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Ratsnakes and Brush Piles: Intended and Unintended Consequences of Improving Habitat for Wildlife?

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ABSTRACT.—Brush pile creation is a common habitat management method used to attract wildlife. However, there is a paucity of data regarding effectiveness of brush pile creation and the indirect effects of brush piles on multi-species interactions. Here we document use of man-made brush piles by Texas ratsnakes (*Elaphe obsoleta*), examine mechanisms behind that use, and present results of a pilot study comparing avian nest success in areas with and without brush piles to determine if predator attraction to brush piles negatively affects the surrounding bird community. Radio-tracked snakes were found in brush piles 10% of the time, despite brush piles comprising less than 0.2% of the habitat by area. More abundant small mammals and more moderate temperatures in brush piles than in surrounding habitats could explain snakes' attraction to brush piles. Nest success of birds was similar in areas with and without brush piles in the year following brush pile creation. Because it may take substantially longer than 1 y for snake use to reach its maximum, however, it is premature to conclude that brush piles do not affect birds nesting in adjacent habitat. Given the apparent prevalence of brush pile creation, and the demonstrated preference of brush piles by ratsnakes, further research to document the consequences of brush pile creation is warranted.

INTRODUCTION

Land managers commonly manipulate habitat to attract or increase the survival of wildlife. Brush piles have been promoted as a simple way to attract a variety of species, including rabbits (Haugen, 1943), small mammals (Swihart and Slade, 1985) and ground birds (Webb and Guthery, 1982). In addition to providing cover for wildlife, brush piles are also created to shelter seeds and saplings to encourage growth of target plants (Weitkamp *et al.*, 2001). An internet search revealed that at least 11 U.S. state agencies (AL, CT, IL, IN, MD, MI, NC, PA, TX, VA, WI; Google) and numerous U.S. non-government agencies advise land owners to create brush piles to benefit wildlife. For example, Texas House bills H.B. 1358 and H.B. 3123 require landowners who wish to have their agricultural land qualify for tax benefits associated with wildlife management to perform at least three of seven activities aimed at maintaining wildlife populations. One of those activities is the creation of wildlife shelters, and a recommended approach for doing so is creating and retaining brush piles.

Promotion of brush piles as a method for improving wildlife habitat is based on surprisingly little empirical evidence. Few studies have assessed the effects of man-made brush piles on target species (*e.g.*, Webb and Guthery, 1982) and we found only one study that examined effects on non-target species (Webb and Guthery, 1983). Therefore, there is a clear need for research to determine the effect of brush pile creation, not only on target species, but for all wildlife species. Here we present observations of brush pile use by Texas ratsnakes (*Elaphe obsoleta*) and examine possible mechanisms behind that use.

Snakes often prefer areas close to retreat sites such as rocks, logs (*e.g.*, Blouin-Demers and Weatherhead, 2001a; Harvey and Weatherhead, 2006) and hedgerows (Durner and Gates,

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1993). Therefore, it seems likely that snakes would use brush piles. Retreat sites are primarily used by snakes for thermoregulation (Huey *et al.*, 1989; Webb and Shine, 1998) and protection from predators (Webb and Whiting, 2005). Brush piles might also attract small mammals on which the snakes prey, further enhancing the attractiveness of brush piles for snakes. We assess both possibilities by comparing thermal profiles and small mammal abundance in brush piles and in adjacent habitat.

Should brush piles improve habitat for snakes, an unintended consequence could be reduction of habitat quality for endangered songbirds. Recent studies have identified snakes as important avian nest predators (Weatherhead and Blouin-Demers, 2004). In particular, Texas ratsnakes have been shown to be the primary predator of two endangered bird species breeding on Fort Hood, the black-capped vireo (*Vireo atricapilla*; Stake and Cimprich, 2003) and golden-cheeked warbler (*Dendroica chrysoparia*; Stake *et al.*, 2004). Brush piles are often created in and adjacent to habitat used by both these species, which could have consequences for the birds. Given that ratsnakes are attracted to brush piles, this could create a halo of high nest success around brush piles if snakes hunt primarily within brush piles. Alternatively, however, a halo of low nest success around brush piles could result if snakes hunt primarily in the adjacent habitat. Given the goal of enhancing nest success of both endangered birds, the implication of using brush piles as a management technique where endangered birds nest will depend on whether either of these scenarios is realized. Here we document avian nest survival (including nests of black-capped vireos) adjacent to newly created brush piles and in control areas lacking brush piles.

