Spatial response of American black bears to prescribed fire in northwest Florida

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Abstract: Little is known about the effects of prescribed burning on American black bears (*Ursus americanus*) in the Southeastern Coastal Plain. In Florida, Eglin Air Force Base is home to 1 of 8 relatively disjunct populations of black bears (*U. a. floridanus*) in the state. Prescribed burning has been used on Eglin since the late 1980s to reduce the dense oak (*Quercus* spp.) midstory that occupies the longleaf pine (*Pinus palustris*)–wiregrass (*Aristida beyrichiana*) community. We studied black bear habitat use during 1994–96 to determine if temporal and spatial relationships existed between prescribed fire and black bear habitat use from 9 years of burning data. Within all habitat types, our results showed that black bears used unburned areas more than burned areas, both annually and seasonally. Among burned areas, black bear use was greatest in 3- and ≥5-year-old burns, both annually and seasonally, for most habitat types. Our results are consistent with published reports on timing of peak soft mast production following prescribed fire, and we conclude that higher use of particular burn ages was related to production of several soft-mast species. We suggest that longer burning cycles be applied within and adjacent to important habitats, like riparian zones, in the Southeastern Coastal Plain. Planning for juxtaposition of various successional post-fire stages is the best approach for managing habitats to maintain cover and availability of primary bear foods and effectively minimize the area needed to satisfy the needs of black bears.

Key words: age class, American black bear, burns, compositional analysis, Florida, habitat, oaks, prescribed fire, riparian zones, soft mast, *Ursus americanus floridanus*

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Fire is a natural ecological force in the Southeastern Coastal Plain of the United States. From before the days of European settlement until the mid-1920s, forests were frequently burned to provide palatable forage for wildlife and livestock, and to reduce fuel loads (Kalisz et al. 1986, McWhite et al. 1993, Earley 2004). Whether from natural origin (lightning) or human-induced, fire — or lack thereof — has played a significant role in developing the landscape in this region. Today, resource agencies use prescribed fire as a management tool to accomplish a wide range of objectives including fuel hazard reduction, site preparation for revegetation, and increasing quality and quantity of forage.

In the early 1900s, much of the forested landscape in northwest Florida was dominated by longleaf pine (*Pinus palustris*; Frost et al. 1986, Schwartz 1994), and most of these forests were being worked for naval stores and subsequently logged. As this resource became exhausted and the industry declined in the late 1920s, management emphasis shifted to timber production. This management shift prompted the US Forest Service to implement fire control practices on all forests in public domain in 1927 (McWhite et al. 1993). Over the next 60 years, fire was a limited component of the landscape, and because pines were selectively logged during this time, hardwood trees were allowed to invade and dominate former pine stands (McCormack 1950, Kautz 1993, McWhite et al. 1993).

On Eglin Air Force Base (AFB) in northwest Florida, oak (*Quercus* spp.) encroachment fueled by fire control practices continued until the late 1980s, when prescribed fire was reintroduced in the sandhills (McWhite et al. 1993). Since then, prescribed fire has been used to restore longleaf pine (*Pinus palustris*) sandhill communities to a perceived natural state and to improve quality habitat for the endangered red-cockaded woodpecker (*Picoides borealis*) by reducing or eliminating the hardwood

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midstory (McWhite et al. 1993, Provencher et al. 1996). Prescribed fire rotations generally followed a 1–3 year cycle in pine-dominated areas and from 1988 to 1995, an average of 12,000 ha (range 4,000–15,000) were burned annually.

On Eglin AFB, prescribed fires were generally concentrated in upland habitats using the extensive network of roads and streams as natural fire breaks. Dissecting upland habitats were numerous small riparian corridors (<50 m) that were routinely burned even though adjacent uplands were the primary target. However, these narrow riparian zones constituted a large portion of the primary habitat used by black bears (*Ursus americanus*) on Eglin, both annually and seasonally (Stratman et al. 2001). Stratman et al. (2001) discussed the importance of these riparian zones for providing food, thermal relief, denning habitat, and travel corridors by enabling black bears to move to seasonal feeding areas while remaining near escape cover. Stratman and Pelton (1999) found that in the absence of palm fruit (*Serenoa repens*) during fall, acorns were the primary food source for black bears on Eglin. During years of saw palmetto (*Serenoa repens*) crop failures, bears made extensive seasonal movements (15–30 km) during fall in search of mature oak stands. Their dependence on acorns as an alternative fall food source is important for survival of the black bear on Eglin and elsewhere (Hellgren and Vaughan 1988, Wooding and Hardisky 1994, Brandenburg 1996, Stratman and Pelton 1999). The frequent burning regime within critical bear habitat and large-scale suppression of mast producing oaks in upland habitat has raised concerns about the effect of this management practice on the black bear population on Eglin AFB and vicinity.

