Surveys

Fidelity of Bats to Forest Sites Revealed From Mist-Netting Recaptures

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Abstract

Although site fidelity to permanent roost structures by bats is generally known, long-term fidelity to areas such as foraging or drinking sites is unknown. Furthermore, mist-net recaptures of bats over multiple years are rarely reported. Extensive mist-net surveys were conducted over the course of 8 y in the Ouachita National Forest of central Arkansas, United States to investigate long-term site fidelity and recapture rates of individually marked forest bats. Among eight species that were captured, five species were recaptured over spans ≥1 y, including eastern red bats *Lasiurus borealis*, Seminole bats *L. seminolus*, evening bats *Nycticeius humeralis*, tri-colored bats *Perimyotis subflavus*, and northern long-eared bats *Myotis septentrionalis*. Some individuals were recaptured multiple times over multiple years, and the maximum span over which an individual was recaptured was 1 y for Seminole bats, 2 y for tri-colored bats, 3 y for evening bats, 4 y for eastern red bats, and 5 y for northern long-eared bats. These results indicate long-term site fidelity by multiple bat species to particular forest sites, primarily pools along small intermittent streams. Proximity to these sites should be considered when conducting management activities.

Keywords: recaptures; banding; evening bat; northern long-eared bat; red bat; Seminole bat; tri-colored bat

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Introduction

Banding has been used for decades to determine longevity, survival, population size, homing ability, movements, migrations, and site fidelity of bats (Ellison 2008). Historically, these banding efforts targeted bats that exhibited strong site fidelity to a particular location and were easily relocated in relatively permanent structures, such as caves, mines, bridges, and buildings. Consequently, much information is available on intra- and inter-annual fidelity by bats to these permanent structures. Recent interest in forest-roosting bats has resulted in abundant studies on roosting in forests (e.g., Lacki and Baker 2003; Kalcounis-Rüppell et al. 2005), and studies have demonstrated short-term fidelity to a single tree or group of trees by these species during summer (e.g., Perry and Thill 2007a, b; Veilleux and Veilleux 2004). However, these studies were generally limited by the longevity of batteries in radio transmitters used to locate bats (typically 10–30 d). Revisiting trees previously used for roosting has resulted in information on fidelity within a season (e.g., Constantine 1958, 1966) and fidelity to tree cavities over multiple years (e.g., Humphrey et al. 1977; Willis et al. 2003; Lučan et al. 2009). Short-term studies occasionally report intra- and inter-annual recaptures during mist netting in forests (e.g., Broders et al. 2003; Leput 2004; Veilleux and Veilleux 2004; Boyles and Robbins 2006). Nevertheless, studies rarely demonstrate fidelity over multiple years by individual bats to foraging or drinking areas. For migratory foliage-roosting species, little is known about migration, movements, or long-term site fidelity to forested sites.

Although studies often entail mist netting and banding of bats over streams or flyways (e.g., Fenton 1997; Weller and Zielinski 2006), recaptures of banded bats at nonroost locations are infrequently reported, and

long-term or extensive mist-netting efforts that involve banding forest-dwelling bats over multiple years are rare. It is generally believed that bats become 'net-wise' after capture and are difficult to recapture. Consequently, capturing bats in areas not affiliated with a permanent roosting structure, such as foraging and drinking areas, has historically produced few band returns, making studies such as mark–recapture of forest-roosting bats a challenge. However, information gleaned from recapturing tree-roosting bats provides insight into ecology, movements, migrations, and site fidelity for many species, including migratory tree bats (Cryan and Veilleux 2007). In this study, recaptures from 8 y of extensive mist netting over forest streams were used to provide evidence of intra-annual and inter-annual site fidelity by individual forest-roosting bats to specific forested areas during summer.

Methods

The study was conducted in a 6,545-ha area of the Ouachita National Forest (U.S. Forest Service), in northwestern Saline County (34°45′N, 93°15′W), within the Ouachita Mountains of central Arkansas. Predominant forest types were shortleaf pine *Pinus echinata*–hardwood, oak *Quercus* spp.–hickory *Carya* spp., and intensively managed industrial timberlands consisting primarily of closed canopy and older thinned plantations of loblolly pine *P. taeda*. For a detailed description of the study area, see Perry et al. (2007).

