential sources of conflict will require increasingly sophisticated use of prescribed fire to achieve multiple ecological objectives. The tools at the disposal of the manager who employs fire (severity, season, size, etc.) need to be matched carefully with our best knowledge of the environmental influences of one or more species of interest.

- One current framework for understanding the effects of fire on birds (see Smith 2000) follows the theory of the environment developed by Andrewartha and Birch (1983). The envirogram is a useful graphical technique that captures the multiple direct and indirect effects of fire—both positive and negative—in the life history of an organism.

- The envirogram is a single-species approach that could be used in multi-species conservation planning by selecting indicator species and examining the location and nature of fire within those envirograms. The complexity of managing for multiple species suggests that a coarse-grained approach may be necessary for long-term sustainability.

- The longleaf pine ecosystem is largely a grassland that has largely been eliminated and degraded. Fire exclusion has dramatic effects on the avian communities of longleaf pine woodlands, and groundcover disturbance, habitat fragmentation, and ecotone disruption have more subtle, long-term effects on birds. Within relatively intact longleaf pine forests, the frequency, season, ignition pattern, and intensity of fire can be manipulated to obtain the desired structure and function.

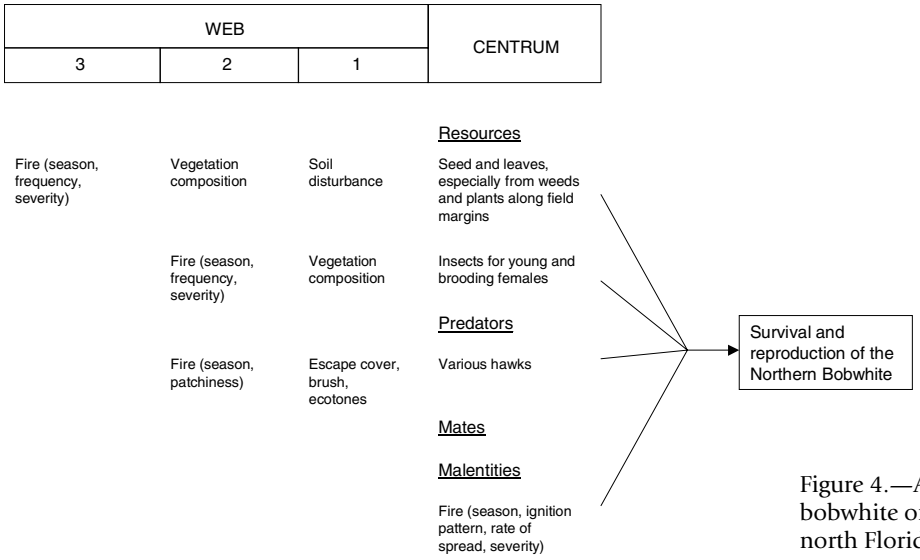

Figure 4.—An abbreviated envirogram for the northern bobwhite on hunting estates in the Red Hills region of north Florida and south Georgia that includes all occurrences of fire in the web and centrum.

Acknowledgments

W. Wilson Baker and Robert Crawford collected the data for the study of NB66.

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