Wildfires and prescribed burning can benefit a variety of wildlife, including bears (Zager et al. 1983, Young and Beecham 1986, Hamer and Herrero 1987, Costello and Sage 1994). However, studies on response of black bears to intensive annual burning are uncommon. Therefore, we initiated a more thorough examination of the effects of this management activity on black bears. Our objectives were to determine if prescribed fire influenced spatial and temporal habitat use by black bears, both annually and seasonally, by determining (1) level of use of different burn ages in relation to other habitat types within bear home ranges, (2) if bears used different burn ages disproportionately within their home range, and (3) bear use of different burn ages relative to unburned areas within each habitat.

Study area

Eglin AFB (1,875 km^2) is bounded by private land to the north and east and the Gulf of Mexico to the south and west. It is characterized by rolling hills dissected by numerous seepage streams. The Florida Natural Areas Inventory (FNAI) documented 35 natural communities on Eglin AFB (Provencher et al. 1996). The longleaf pine–wiregrass sandhills on Eglin represent the largest acreage of this natural community known to occur under a single ownership (Nature Conservancy 1995). Seventy-two percent of Eglin AFB was comprised of sandhills and pine production areas. Many of these areas contained a dense oak midstory and understory of shrubs, vines, and saw palmetto. Dominant tree species included longleaf pine, slash pine (*P. elliottii*), sand pine (*P. clausa*), turkey oak (*Q. laevis*), laurel oak (*Q. hemisphaerica*), and sand live oak (*Q. geminata*). Twelve percent of the land has been cleared for airfields, test ranges, rights-of-way, and administrative areas. Test ranges were maintained as open grass. The remaining areas were comprised of wetland and riparian habitats. Dominant tree species in those habitats included slash pine, redbay (*Persea borbonia*), magnolias (*Magnolia* spp.), bald cypress (*Taxodium distichum*), and several mid-story and understory shrubs including titi (*Cyrilla racemiflora*) and fetterbush (*Lyonia lucida*).

Eglin AFB experienced 2 dry periods from April–May and mid-September through November. Until the mid-1980s, about 70% of wildfires were caused by military activity, while lightning and human carelessness accounted for 10% and 20%, respectively. Most military-induced fires originated on test ranges and spread to adjacent timbered areas. Consequently, areas adjacent to test ranges have a characteristically open midstory which approximates the composition and structure of the natural longleaf pine sandhills (McWhite et al. 1993). During 1983–1992, the average number of wildfires was 230/year (range 116–381), which burned an average 1,902 ha (range 1,157–4,540) annually.

Methods

Trapping and handling

We trapped black bears with spring-activated foot snares and immobilized them with a mixture of ketamine hydrochloride (8.81 mg/kg; Bristol Laboratories, Syracuse, New York, USA), xylazine hydrochloride (4.41 mg/kg; Haver-Lockhart, Inc., Shawnee, Kansas, USA), and mepivicaine hydrochloride (0.88 mg/kg; Winthrop Laboratories, New York, New York, USA). The drug was administered with a pole syringe or carbon dioxide-powered dart pistol at a dosage of 1 ml/22.7 kg of estimated body mass. We fitted all captured bears with radiocollars (Telonics, Inc., Mesa, Arizona, USA). All trapping and handling activities were in accordance with approved University of Tennessee Animal Care and Use Protocols.

Radiotelemetry

We determined locations of radiotagged bears using triangulation techniques with 5-element, vehicular roof-mounted antennas (Wildlife Materials, Inc., Carbondale, Illinois, USA) using the loudest signal method (Mech 1983). Telemetry stations were established at known locations that could be accurately identified on 1:24,000 US Geological Survey topographic maps. We plotted each station and assigned an identification number and universal transverse Mercator coordinates.