Most bats were captured over stream pools using mist nets. Bats were captured using mist nets (2.6–12.0 m wide × 2.6 m tall) between 1 May and 17 September 2000–2005, and again in 2007–2008. Nets were opened at dusk (approximately 2015–2115 hours Central Daylight Time, depending on month) and monitored continuously for 3–5 h. Bats were captured at 21 sites distributed throughout an area approximately 4.5 × 10.3 km. However, most (90%) netting was concentrated at 10 sites with high capture success. These sites were centered on pools (typically about 600 m^2) that occurred either along small, intermittent streams beneath the forest canopy ($n = 9$), or on the Alum Fork of the Saline River ($n = 1$). At each capture site, multiple mist nets (2–8) were placed in a variety of locations, but primarily over water. Among all trap sites, net locations included roads (47 net-nights; 1 net-night = 1 net open for 1 evening), forests (8 net-nights), streams (626 net-nights), dry creek beds (30 net-nights), and ponds (3 net-nights). The 10 primary sites were trapped 163 times, and each of these sites was trapped an average of 16.3 times (±2.38 SE; range = 8–29).

Bands were affixed on the forearms of captured bats using two banding schemes, following guidelines of the American Society of Mammalogists for the capture, handling, and care of mammals (Animal Care and Use Committee 1998; Gannon et al. 2007) under permit from the Arkansas Game and Fish Commission. For the first scheme (2000–2005), one split-plastic band was affixed on each forearm. For the second banding scheme (2007–2008), a single, numbered, aluminum band was used.

Results

Over eight summers, 160 different nights were trapped (716 net-nights), resulting in 2,199 total captures (Table 1; *Supplemental Material*, Table S1, http://dx.doi.org/10.3996/082010-JFWM-030.S1). Total captures included 395 captures where bats were not affixed with bands because they either escaped before bands could be attached or there were no more bands available during that trapping night. Thus, 1,717 individuals were banded. There were 94 recaptures of 71 banded individuals over the 8 y, and no bats were captured that were banded by other researchers from other areas. Recaptured species included eastern red bats *Lasiurus borealis*, Seminole bats *L. seminolus*, evening bats *Nycticeius humeralis*, tri-colored bats *Perimyotis subflavus*, and northern long-eared bats *Myotis septentrionalis*. No banded hoary bats *L. cinereus*, silver-haired bats *Lasionycteris noctivagans*, or big brown bats *Eptesicus fuscus* were recaptured. At least 24 individuals were captured more than once on the same night; however, bats often flew into nets within a few minutes after release and were not tabulated. Thus, estimates for recaptures during the same night are biased low. There were 26 individuals that were captured previously on different nights of the same year and 28 individuals that were captured over multiple years.

Among bats captured over multiple years, 18 were recaptured only in the year following initial capture, and 10 were recaptured at intervals ≥2 y. For each species, maximum span over which a bat was captured was 1 y for Seminole bats, 2 y for tri-colored bats, 3 y for evening bats, 4 y for eastern red bats, and 5 y for northern long-eared bats. Some bats were captured multiple times over multiple years. For example, a female eastern red bat was captured over the same stream pool in 2004, 2005, and 2007; a female northern long-eared bat was captured over a stream pool in 2002, but recaptured at another stream pool (approximately 2.5 km away) in 2005 and 2007; and a male evening bat was captured four times over a 3-y period at the same location. Excluding bats that were captured more than once the same night, evening bats represented the group with highest overall proportion of recaptures (12.2%; Table 1). Furthermore, some evening bats showed high fidelity to certain stream pools and were readily recaptured there. For example, one male evening bat that was recaptured >2 y after initial capture had illegible band numbers; thus, it was unknown how many times this bat was previously captured. Bands on the bat were replaced; thereafter, it was recaptured two more times during that summer.

