Rapid Assessment for Basal Cavities on Dahomey National Wildlife Refuge: Implications for Present and Future Bat Conservation

Final Report

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Conservation of forest dwelling bats has been gaining significant interest and review when initiating management strategies to enhance trust wildlife resources (e.g., high priority neotropical migratory birds) within the National Wildlife Refuge System. The predominant issue focuses on silvicultural treatments within bottomland hardwood forest to promote early successional habitat conditions desired by some avian species (Twedt et al. 1998, Wilson et al. 2007). These treatments have the potential to negatively affect bat species which depend on older-growth trees for diurnal roosts. In particular, Rafinesque's big-eared bat (RBEB, *Corynorhinus rafinesquii*) and the southeastern myotis (SEM, *Myotis austroriparius*) rely on hardwood trees to provide basal and upper canopy cavities for diurnal, maternal and winter roosts (Cochran 1999, Clark et al. 1998, Gooding and Langford 2004, Trousdale and Beckett 2005, Stevenson 2007, Rice 2009, Stuemke et al. in review, and others). Both species are listed as a species of concern; threatened or endangered throughout their ranges; and are being reviewed by the United States Fish and Wildlife Service for consideration of listing under the Endangered Species Act (Mike Armstrong, pers. communication 2011, Kentucky ES Office). The deforestation of the bottomland hardwood across 80% of the Mississippi River Alluvial Valley (MAV, Tiner 1984) has devastated historic habitat for these species within this geographic area. The resultant forested area is a patchwork of forest blocks (Twedt and Loesch 1999) and RBEB and SEM populations have been restricted to remnants of a vastly larger system. Moreover, suitable cavities for diurnal roosting is likely limited given almost all the forest blocks in the MAV are comprised of relatively young second growth trees which remain largely for commercial forest production. This collective loss of habitat is presumed to have resulted in significant population decrease of these 2 bat species (Harvey et al. 2011).

Habitat management plans for national wildlife refuges provide the frame-work for management actions over a period of 15 years. This process prioritizes species of concern, describes and implements habitat treatments to meet goals and objectives for wildlife and habitats, and evaluates and resolves potential resource conflicts. With regards to the Dahomey NWR HMP, there is significant debate about conflicts associated with strategies to increase abundance of avian species, long-term loss of bat roost habitat, and efforts to increase the ecological integrity of the forest through adoption of a passive forest management program. Therefore, a rapid assessment of the availability of basal cavities and occupancy of them by RBEB and SEM was conducted to establish baseline information and provide a framework for discussion regarding the Habitat Management Plan for Dahomey NWR.

The objectives of the assessment were:

1) Estimate the availability of basal cavities within mature hardwoods.

2) Describe the tree species and diameter class with basal cavities.

3) Evaluate the suitability of trees with basal cavities for diurnal roosting and use by RBEB and SEM.

4) Provide recommendations concerning the present and future conservation for RBEB and SEM on Dahomey National Wildlife Refuge.

Study Area and Methods

This work was done at Dahomey National Wildlife Refuge located in the delta region of Bolivar County, Mississippi. The refuge is approximately 3 miles east of the main-line levee associated with the Mississippi River. Approximately 8,100 acres of the 9,420 acre refuge is mature bottomland hardwood dominated by trees 45-60 years old; 900 acres in reforested hardwoods (<20 years old), and the remainder in fields and croplands. Most of the forest was thinned or clear cut since1969; cull trees were left throughout the stands following harvest. Overstory canopy was relatively closed with basal area in stands 80-120 ft^2/acre (Smith and Sansing 2008). Dominant hardwood species include bitter pecan, cedar elm, green ash, honey locust, Nuttall oak, sugarberry, sweetgum, water oak, and willow oak. Other common species include overcup oak, swamp chestnut oak, shagbark hickory. Bald cypress was isolated to the margins of 2 sloughs with a few (< 10) relict trees present within them. No water tupelo occurs on or near the refuge. Stand composition varies significantly based on small elevation changes and past timber harvest practices. Topographic relief across the refuge is less than 5 feet. Wetlands on the refuge include 3 narrow bayous (<30 feet wide), 2 sloughs (88 acres) and several small ephemeral wetlands. The refuge is essentially a forested island with nearly all land within 2 miles of the refuge in agricultural row crops.