METHODS

We conducted this study from 2004–2008 at Fort Hood, an 87,890 ha military installation in central Texas (30°10′N, 97°45′W). The habitat of Fort Hood is predominantly oak-juniper (*Juniperus ashei* and *Quercus* spp.) woodlands and oak savannahs. Ashe juniper is commonly cut on Fort Hood to re-establish early successional habitat in which black-capped vireos nest, to increase line-of-site for military training, and to improve grazing. Cut junipers are often left in piles of varying size. Some piles are burned when weather and time permit, but many persist for years.

Snakes were caught opportunistically by hand in 2004–2007. Snakes for which transmitters weighed $<3\%$ total body weight had a radio transmitter surgically implanted and were then released at their capture locations. Snakes with transmitters ranged in weight from 315 g to 825 g and averaged 528 g. Transmitters were implanted using Blouin-Demers and Weatherhead's (2001a) modification of Reinert and Cundall's (1982) method. Transmitters weighed 9 g or 13 g with batteries lasting 12 mo and 24 mo, respectively (Model SI-2T, Holohil Systems Incorporated, Ontario). Snakes were relocated during daylight hours approximately every 48 h during the snake active season (Apr. through Nov.) and once per week during winter. Upon relocation, date and location (UTM coordinates) were recorded. For a concurrent study, we sampled habitat at a random distance and direction from every fourth snake location (*see* Sperry *et al.*, 2009 for a detailed description of methods), which allowed us to estimate the availability of brush piles. Sperry *et al.* (2009) and Sperry and Weatherhead (2009) provide a detailed examination of ratsnake habitat use. Here we focus on brush pile use by ratsnakes and attempt to determine the causes and consequences of that use.

We trapped small mammals for three nights each year in Apr. 2005 and Apr. 2008. Trapping was restricted to early spring to avoid biases in abundance or mortality that can be caused by red fire ants (*Solenopsis invicta*; Masser and Grant, 1986; Gettinger, 1990) which are inactive only during cooler weather. In 2005 we created a trapping grid in and around brush piles with 15 m spacing between traps. We placed a total of 16 traps, as close to the ground as possible, in three large brush piles. The length of the pile dictated how many traps we could place while still retaining 15 m spacing. We placed nine traps in the largest pile and four and three, respectively, in the smaller piles. We created additional transects originating in the brush pile and extending into adjacent savannah habitat. We placed traps 15, 30 and 45 m away, as space allowed, for a total of 63 traps outside brush piles. Because the brush piles used in 2005 were burned, we trapped at 10 smaller brush piles in 2008. The 2008 brush piles had all been created that year and included the brush piles used in our experiment on nest predation (*see* below). In 2008 we placed one trap in the center of each pile (for a total of 10 brush pile traps). We placed four traps 15 m away from each brush pile in the four cardinal directions, for a total of 40 traps outside brush piles. We used Sherman live traps (H.P. Sherman Co., Tallahassee, Florida, USA) baited with black oil sunflower seeds. Traps were baited at sunset and checked at sunrise the following morning. Traps were open for three consecutive nights each year for a total of 201 and 150 traps nights in 2005 and 2008, respectively. All small mammals were identified to species and new captures were marked by clipping a small area of fur from the dorsal surface near the tail to differentiate new captures from previous captures. Capture rate was calculated as the percent of traps with new captures (*i.e.*, new captures per 100 trap nights).

To assess thermal conditions within brush piles and in surrounding habitat, we created physical models of ratsnakes using a 30.5 × 3.8 cm length of metal tubing filled with water and sealed at both ends to mimic the thermal profile of a thermo-conforming snake (Blouin-Demers and Weatherhead, 2001b). A data logger in the tube recorded temperature every 10 min. We placed one snake model inside a brush pile and one in adjacent savannah habitat for 9 d in Aug. 2005 to coincide with the time that ratsnakes used brush piles extensively.