For eastern red bats, 35% of bats recaptured during the same year were females, similar to the percent of females banded (31%; Table 1). However, 70% of eastern red bats recaptured over multiple years were female, suggesting female eastern red bats may have greater long-term site fidelity than males. Likewise, although 49% of banded northern long-eared bats were female, most (80%) bats recaptured over multiple years were female. Nearly all (92–96%) banded evening bats, silver-haired bats, and Seminole bats were males; consequent-

Table 1. Total captures of each species by sex (♂ = male, ♀ = female, Unk. = unknown), number of individual bats banded, number of individuals recaptured on the same night (Same night), number recaptured on different nights of the same year (Multiple nights), number recaptured over intervals ≥1 y (Multiple years), and the percentage of all individuals recaptured over intervals ≥1 y (% of total banded) during May–September in the Ouachita Mountains of Arkansas, United States, in 2000–2005 and 2007–2008. Total number of trapping net-nights was 716, conducted over 160 nights.

							Number of individuals recaptured						
	Total captures			Number banded			Same night		Multiple nights		Multiple years		% of total banded
Species	♂	♀	Unk.	♂	♀	Unk.	♂	♀	♂	♀	♂	♀	
Eastern red bat *Lasiurus borealis*	1,028(78)[a]	434(42)	203	867(73)	389(39)	1	18(1)	3(1)	13(2)	7(0)	3	7	0.8
Seminole bat *L. seminolus*	46(0)	4(0)	0	40(0)	1(0)	0	0	0	1(0)	0	1	0	2.4
Hoary bat *L. cinereus*	29(1)	17(0)	6	27(1)	16(0)	0	0	0	0	0	0	0	0
Silver-haired bat *Lasionycteris noctivagans*	43(0)	2(0)	0	41(0)	2(0)	0	0	0	0	0	0	0	0
Tri-colored bat *Perimyotis subflavus*	61(7)	21(3)	3	58(7)	18(2)	0	0	0	0	0	1	0	1.3
Big brown bat *Eptesicus fuscus*	19(2)	6(0)	0	17(2)	6(0)	0	0	0	0	0	0	0	0
Evening bat *Nycticeius humeralis*	96(2)	5(3)	3	77(2)	5(3)	0	2(0)	0	4(0)	0	10	0	12.2
Northern long-eared bat *Myotis septentrionalis*	78(11)	86(7)	9	77(11)	75(7)	0	0	1(0)	0	1(0)	1	5[b]	3.9
Total	1,400(101)	575(55)	224	1,204(96)	512(51)	1	20(1)	4(1)	18(2)	8(0)	16	12	1.6

[a] Total captures (number that were juveniles in brackets).
[b] Includes one recapture from previous year of unknown sex.

ly, the likelihood of recapturing females of these species was low.

Discussion

At least five of eight species of forest-roosting bats demonstrated inter-annual site fidelity to relatively small areas of forest. Twenty-eight individual bats were captured at the same sites over multiple years, indicating inter-annual fidelity to foraging or drinking areas. Although bat trapping was not conducted during the winter months, some eastern red bats, Seminole bats, tri-colored bats, evening bats, and northern long-eared bats either utilized the same forested streams throughout the year or returned to the same sites each summer.

Few reports of recaptures or inter-annual site fidelity for tree-roosting bats exist, especially for migratory tree bats (red, hoary, and silver-haired bats). Davis (1969, 1970) reported band returns on two hoary bats in Texas and Arizona, United States; one was recovered 3 y later (approximately 90 miles away) and another recovered 4 y later (approximately 180 miles away). In the Cypress Hills of Saskatchewan, a hoary bat that was banded in its roost as a juvenile was recaptured in a net the following year, and then radiotracked to a roost located approximately 50 m from the previous year's roost (C.K.R. Willis, University of Winnipeg, Manitoba, personal communication). Although a few recaptures between years have been reported for eastern red bats (Leput 2004), tri-colored bats (Veilleux and Veilleux 2004), and evening bats (Boyles and Robbins 2006), I am unaware of reported recaptures of Seminole bats or northern long-eared bats in forests over multiple years. Nevertheless, for migratory tree bats, little is known about their inter-annual site fidelity and it is not known if they commonly remain in the same areas in southern latitudes or return annually to areas based on latitude and climate.