Basal Cavity Estimation and Bat Use

A survey of mature bottomland hardwood stands was conducted October 7-26, 2011 to locate trees with basal cavities. Sample sites were logistically designed to encompass the entire refuge and generally geographically defined by roads or trails. A single observer walked the center of an elongated 1 acre plot (66 feet x 660 feet). Trees with a DBH $\geq$ 6 inches and within 33 feet of plot center with a basal cavity were measured. Metrics recorded for all trees included species and diameter at breast height (DBH, in 2-inch diameter classes). It was recognized that a singular observer would miss some basal cavities on the blind side of the trees; however, the process provided a rapid index of basal cavities by species and DBH class regardless of the suitability of the cavity to bats. Visual inspection of the inside chamber was restricted to trees with a ≥14-inch DBH. This was done based on a minimum threshold of detection of RBEB and SEM in trees with a 16-inch DBH reported by Stevenson (2008). The decrease in the DBH class of the present survey was done to insure higher detection probability. A mirror was inserted within the chamber and the light from a flashlight reflected upward to examine for presence of bats on the walls and ceiling of the chamber. The width and height of cavity entrance were measured to the nearest inch; inside chamber height (feet) was estimated for visually inspected trees, and trees geo-referenced (latitude, longitude, NAD 83). Chamber height was visually estimated because no reliable or easy method was possible to measure the inside chamber. Means and ranges were generated for estimates of basal cavities by tree species, diameter classes, and sample sites. Potential differences of cavity densities between diameter classes were evaluated using a t-test with an alpha= 0.05. An estimate of total basal cavity and suitable basal cavity tree abundance for the refuge was generated by multiplying the estimated basal cavity tree density by 8,100.

Because this was a rapid assessment, forest stand measurements were not taken when conducting plots to provide a comparison of availability of tree species, diameter classes or age structure. However, similar information has been taken during a refuge wide forest inventory but not available for this preliminary report (unpublished data, 2008, USFWS).

Ancillary Trees

To increase sampling effort for potential bat use, trees with a basal cavity and DBH ≥14 inches outside the plots were inspected and recorded when conducting plot surveys or walking between plots. These trees had the same metrics recorded as trees within plots but were not used to calculate the index of mean basal cavities/acre. However, they were used to generate a percentage of suitable cavities inspected. Suitable cavities for occupancy by RBEB and SEM were deemed those with a ≥ 14-inch DBH and inside chamber of ≥ 8 feet based on tree metrics of used trees reported by Stevenson (2008).

In addition to the survey plots, targeted inspection of individual cypress trees was done within 88 acres of 2 sloughs to identify relict trees for basal cavities or hollowness near the base and possible upper cavity entrances. The base of each tree was thumped with a hammer to discern internal hollowness within 7 feet of the ground if no basal cavity was present. Bald cypress and water tupelo have been previously shown to provide important winter and maternal roost sites especially within hollow trees without basal cavities (Gooding and Langford 2004, Stevenson 2008, Rice 2009, Clement 2011).

Acoustical Detection

To provide a broader potential for detection of RBEB and SEM on the refuge, an acoustical survey was done along a 25 mile route of the refuge road system on November 8, 2011 (Figure 3). An Anabat II (Titley Electronics, Ballina NSW, Australia) was fixed to the roof of a vehicle with the microphone pointed directly vertical. The route began 30 minutes after sunset and was conducted at 15-20 mph. The detector was run continuously including portions of the route which overlapped previous sampled sections of roadway. Individual call sequences were identified to species using BCID_10 Version 2.2.1.4 (Bat Call Identification, Inc, Kansas City, Missouri). Filter parameters were set to restrict analysis to files with a minimum of 5 calls/15 second interval and species delineation to big-brown bat, red bat, evening bat, hoary bat, RBEB, SEM, silver-haired bat, and tricolored. The parameters were designed to reduce false positives and erroneous species designation based on known or suspected bat species occurring within the MAV.