We obtained $\geq$2 azimuths to estimate bear locations. We selected azimuths based on the following criteria: (1) angles between all azimuths had to be 60–120°, and (2) time intervals between all azimuths had to be $\leq$20 minutes. We located individual bears 2–5 times/week. We also obtained hourly locations on 8 individual bears during 24-hour tracking periods conducted 1–2 times during summer and fall seasons (Stratman 1998). We collected radiolocations from November 1994 through October 1996. We used the software program TELEM 88 (Coleman and Jones 1988) to generate animal location coordinates from azimuth and telemetry station data. We combined locations for all years and used the adaptive kernel method (Worton 1989) with the software program CALHOME (Kie et al. 1994) to estimate seasonal and annual home ranges of bears. We determined the minimum number of radiolocations needed to estimate bear home ranges by plotting home range size against the number of locations for 95% adaptive kernel estimates (van Manen 1994, Stratman 1998). Annual and seasonal home ranges stabilized after 70 and 30 locations, respectively. Therefore, annual home range estimates were calculated for bears with $\geq$70 locations that were monitored for $\geq$9 months, and seasonal home ranges were determined for bears with $\geq$30 locations within a season. We defined summer as 1 June–30 September and fall as 1 October–31 January (Stratman and Pelton 1999). We did not include spring as a season because of low sample sizes. Stratman et al. (2001) tested effects of telemetry error on accurately placing telemetry locations within proper habitats on Eglin AFB and found no effect on annual or seasonal black bear habitat use estimates; thus no further analysis of telemetry error was conducted.

Habitat composition

We obtained habitat data including coverage maps for streams, rivers, wetlands, roads, and habitat types in a digital database from the Natural Resources Division, Jackson Guard, Eglin AFB. They determined habitat types from aerial photographs and digitized habitat features from 1:24,000 maps using a cell grid density of 10 m (10- x 10-m cells). Landscape features were validated by field surveys conducted by FNAI. We converted the database into Arc/Info® format (Environmental Systems Research, Inc., Redlands, California, USA) for manipulation and reclassification. Because the habitat coverage map contained >20 habitat types, we grouped habitats based on floral and geophysical similarities (McWhite et al. 1993) for analysis.

We defined 5 habitat associations: sandhills, pine production areas, riparian zones, swamps, and open areas (Stratman et al. 2001). Pine production areas were managed strictly for timber and pulpwood production (McWhite et al. 1993); thus, we separated them from sandhills to determine their use by bears. Riparian zones were areas $\leq$50 m from a river and $\leq$25 m from a stream; these distances were generally where vegetational composition between riparian zones and other habitat associations differed. Individual coverage maps for rivers and streams were used to identify the 2 types of water systems. Open areas consisted of cleared airfields, test ranges, rights-of-way, clearcuts, and sewage spray fields.

Prescribed fire analysis

We obtained digitized prescribed burning information for the study area from the Natural Resources Division, Jackson Guard, Eglin AFB and converted them into Arc/Info format. We obtained fire information for years 1988 through 1996. Unburned areas were those with no history of burning or that were burned prior to 1988, for which no data were available. All habitat types identified were burned at varying levels in each of the 9 years examined. Because the date of each burn was not available for all burns in all years, we grouped burns by year for analysis.

For all analyses, we used radiolocations collected from January 1995 through October 1996. For fall analyses, locations collected in January were included with the previous October–December data and analyzed using the previous year's burn map. Because some bears were monitored both years, we assigned each location to a specific burn based on its date. We classified all areas burned within 1 year of any bear location as <1-year old burns. For each year, we superimposed annual and seasonal home ranges and bear locations on yearly burn maps to estimate the proportion of burned areas (i.e., burns) within home ranges and their use by bears.

We compared bear use to the proportion of each habitat association and burn-age within each bear's home range using compositional analysis (Aebischer et al. 1993). In compositional analysis, a log-ratio transformation is applied to each bears' available and utilized habitat composition. If use of habitats is proportional to availability, animal use was considered random. Log-ratios were entered into a multiple regression analysis to test for differential habitat use and to determine significant nonrandom use at $P \leq 0.05$. If nonrandom use is detected, a multivariate analysis of variance is conducted to calculate a covariance matrix of residuals to rank habitats in order of increasing relative use. In compositional analysis, sample size is the number of tracked animals, not the number of radiolocations. We regarded serial correlation between radiolocations as irrelevant because locations were collected consistently throughout the sampling period and sampling intensity was uniform (Aebischer et al. 1993). Thus, we included diel locations in the analyses, which provided a more precise estimate of proportional habitat and burn use (Aebischer et al. 1993).