In 2008 we initiated an experiment in which we found and monitored bird nests on three treatment (brush piles) and three control (no brush piles) study plots. Study plots ranged in size from 0.25–0.40 km^2 and were chosen based on similarity of habitat characteristics and presence of black-capped vireos. The experimental brush piles were created using brush cut by land managers in 2007. Size and location of brush piles was dictated by the quantity of brush available and ranged in size from approximately 2–5 m in diameter. Three technicians spent approximately equal time searching for nests on control and treatment plots. Nests were monitored every 2–4 d until fledging or failure.

We compared percentage brush pile use by individual snakes and percentage of random locations that fell within brush piles using ANOVA. We compared small mammal capture rates inside brush piles and in surrounding habitat using a chi-square analysis. We used mean capture rates for all traps (brush pile and non-brush pile traps) as the expected value. We compared mean snake model temperatures in the brush pile and savannah using two-sample *t*-tests. Nest survival was calculated using the Mayfield method (Mayfield, 1975) and compared with program CONTRAST (Hines and Sauer, 1989). All other analyses were conducted using NCSS (Hintze, 2006). All means are presented ±1 standard error. All protocols were approved through the University of Illinois Institutional Animal Care and Use Committee (protocol #04058).

RESULTS

We tracked 63 Texas ratsnakes (25 females and 38 males) between 2004 and 2007, resulting in 7627 locations. Individual snake use of brush piles varied from 0 to 56% of

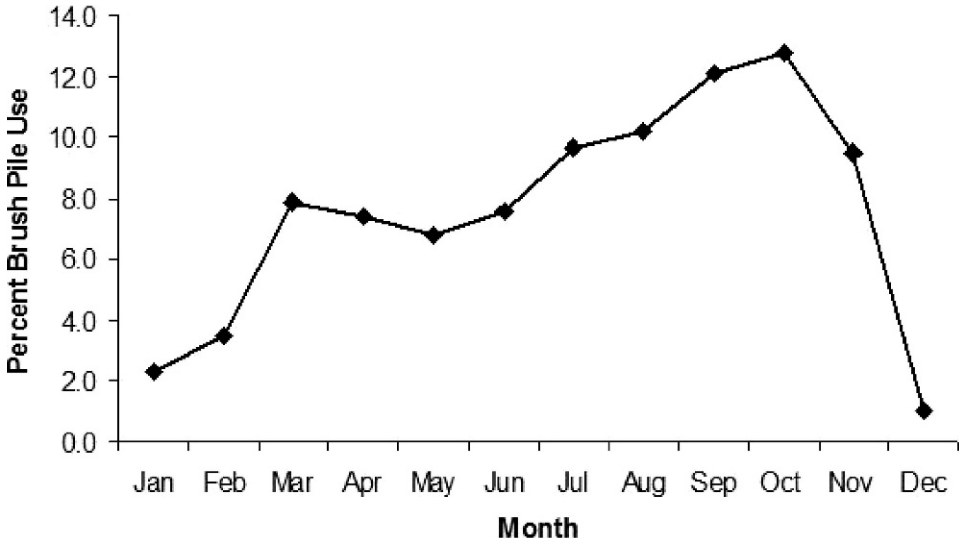

FIG. 1.—Percentage of radio-tracked Texas ratsnakes found in brush piles at Fort Hood, Texas 2004–2007

relocations (mean = 10.7% ± 1.59). Snake use of brush piles did not differ between males and females (mean = 11.5% ± 2.2 and 10.0% ± 2.3, respectively; $t = 0.5$, P = 0.65) nor was it related to snake snout-vent length (mean = 539.6 ± 2.75, $R^2 = 0.13$) or body mass (mean = 120.1 ± 0.23, $R^2 = 0.07$). Including only the 35 snakes that had home ranges in savannah habitat, and thus had access to brush piles, individual use varied from 2 to 56% of relocations (mean = 16.7% ± 2.34). Of 590 random habitat assessment points, only one landed on brush piles, so snakes used brush piles much more than expected ($F = 45.96$, P < 0.001). Ratsnakes used brush piles least in winter (Dec.–Mar. = 2.3% of relocations ± 0.71) and most in late summer (Aug.–Oct. = 11.7% of relocations ± 0.78, Fig. 1). Anecdotally, one tracked ratsnake used a brush pile within 48 h of the juniper being cut in fall 2007 and 2 tracked snakes used brush piles within 1 mo of them being created in spring 2008. Snakes often used brush piles for extended periods, with one snake remaining in the same brush pile for 36 d and another spending 93 d of the winter in one brush pile.

