Prescribed fire and raccoon use of longleaf pine forests: implications for managing nest predation?

David D. Jones, L. Mike Conner, Theresa H. Storey, and Robert J. Warren

Abstract If nest predation at least partially results from incidental encounters between predators and nests, then management practices that reduce the probability of such encounters could increase nest success. Therefore, we studied effects of prescribed fire on raccoon (*Procyon lotor*; a documented nest predator) use of longleaf pine (*Pinus palustris*) and mixed longleaf pine–hardwood (*Quercus* spp.) forests in southwestern Georgia during the nesting seasons of ground- and shrub-nesting birds (i.e., mid-April–mid-August) of 1999 and 2000. Forested stands that had been burned since the previous growing season were 52% and 80% less likely to be used by raccoons than unburned stands during 1999 and 2000, respectively. Overall, prescribed fire after the previous growing season resulted in a 62% reduction in probability of use by raccoons during the nesting season. Prescribed fire may serve as a tool to reduce incidental encounters between raccoons and nests, but further work is needed to determine the overall effect of prescribed fire on nest success.

Key words Georgia, nest predation, predation management, prescribed fire, *Procyon lotor,* raccoon, radiotelemetry

Predation is a major cause of nest failure in birds (Heske et al. 2001, Rollins and Carroll 2001) and herpetofauna (Butler and Sowell 1996), and nest predation is thought to occur as the result of incidental encounters with nests (Roseberry and Klimstra 1970, Vickery et al. 1992). Thus, conservation practices that reduce the opportunity for incidental encounters between predators and nests may result in increased nest success.

Prescribed burning is an important management tool used to manipulate habitat in the Southeast (Waldrop et al. 1992). Prescribed fire maintains open vegetation communities and enhances growth of herbaceous vegetation (Waldrop et al. 1992, Cain et al. 1998). However, many plants (e.g., blackberries, *Rubus* spp.; and blueberries, *Vaccinium* spp.) do not fruit during the growing season following fire, but produce 2–4 years after fire (Stoddard 1963, Johnson and Landers 1978). Because berry production and avian nesting seasons overlap temporally, presence of fruit near a nest may increase the opportunity for a predator to encounter a nest (Vickery et al. 1992). Because fire inhibits fruit production during the growing season following the fire, prescribed burning may serve as a tool for managing nest predation by reducing the probability of an incidental encounter between a nest predator and a nest.

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Within the longleaf pine ecosystem, raccoons are significant predators of ground-nesting birds (Speake 1980, Rollins and Carroll 2001) and gopher tortoises (*Gopherous polyphemus*; Landers et al. 1980), and raccoon habitat use is associated with fruit production during spring and summer (Johnson 1970). Therefore, prescribed fire may reduce raccoon use of an area by inhibiting fruit production during the growing season following prescribed fire. However, data are lacking that explicitly address this idea. Herein, we examine effects of prescribed fire on raccoon use of upland pine and mixed pine–hardwood forests during the avian nesting season. We predicted that prescribed fire would result in decreased use of these habitats by raccoons.

Study area

Our study took place in Baker County, Georgia, on Ichauway, the research facility of the Joseph W. Jones Ecological Research Center. This 11,700-ha ecological reserve had one of the most extensive tracts of privately owned longleaf pine (*Pinus palustris*) in the Southern Coastal Plain. Natural loblolly pine (*P. taeda*) forests, slash pine (*P. elliotti*) flatwoods, and mixed hardwoods (*Quercus* spp.) were patchily distributed throughout the longleaf pine forest. Wiregrass (*Aristida beyrichiana*) and old-field grasses (e.g., *Andropogon* spp.) dominated the understory (Goebel et al. 1997).

Topography was flat to gently rolling, with elevation ranging from 30–100 m (Beck and Arden 1983). Ichawaynochaway Creek bisected the property, while the eastern boundary of Ichauway was the Flint River. The climate was subtropical, with mild, short, wet winters and humid, hot summers (Lynch et al. 1986). Average temperatures ranged from 11°C in winter to 27.5°C in summer. Annual precipitation averaged 131 cm (Goebel et al. 1997); however, drought conditions existed during 1998–2000.

Prescribed fire was the prominent management practice on Ichauway. Most of Ichauway was burned by prescription on a 2-year rotation to reduce hardwood encroachment and fuel accumulation while enhancing herbaceous ground cover and wildlife habitat. Prescribed fires were generally begun by igniting a backfire to establish a burn boundary. Head and strip fires were then used to complete the burn. All ignitions occurred using drip torches. Prescribed fires were conducted throughout the year; thus, we used both dormant- and growing-season fires.

Methods

Animal capture and monitoring

We captured raccoons using Tomahawk wire cage traps and egg-traps (Hubert et al. 1996). Our trapping efforts were focused during the winters of 1998–1999 and 1999–2000, but limited trapping occurred throughout the duration of study. We anesthetized captured raccoons with ketamine hydrochloride (15 mg/kg of body weight). We fitted females weighing ≥3 kg and males weighing ≥4 kg with a radiocollar (Advanced Telemetry Systems, Isanti, Minn.). We released raccoons at the capture site following recovery.

We radiotracked raccoons with a Wildlife Materials TRS 2000 (Carbondale, Ill.) receiver and a 3- or 4-element hand-held Yagi antenna. We estimated locations using triangulation from known reference points established using differentially corrected global positioning. We maintained time between bearings at ≤20 minutes to reduce error (Harris et al. 1990). We used a FORTRAN computer program (M. Conner, Joseph W. Jones Ecological Research Center, unpublished data) to convert bearings to UTM coordinates.