There are several assumptions to the compositional analysis of habitat use: (1) each animal provides an independent measure of habitat use within the population; (2) compositions from different animals are equally accurate; (3) residuals maintain a multivariate normal distribution; and (4) each animal uses all available habitat types. Because the number of radiolocations was not consistent for all bears, we weighted the log-ratios by the square root of the number of locations to satisfy assumption 2 (Aebischer et al. 1993, Alldredge et al. 1998, Thomas and Taylor 2006). For all analyses, we included only those bears where individuals were located at least once within each burn age. Aebischer et al. (1993) recommended substituting zero use values with replacement values that are less than the smallest non-zero proportion to satisfy assumption 4. However, unacceptably high type I error rates have been shown to occur from this approach (Bingham and Brennan 2004, Thomas and Taylor 2006); therefore, we excluded bear-years with zero use values within any burn to avoid the associated bias.

Because a minimum sample size of 6 was required to show a significant difference from zero at $P \leq 0.05$ (Aebischer et al. 1993), we considered sample sizes for testing sex and age class differences insufficient for analysis. Stratman et al. (2001) tested for individual habitat selection and found no significant individual effects ($P = 0.242$); therefore, sex- and age-classes were pooled. When we detected nonrandom use ($P \leq 0.05$), we ranked habitat associations or burned areas in order of decreasing relative use, for each burn age. Because nearly 50% of bear home ranges on Eglin were comprised of various burn ages, we refined our analyses of bear use of burns as described below.

Burn use among habitats

We compared bear use of each burn age, irrespective of its habitat composition, to all remaining burned and unburned habitats classified by habitat association. For burns <1 year-old, we ran two analyses, one using bear locations obtained before the burn and another using locations obtained after the burn. The before and after effects of burns <1 year-old on habitat use were examined for annual and summer use only; fall was excluded because of insufficient data. As a consequence of eliminating bears with zero use values, 5-year-old burns were excluded from summer analysis and 2-year-old burns were excluded from fall analysis because of low sample sizes. Thus, 6 habitat classes were examined in 10 burn-age analyses for annual use, 9 burn-age analyses for summer use, and 7 burn-age analyses for fall use.

Temporal burn use

We compared bear use of each burn age to all other burn ages, irrespective of their habitat composition. We selected only locations within burns and ranked use of each burn age.

Table 1. Rankings of annual and seasonal black bear use of prescribed burns conducted from 1988–1996 in relation to other habitat associations on Eglin Air Force Base, Florida. Within each burn-year column, the sign following the ranking represents when black bears used a habitat significantly more (+) or less (−) than burned habitat at $P \leq 0.05$.

Season	Year following burning									
Habitat association	<1A[a]	<1B[b]	1st	2nd[c]	3rd	4th	5th[d]	6th	7th	8th
Annual	(n = 9)	(n = 9)	(n = 9)	(n = 7)	(n = 9)	(n = 9)	(n = 9)	(n = 9)	(n = 9)	(n = 8)
Open	5	6−	6−	6	6−	6	R[e]	6	6−	6
Pine	3+	4	3	3	3	3+	R	3	4	3
Sandhill	4+	5	4	4	5	4	R	4	5−	4
Swamp	2+	2+	2+	2+	2+	2+	R	2+	2	2
Riparian	1+	1+	1+	1+	1+	1+	R	1+	1+	1+
Burned	6	3	5	5	4	5	R	5	3	5
Summer	(n = 9)	(n = 8)	(n = 10)	(n = 6)	(n = 10)	(n = 8)		(n = 8)	(n = 8)	(n = 7)
Open	6−	6−	6−	R	6−	6−	NA[e]	6−	6−	6
Pine	3+	3	4	R	3	3	NA	3	4	3
Sandhill	4+	4	5	R	5	4	NA	4	5	4
Swamp	2+	2+	2	R	2+	2+	NA	2+	2	2
Riparian	1+	1+	1+	R	1+	1+	NA	1+	1	1+
Burned	5	5	3	R	4	5	NA	5	3	5
Fall			(n = 8)		(n = 10)	(n = 8)	(n = 7)	(n = 7)	(n = 7)	(n = 6)
Open			6−	NA	6−	6−	6	6−	6−	6−
Pine			3	NA	4	4	3+	4	4	3
Sandhill			4	NA	5−	3	4	5	3	4
Swamp			2+	NA	2	2+	2+	2+	2+	2+
Riparian			1+	NA	1+	1+	1+	1+	1+	1+
Burned			5	NA	3	5	5	3	5	5