Small mammal trapping yielded only 12 captures in 351 traps nights (7 Texas mice [*Peromyscus attwateri*], 2 hispid cotton rats [*Sigmodon hispidus*] and 3 eastern wood rats [*Neotoma floridana*]). All these species are consumed by Texas ratsnakes (Sperry and Weatherhead, 2009). Although sample sizes were small, capture rates were higher inside than outside brush piles in both 2005 and 2008 (7.9% vs. 2.2%, $\chi^2 = 3.28$, P = 0.07 and 10.0% vs. 0.8%, $\chi^2 = 7.76$, P = 0.01 respectively).

Snake models in brush piles and savannah habitat from 2–11 Aug. 2005 produced 2643 temperature readings. Temperatures inside brush piles were cooler and less variable (range = 19.4 to 34.4°; mean = 23.6° ± 0.08) compared to outside (range 21.3 to 41.05°; mean = 26.8° ± 0.11; $t = -23.07$, P < 0.001; Fig. 2).

We found and monitored a total of 57 nests of four bird species on control plots and 34 nests of nine species on treatment plots, resulting in 607 observation days on control and 400 observation days on treatment plots. Overall, daily nest survival was similar on treatment and control plots (survival = 0.94 ± 0.01 and 0.92 ± 0.01, respectively; $\chi^2 = 1.24$, P = 0.27).

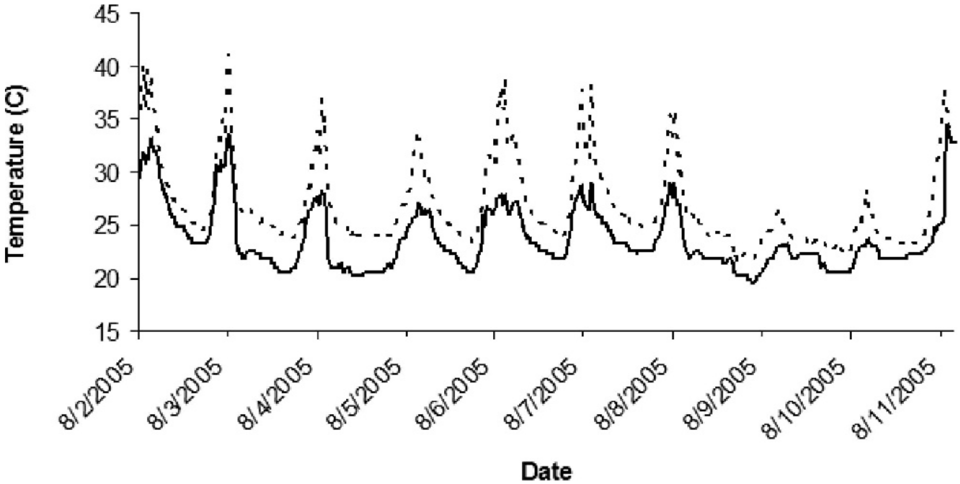

FIG. 2.—Temperature from snake models in brush piles and in adjacent savannah habitat from 2–11 Aug. 2005 on Fort Hood, Texas. Solid line indicates brush pile temperatures and dashed line indicates savannah habitat

We had adequate samples for species-specific analyses for northern cardinals and black-capped vireos. We monitored 30 cardinal nests on control plots and 11 on treatment plots, resulting in 271 and 124 observation days, respectively. Daily nest survival was similar on treatment and control plots (survival = 0.93 ± 0.02 and 0.90 ± 0.02, respectively; $\chi^2 = 1.07$, P = 0.30). We monitored 22 vireo nests on control plots and nine on treatment plots, resulting in 295 and 121 observation days, respectively. Mayfield analysis indicated that daily nest survival was similar between treatment and control plots (survival = 0.94 ± 0.02 and 0.95 ± 0.01, respectively; $\chi^2 = 0.08$, P = 0.77).