Data analysis

We used Arc/Info (Environmental Systems Research Institute 1997) to select all forested types managed with prescribed fire (i.e., mature pine and mixed pine–hardwood forests). We further partitioned data into stands burned between August of the previous year (i.e., the last growing season) and 15 April of the current year. These stands represented areas that would have little fruit production during the current nesting season.

We developed a minimum convex polygon around all raccoon locations obtained during the nesting season (15 April–15 August) and considered these polygons as our study area. We overlaid the study area onto our data layer of burned and unburned forested stands. Because some areas were burned during the nesting season, we calculated availability of burned stands as the percentage of area/days that stands were in a burned condition during the study. For example, assume that 2,000 ha of the study area were managed using prescribed fire, and assume that the nesting season is 100 days in length. At the start of the season, assume that 1,000 ha had been burned; 50 days later an additional 500 ha were burned. The availability for burned stands would be 62.5% (i.e., $(1{,}000\times100+500\times50)/(2{,}000\times100)=0.625$).

We overlaid raccoon locations obtained during the nesting season onto a map of mature pine and mixed pine–hardwood forests and retained locations that fell into one of these forest types for further analysis. We then classified these data based on burn condition (burned or unburned) when the location was obtained and calculated percentage use of burned and unburned forests. Thus, although raccoons were individually identifiable, we used Manly et al.'s (1993) Sampling Design I while restricting estimates of habitat availability to encompass only those forest types of interest: burned and unburned mature pine and mixed pine–hardwood forests.

Because our primary interest was to determine whether prescribed fire had the potential to result in a decreased probability of encounter between a raccoon and a nest (i.e., resulted in reduced probability of habitat use by raccoons), we used χ^2 to test the null hypothesis that raccoon use of mature pine and mixed pine–hardwood forests was independent of whether the area had been burned (Zar 1996). We then calculated odds-ratios (Allison 2000) as an estimate of the effect of prescribed fire on raccoon use of mature pine and mixed pine–hardwood forests.

Results

Of 1,458 raccoon locations obtained on 30 (10 M, 20 F) raccoons during the nesting season of 1999, 563 fell in mature pine or mixed pine–hardwood forests. Of these, 34.2% were in burned and 65.8% were in unburned stands. Of the area in mature pine or mixed pine–hardwood forests, 44.2% was burned and 55.8% was not burned during the 1999 nesting season.

Of 1,180 raccoon locations obtained on 27 (13 M, 14 F) raccoons during the nesting season of 2000, 443 fell in mature pine or mixed pine–hardwood forests. Of these 26.6% were in burned and 73.4% were in unburned stands. Of the area in mature pine or mixed pine–hardwood forests, 39.5% was burned and 60.5% was not burned during the 2000 nesting season.

Raccoons did not use burned and unburned pine and mixed pine–hardwood forests as expected during the nesting season of both 1999 ($\chi^2_1 = 23.92$, $P < 0.001$) and 2000 ($\chi^2_1 = 32.69$, $P < 0.001$). Raccoons were 52% and 80% more likely to use unburned than burned stands during 1999 and 2000, respectively. When data were pooled across years, use of burned and unburned forests differed ($\chi^2_1 = 53.28$, $P < 0.001$) from expectation; raccoons were 62% more likely to use unburned than burned stands.

Discussion and management implications

Our data suggest that raccoon use of pine and mixed pine–hardwood forests during the nesting season can be reduced by using prescribed fire. However, we do not know whether reduced use of these areas by raccoons actually will result in increased nest success because predators other than raccoons may use recently burned areas, resulting in compensatory predation (Jones et al. 2002). Further, some animals may not nest in recently burned areas due to a lack of nesting cover. Finally, nests located in recently burned areas may be more detectable by predators, if even to a fewer number of predators.

The aforementioned caveats aside, we believe that prescribed fire warrants further investigation as a mechanism for managing nest predation by eliminating a major food source of nest predators. If nest predation is the result of an incidental encounter with a predator (Roseberry and Klimstra 1970, Vickery et al.1992), prescribed fire may be a suitable tool for reducing nest predation. Because fire inhibits production of soft mast (Johnson and Landers 1978) and many nest predators (e.g., raccoons, opossums [*Didelphis virginiana*], etc.) rely greatly on soft mast when available (Johnson 1970, McManus 1974, Lotze and Anderson 1979), these predators may avoid (i.e., use less than expected) areas that have been burned since the previous growing season. Indeed, such a response was reported by Chamberlain et al. (2003), prompting them to suggest that prescribed fire on a short (2–3-year) rotation likely would reduce habitat quality for raccoons. If prescribed fire results in reduced use of an area by nest predators, animals nesting in recently burned areas may experience increased nest success.

Jones et al. (2002) used artificial nests to evaluate predator use of forested stands relative to time since prescribed fire. They noted decreased mesomammal (e.g., raccoons, opossums) predation of artificial nests in areas that had been recently burned, as would be predicted by this study. Unfortunately, decreased mesomammal predation was offset by increased corvid predation, and no overall increase in nest success occurred. However,

artificial nests may have been more exposed to corvids than real nests because no incubating bird was present (Jones et al. 2002). Because reduced use of an area by predators does not ensure reduced nest predation in that area, and because artificial nest success may not mimic real nest success (King et al. 1999), research using real nests should be conducted to evaluate effects of prescribed fire on nest success and cause-specific nest failures.

The effects of prescribed fire on nesting behavior varies widely and should be taken into consideration when contemplating prescribed fire as a tool to manage nest predation. For example, nesting behavior in some species appears to be unaffected by prescribed fire (Landers et al. 1980), whereas other species abandon nesting attempts following recent fire events (Seaman and Krementz 2000). Clearly, if a species will not nest in a particular area, reducing predator use of that area provides no opportunity for reducing nest predation. Thus, research is needed to evaluate the tradeoffs between reduced use by predators and willingness of species to nest in recently burned areas.

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