[a]Rank of black bear use of burned areas in relation to other habitat associations after the areas were burned.
[b]Rank of black bear use of burned areas in relation to other habitat associations before the areas were burned.
[c]Low sample size precluded analysis of this burn year for fall black bear use.
[d]Low sample size precluded analysis of this burn year for summer black bear use.
[e]Random use by black bears was detected at $P > 0.05$.

Burn use within habitats

Because bear use differed among habitat types (Stratman et al. 2001), we separated each burn by habitat type to determine if bears used burn ages differently than unburned areas within habitat associations. We excluded analysis of open areas, because no bears were located in burned portions of this habitat. Also, 6-year old burns were excluded from seasonal analysis because of low sample size of bears. We examined 9 burn classes (8 burn ages + unburned areas) for annual use, and 8 burn classes for seasonal use and determined their use by bears within each of the remaining 4 habitat associations.

Results

We collected 1,891 location estimates from 9 bears (3F, 6M) to determine annual use burned habitat. Seasonal burn use was based on 10 bears (3F, 7M) located during summer (1,049 locations) and fall (794 locations). Number of locations per individual per year ranged from 64–146 for annual burn use, 27–85 for summer burn use, and 31–67 for fall burn use.

Burn use among habitats

Annual burn use by black bears relative to use of other habitat associations was not random ($P \leq 0.05$) for all burn ages except 5-year old burns ($\Lambda = 0.0729$, $F = 7.63$, $P = 0.0625$). Thus, no rankings were conducted for 5-year old burns. For the remaining ages, burned areas generally ranked higher than open areas but lower than all other habitat associations. Among burn-ages, 7- and 3-year-old burns were highest in bear use, ranking third and fourth, respectively (Table 1). For <1-year-old burns, burned areas ranked third in bear use before they were burned and sixth after they were burned.

Summer use of burned habitat by black bears was not random ($P \leq 0.05$) for all burn ages except 2-

Table 2. Rankings of annual and seasonal black bear use of prescribed burns conducted from 1988–1995 in relation to unburned areas within each habitat association on Eglin Air Force Base, Florida. Within each burn-year column, the sign following the ranking represents when black bears used a burned habitat significantly less (−) than the unburned habitat at $P \leq 0.05$.

Season	Year following burning								
Habitat association	1st	2nd	3rd	4th	5th	6th[a]	7th	8th	Unburned
Annual (n = 9)									
pine	3	8−	6−	9−	7−	5−	2	4−	1
sandhills	2	9−	4	7−	8−	6−	3	5−	1
swamp	7−	6−	2	5−	9−	8−	4−	3	1
riparian	3	6−	2	9−	8−	5−	4−	7−	1
Summer (n = 8)									
pine	4−	7−	5−	8−	6−	NA	2	3−	1
sandhills	3	7−	5	8−	6	NA	4	2	1
swamp	6	7−	2	5	8−	NA	4	3	1
riparian	5−	4−	3−	8−	6−	NA	2	7−	1
Fall (n = 8)									
pine	3	8−	4−	7−	6−	NA	2	5−	1
sandhills	3	8−	2	5	7−	NA	4	6−	1
swamp	8−	5−	2	6−	7−	NA	3	4−	1
riparian	3−	6−	2	8−	7−	NA	5−	4−	1

[a]Low sample size precluded analysis of this burn year for summer and fall black bear use.

year-old burns ($\Lambda = 0.0150$, $F = 13.10$, $P = 0.2066$). Therefore, 2-year-old burns were not ranked. During summer, 1- and 7-year-old burns ranked highest among the remaining burn ages for bear use; both ranked third in relation to other habitats (Table 1). For <1-year-old burns, the summer ranking of preburn and postburn habitat use did not change. In both cases, burned areas ranked fifth in bear use. Nonrandom use ($P \leq 0.05$) was detected for all burn ages for fall habitat use. During fall, 3- and 6-year-old burns ranked highest among burn ages, both ranking third in bear use (Table 1).