DISCUSSION

If the goal is to improve habitat for wildlife generally, our results suggest that creating brush piles is likely to meet that goal. Texas ratsnakes used brush piles soon after they were created and used older brush piles far more than expected given their availability. Although sample sizes were small, capture rates of small mammal were greater in brush piles than in adjacent savannah habitat, suggesting that brush piles are also attractive to small mammals. Savannah habitats in this area have low prey densities (Sperry and Weatherhead, 2009), so it is possible that ratsnake use of brush piles is a response to concentrated prey. However, snake use of brush piles soon after they were created likely preceded use by small mammals, suggesting that snakes may use brush piles for multiple purposes.

Thermoregulation is probably one of the primary reasons snakes use brush piles. In the heat of summer, brush piles provide cooler temperatures closer to those preferred by ratsnakes elsewhere (27–30 C; Blouin-Demers and Weatherhead, 2001b), whereas model snake temperatures outside brush piles were more extreme and often exceeded the lethal maximum for snakes (40–45 C; Spellerberg, 1972; Scott *et al.*, 1982; Blouin-Demers *et al.*, 2003). Peak use of brush piles in late summer when temperatures were highest is also consistent with ratsnakes using brush piles for thermal reasons.

Central Texas has a high diversity of snake species, many of which also prey on small mammals and all of which are likely to use habitat selection to varying degrees to maintain optimal body temperatures. Therefore, brush piles seem likely to improve habitat quality for many of these species. Similarly, other mammal species not susceptible to capture in small traps baited with seeds may also be attracted to brush piles. Studies on the broad ecological impacts of brush piles should be undertaken to determine whether these expectations are met. Such research will provide the evidence necessary to determine whether brush piles actually improve wildlife habitat as is assumed in public policy promoting brush pile creation.

Animals attracted to and spending time in brush piles are also likely to affect species that live in adjacent habitat and this is where unintended consequences of brush pile creation might arise. Snakes are predators of many brush pile target species (small mammals and rabbits, Weatherhead *et al.*, 2003; northern bobwhite, Staller *et al.*, 2005) and so may influence the survival of species attracted to brush piles as well as species in surrounding habitats. Our results indicate that avian nest success near brush piles was similar to nest success away from brush piles. These results should be interpreted cautiously, however, because our experiment examined nest success only in the year following brush pile creation. Although snakes apparently respond quickly to new brush piles, it may take several years or more for snake use of a new brush pile to reach a maximum. Furthermore, if brush piles are beneficial to ratsnakes, then over an even longer time ratsnake populations may increase in response to brush pile creation. Therefore, longer-term studies are required to determine how snake use of brush piles affects birds nesting in the adjacent habitat. Ideally such research would examine where ratsnakes forage when using brush piles, how avian nest success varies with proximity to brush piles, and the long-term effects of brush piles on snake and bird populations. In the absence of such research it remains possible that actions intended to improve habitat for endangered birds could have the unintended consequence of harming the birds by helping their principal nest predator.

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LITERATURE CITED

BLOUIN-DEMERS, G. AND P. J. WEATHERHEAD. 2001a. Habitat use by black ratsnakes (*Elaphe obsoleta obsoleta*) in fragmented forests. *Ecology*, **82**:2882–2896.

——— AND ———. 2001b. Thermal ecology of black rat snakes (*Elaphe obsoleta*) in a thermally challenging environment. *Ecology*, **82**:3025–3043.

———, ——— AND H. A. MCCRACKEN. 2003. A test of the thermal coadaptation hypothesis with black rat snakes (*Elaphe obsoleta*) and northern water snakes (*Nerodia sipedon*). *J. Therm. Biol.*, **28**:331–340.

DURNER, G. M. AND J. E. GATES. 1993. Spatial ecology of black rat snakes on Remington farms, Maryland. *J. Wildl. Manage.*, **57**:812–826.

GETTINGER, R. D. 1990. Effects of chemical insect repellents on small mammal trapping yield. *Am. Midl. Nat.*, **124**:181–184.

HAUGEN, A. O. 1943. Management studies of the cottontail rabbit in Southwestern Michigan. *J. Wildl. Manage.*, **7**:102–119.