Hoary bats, silver-haired bats, and big brown bats were not recaptured, but it is unlikely this was due to avoidance of nets (i.e., being net-wise). For big brown bats, sample size (n = 23 bats banded) was probably too low for recaptures. Both hoary bats and silver-haired bats are migratory, and most captured silver-haired bats were likely migrating; they are not resident in Arkansas during the summer reproductive season (Perry et al. 2010). Likewise, although hoary bats breed in the Ouachita Mountains, they are relatively rare in this area during the summer reproductive season (Perry et al. 2010). Most hoary bats were captured in late spring and late summer during the migration periods, and hoary bats tracked with radio transmitters during these times suggested most were migrating (Perry and Thill 2007c).

Studies suggest some species may be more readily recaptured than others (Fleming et al. 1972), and most studies of bats captured via nets in forests report short-term recapture rates (e.g., among nights or weeks) of roughly 1–3% in temperate North America (e.g., Wilhide et al. 1998; Leput 2004; Winhold and Kurta 2008). Overall recapture proportion among different nights in this study (3.1%) was higher than most previously reported and was as high as 12.2% for male evening bats, probably because

of more intense, multiyear sampling. Among the species captured, evening bats appeared to be most readily recaptured, similar to results from other studies (Leput 2004; Boyles and Robbins 2006). Furthermore, studies suggest evening bats may remain in the same geographic area throughout the year in southern latitudes (Boyles and Robbins 2006), indicating relatively strong inter-annual site fidelity for this species in the southeastern U.S.

Although eastern red bats were the most frequently captured species (76% of all captures), they had one of the lowest recapture rates. Many (70%) of the total captures of eastern red bats were during the August to September swarming–migration period, but no eastern red bats recaptured during this time were captured in previous years. All recaptures of eastern red bats during the swarming–migration period were originally banded during the same period. However, other species (i.e., northern long-eared bats, evening bats, and tri-colored bats) originally banded in previous years were recaptured during this period. Thus, many eastern red bats captured in August and September likely were migrants. One eastern red bat that was originally banded on 6 August was recaptured on 17 September (42 d later), suggesting some eastern red bats may have short-term site fidelity during late summer, but it is currently not possible to distinguish permanent residents from migrants. Stable isotope analysis (e.g., Peterson and Fry 1987; Cryan et al. 2004) may help delineate residents from migrants in the future.

This study is the first to report relatively frequent recaptures of tree-roosting bats, especially eastern red bats, and the first to report recaptures of some species (e.g., Seminole bats) over multiple years. These results indicate that intra- and inter-annual site fidelity by forest-dwelling bats to individual forest stands or foraging areas, including particular stream pools, may be a common phenomenon. Because bats are long-lived (e.g., Holmes and Austad 1994), areas where bats remain or return are likely discovered through trial and error or learned via philopatry, and there are likely benefits for remaining or returning to the same areas. Familiarity with satisfactory roosting, foraging, and drinking locations, and areas that may enhance predator avoidance or mating opportunities, along with reduced time searching for these adequate areas likely improves fitness for those individuals that exhibit site fidelity.

Although 87% of captures were over the larger pools of small, intermittent streams under the forest canopy, all recaptures were over pools. Furthermore, trial-and-error trapping in various locations suggested these areas had the greatest bat activity. Thus, larger pools along small streams under the forest canopy likely provide important and familiar foraging and drinking habitat that are frequented throughout the lives of many bats across a landscape. Proximity to these pools should be considered when planning management activities.

Supplemental Material

Please note: The *Journal of Fish and Wildlife Management* is not responsible for the content or functionality of any supplemental material. Queries should be directed to the corresponding author.

Table S1. Bat capture and recapture data, 2000–2008. See Metadata tab for detailed explanations and abbreviation definitions.

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