Temporal burn use

Black bears used burned areas randomly within their home ranges regardless of time since burning for annual ($\Lambda = 0.0462$, $F = 5.896$, $P = 0.1892$), summer ($\Lambda = 0.0727$, $F = 1.822$, $P = 0.6957$), and fall ($\Lambda = 0.0151$, $F = 9.228$, $P = 0.3363$) burn use. Thus, no ranking of annual burns was conducted.

Burn use within habitats

Black bear use of burns within the 4 habitat associations was not random for annual ($\Lambda = 0.2537$, $F = 8.0877$, $P = 0.0001$), summer ($\Lambda = 0.3592$, $F = 5.3524$, $P = 0.0013$), and fall ($\Lambda = 0.0556$, $F = 3.8810$, $P = 0.0001$) use. Comparing black bear use of burned and unburned areas by habitat type, unburned areas ranked highest in all habitat associations, both annually and seasonally (Table 2). For annual bear use among the 8 burn ages, 7-year-old burns ranked highest in pine habitat, 1-year-old burns ranked highest in sandhills, and 3-year-old burns ranked highest in swamp and riparian habitats (Table 2).

For bear use of burns during summer, 7-year-old burns ranked highest in pine and riparian habitats, 8-year-old burns ranked highest in sandhills, 3-year-old burns ranked highest in swamp habitat (Table 2). During fall, 7-year-old burns ranked highest in pine habitat and 3-year-old burns ranked highest in sandhills, swamp, and riparian habitats (Table 2).

Discussion

Because most burned areas were within pine and sandhill habitats, which ranked third and fourth for annual and seasonal black bear use (Stratman et al. 2001), a lower ranking of burn use was expected when burns were compared with other habitat associations. Use of a short burning regime (1–2 yr) appears to have limited benefits for black bear in northwest Florida. Within all habitat types, black bears used unburned areas more than burned areas, both annually and seasonally. Higher seasonal and annual use of some burn ages was likely attributable to the increased cover and food availability that some burned areas provided. Higher use of 3 and

≥5 year-old burns was consistent with several published reports on peak soft mast production following prescribed fire. We conclude that several soft mast species may have been attaining peak production; this likely attracted bears.

Prescribed burning every 3 years can benefit bears by stimulating soft mast production (Zager et al. 1983, Hamer and Herrero 1987), and peak production of some soft mast species was attained the third year following burning (Johnson and Landers 1978, Hon 1981, Landers 1987). On Eglin, bear foods like blackberry (*Rubus* spp.), sweet gallberry (*Ilex coriacea*), wild grape (*Vitis rotundifolia*), and greenbriar (*Smilax* spp.) were commonly found in habitats subjected to a short burning cycle. This likely explains the high use of 1- and 3-year old burns. Although these foods were not the primary foods consumed by bears on Eglin (Stratman and Pelton 1999), bears likely took advantage of their seasonal abundance to meet their nutritional needs in absence of other preferred foods.

Research has also shown that several plants that produce fruit important to black bears require ≥5 years following fire to produce significant yields (Hilmon 1969, Johnson and Landers 1978, Hon 1981, Gholz et al. 1999, Maehr and Larkin 2004*a*). Martin (1983) found that huckleberry (*Vaccinium globulare*) was most productive on clearcuts that were broadcast burned 8–15 years previously. Similarly, a 5–10 year burning rotation in pine–hardwood habitats was recommended for maintaining adequate food supplies for black bears in coastal North Carolina and elsewhere (Hamilton 1981, Landers 1987). Others have suggested rotations of 10–23 years as the more typical cycles in similar habitat (Maehr and Larkin 2004*a*,*b*). Maehr and Larkin (2004*a*) argued that a long-rotation, growing season approach was needed to adequately maintain saw palmetto habitat for large carnivores in south Florida. We conclude that providing a mosaic of burned habitats that includes a diversity of burn ages is the best approach for maintaining conditions that are beneficial for black bears.