HARVEY, D. S. AND P. J. WEATHERHEAD. 2006. A test of the hierarchical model of habitat selection using eastern massasauga rattlesnakes (*Sitrurus c.catenatus*). *Biol. Conserv.*, **130**:206–216.

HINES, J. E. AND J. R. SAUER. 1989. Program CONTRAST: a general program for the analysis of survival or recovery rate estimates. United States Fish and Wildlife Service Technical Report 24.

HINTZE, J. 2006. NCSS, PASS and GESS. Kaysville, Utah.

HUEY, R. B., C. R. PETERSON, S. J. ARNOLD AND W. P. PORTER. 1989. Hot rocks and not-so-hot rocks: retreat-site selection by garter snakes and its thermal consequences. *Ecology*, **70**:931–944.

MASSER, M. P. AND W. E. GRANT. 1986. Fire ant-induced trap mortality of small mammals in east-central Texas. *Southwest. Nat.*, **31**:540–542.

MAYFIELD, H. F. 1975. Suggestions for calculating nest success. *Wilson Bull.*, **87**:456–466.

REINERT, H. K. AND D. CUNDALL. 1982. An improved surgical implantation method for radio-tracking snakes. *Copeia*, **1982**:702–705.

SCOTT, J. R., C. R. TRACY AND D. PETTUS. 1982. A biophysical analysis of daily and seasonal utilization of climate space by a montane snake. *Ecology*, **63**:482–493.

SPELLERBERG, I. F. 1972. Temperature tolerances of Southeast Australian reptiles examined in relation to reptile thermoregulatory behaviour and distribution. *Oecologia*, **9**:23–46.

SPERRY, J. H., D. A. CIMPRICH, R. G. PEAK AND P. J. WEATHERHEAD. 2009. Is nest predation on two endangered bird species higher in habitats preferred by snakes? *Ecoscience*, **16**:111–118.

——— AND P. J. WEATHERHEAD. 2009. Does prey availability determine seasonal patterns of habitat selection in Texas ratsnakes? *J. Herpetol.*, **43**:55–64.

STAKE, M. M. AND D. A. CIMPRICH. 2003. Using video to monitor predation at Black-capped Vireo nests. *Condor*, **105**:348–357.

———, J. FAABORG AND F. R. THOMPSON, III. 2004. Video identification of predators at Golden-cheeked Warbler nests. *J. Field Ornithol.*, **75**:337–344.

STALLER, E. L., W. E. PALMER, J. P. CARROLL, R. P. THORNTON AND D. C. SISSON. 2005. Identifying predators at Northern Bobwhite nests. *J. Wildl. Manage.*, **69**:124–132.

SWIHART, R. K. AND N. A. SLADE. 1985. Seasonal use of brush piles by the hispid cotton rat (*Sigmodon hispidus*). *J. Mammal.*, **66**:577–580.

WEATHERHEAD, P. J. AND G. BLOUIN-DEMERS. 2004. Understanding avian nest predation: why ornithologists should study snakes. *J. Avian Biol.*, **35**:185–190.

———, ——— AND K. M. CAVEY. 2003. Seasonal and prey-size dietary patterns of black ratsnakes (*Elaphe obsoleta obsoleta*). *Am. Midl. Nat.*, **150**:275–281.

WEBB, W. M. AND F. S. GUTHERY. 1982. Response of bobwhite to habitat management in Northwest Texas. *Wildl. Soc. B.*, **10**:142–146.

——— AND ———. 1983. Avian response to habitat management for northern bobwhites in Northwest Texas. *J. Wildl. Manage.*, **47**:220–222.

WEBB, J. K. AND R. SHINE. 1998. Using thermal ecology to predict retreat-site selection by an endangered snake species. *Biol. Conserv.*, **86**:233–242.

——— AND M. J. WHITING. 2005. Why don't small snakes bask? Juvenile broad-headed snakes trade thermal benefits for safety. *Oikos*, **110**:515–522.

WEITKAMP, W. H., W. D. TIETJE AND J. K. VREELAND. 2001. Brush piles and mesh cages protect blue oak seedlings from animals. *Calif. Agr.*, **55**:23–27.

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