Saw palmetto fruit and oak mast have been shown to be the primary sources of fall food for bears on Eglin and elsewhere (Maehr and Brady 1982, Pelton 1989, Maehr 1997, Roof 1997, Stratman and Pelton 1999). Fruit production in saw palmetto can be delayed for 6–9 years following a fire (Hilmon 1969), and frequent burning in some areas of Eglin has virtually eliminated the oak midstory. Large-scale suppression of oaks and disruption of palm fruit production could have detrimental effects on the long-term survival of this small black bear population (40–70 bears; Freedman 2000) and other populations in the Southeastern Coastal Plain. A longer burning regime would benefit bears by maintaining cover and adequate supplies of these important fall foods. However, because of the wide distribution and abundance of these plant species on Eglin, impacts from annual burning on their availability may not be revealed for several years.

On Eglin, the most productive stands of important soft mast species like blueberry (*Vaccinium* spp.), huckleberry (*Gaylussacia* spp.), blackgum (*Nyssa* spp.), odorless wax myrtle (*Myrica inodora*), and saw palmetto were commonly found within riparian zones, swamps, and adjacent uplands that had not been burned for several years. These older-age burns likely enhanced the supply and diversity of these foods within and adjacent to some of the best cover that these habitats could provide for black bears. Despite the overall lower use of upland habitats by black bears (Stratman et al. 2001), upland habitat adjacent to riparian zones and swamps play a substantial role in meeting the annual and seasonal dietary needs of black bears on Eglin. Over 38% of all bear locations in upland habitat were <100 m from riparian zones or swamps and 54% were <200 m. High use of these adjacent uplands reflects their importance to black bears. Because important bear foods can be found within and adjacent to riparian habitats, fire should be restricted, or a burning cycle >5 years be used within these areas to maintain adequate food supplies and escape cover for bears. The combination of abundant food with nearby escape cover may be an ideal setting for bears.

Management implications

Because of the need to maintain open habitat conditions for other species including the red-cockaded woodpecker, we acknowledge that a short burning regime will continue to be an integral part of the management of upland habitats in this region and elsewhere along the Southeastern Coastal Plain. There is evidence from this study that bears will use upland habitats subjected to burning every 1–3 years. However, these short rotation burns likely reduced availability of primary foods consumed by black bears throughout the year.

Because riparian zones have high moisture levels resulting in a naturally dense vegetational composition, subjecting this habitat to frequent burning to provide open habitat seems counterproductive. Because riparian zones represent <5% of the land area on Eglin AFB, the uniqueness of this limited habitat feature and its importance to black bears in the area should be preserved with little consequence to other wildlife species. Frequent burning within this important habitat may force bears to look elsewhere for adequate food supplies and cover, potentially increasing their risk of mortality.

The importance of adequate fall food supplies to the population dynamics of bears is well documented and should be a key management objective for any bear population. Identifying areas adjacent to riparian zones and swamps that provide abundant soft and hard mast production should be managed under longer burning rotations (≥5 years) to provide important foraging areas for bears. This would maintain plant species diversity, especially for primary bear food producers like blueberry, saw palmetto, and oaks, within and adjacent to riparian zones and effectively minimize the area needed to satisfy nutritional needs of black bears on Eglin and vicinity.

Managers need to carefully assess habitat changes that occur from the seasonal use of prescribed fire. In this study, effects of cool-season versus warm-season burning on black bear use could not be examined due to a lack of fire information. Further research is needed to monitor effects of cool- and warm-season burning on vegetation responses and black bear habitat use, and evaluate landscape changes that result. Because most species require at least some habitat patchiness, we recommend that smaller-scale burning (<65 ha) be used in upland habitat adjacent to riparian and swamp habitat to provide diversity and a mosaic of post-fire stages. Planning for juxtaposition of successional stages centered on important food and habitat sources is the best approach for managing habitat for black bears in the Southeastern Coastal Plain.

Careful consideration should be given to effects on all wildlife species before dramatic landscape alterations are instituted. By identifying important habitat components and proper planning and design of burn plans across the landscape, these recommendations can be implemented for the benefit of black bears without jeopardizing management goals for maintaining habitat conditions for other species. Before burning regimes are changed, we suggest that managers thoroughly evaluate effects of large-scale annual burning practices on blueberry, acorn, and palm fruit production in areas occupied by black bears to determine their effects on food availability and the potential implications on black bear survival.

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