Results

Plot Trees

Seventeen sites were sampled within mature bottomland hardwood across the refuge (Figure 1). A total of 211 plots were surveyed for trees with basal cavities. Basal cavities were recorded in twenty tree species (Table 1). Representative small diameter class trees (DBH < 14 inches) had small developing cavity entrances whereas larger trees had well developed entrances. (Figure 2). The estimate of basal cavities/acre among 17 sample sites varied from 0.29 – 1.80 cavities (Table 1). However, because sample sites were not stratified based on any known habitat differences, data were pooled for general estimates by tree species and diameter classes. Thus, the overall mean index of trees with basal cavities was 1.07/acre (range = 0-7, SD =1.17)(Table 2). Basal cavity density was slightly higher but not significant for trees with a DBH $\geq$14 inches compared to trees with a DBH <14 inches (t=1.23, P=0.21, Table 2). The estimated density of suitable cavities was 0.21 /acre (SD = 0.47). The proportion of suitable cavities (44 trees observed) in relation to those with a minimum DBH $\geq$ 14 inches (122 trees) was 31%. Estimated abundance of all trees with basal cavities and those with suitable basal cavities on the refuge is 8667 (95% CI, 7373-9961) and 1689 (95% CI, 1170- 2208), respectively.

A visual inspection of the interior chamber of 118 of 122 cavities was done; 3 entrances were too small to inspect and 1 entrance was obstructed by an eastern wood rat nest (*Neotoma floridana*, Figure 1d). No bats or obvious signs of bat feces were observed.

Ancillary Trees

Thirty-one potential roost trees consisting of 10 tree species were examined outside the defined plots for bat occupancy (Table 3). Twenty-seven of these were considered suitable. No bats or obvious signs of bat feces were observed. Eastern wood rat nests were located in 9 of the 31 trees.

Ten relict bald cypress trees were inspected within 2 sloughs (Figure 1). One tree had a fire scar at the base which extended 7 feet up that provided a shallow chamber (1 foot). The other nine relict cypress (DBH >50 inches) contained no basal cavities.

Visual inspection of the upper canopy did not identify any cavity entrances, and all appeared not to be hollow at the base.

Acoustical detection

Passive monitoring for bats along the vehicle route recorded 359 high frequency data files. These were not visually examined to determine those with actual bat calls embedded. Of the 359 data files, the BCID_10 software characterized the call structure of bats from 68 data files based on a filter parameter of $\geq$5 calls/15 second. Bats were identified as red bat (n=12), tricolored bat (n=39), evening bat (n=16), and1 unknown.

Discussion

The importance of tree hollows as natural roosts for RBEB and SEM within bottomland hardwoods has been well documented. Only recently have a few studies attempted to combine cavity availability and suitability, with detection probability and occupancy rates by RBEB and SEM as a means of indexing species presence (Stevenson 2008, Stuemke et al. in review, Clement 2011). The relative abundance of trees with basal cavities across the refuge was substantial (approximately 1 per acre) with a density of suitable cavities at 0.21/acre. The only comparative study showed a suitable cavity index of only 0.02/acre (Stuemke et al., in review). All dominant hardwood species on the refuge produced cavities with highest densities recorded for cedar elm, green ash, sugarberry and sweetgum. It was not possible to determine the propensity of a tree species to develop a cavity because stem density was not measured. Nonetheless, a wide range of tree species with differing diameter classes are providing present and future basal cavities for bats and other cavity dependant species.

The apparent absence of either bat species on the refuge was unexpected given the number of suitable cavities examined. Tree diameter and internal chamber height of suitable basal cavities and the type of tree species were similar to use trees reported by Stevenson (2008) and Stuemke et al. (in review). Clement (2011) suggested occupancy could be better explained in part by interior chamber roughness. In the current study, many of the walls were much rougher and the ceiling contained dangling debris compared to occupied trees observed by Stevenson (2008, pers. observation). However, in a companion study at Panther Swamp NWR in the Delta of MS, multiple inspections of 120 suitable basal cavities within hardwood trees failed to detect roosting bats (H. Flemming, unpublished data). Many other studies have also reported very limited occupancy of hardwood trees (excluding water tupelo and bald cypress) but did not systematically search study areas for availability (Lance et al. 2001, Trousdale and Beckett 2005, Mirowsky et al. 2004, Stuemke et al. in review, Clement 2011). Water tupelo has been reported as the most frequently used tree for RBEB and SEM diurnal roosts (Gooding and Langford 2004, Carver and Ashley 2008, Clement 2011). This may be in part a function of a very high density of suitable cavities in relatively monotypic stands of water tupelo (Gooding and Langford). The 2 small sloughs on the refuge contained no water tupelo and had been cleared of native cypress in the late 19th and 21st century (Saikku 2005). It is possible that water tupelo and cypress breaks adjacent to the refuge may be supporting bats. The rapid assessment also was limited to basal cavities for determination of occupancy. While basal cavities provide a repeatable and easy site for RBEB and SEM detection (Carver and Ashley 2008), many potential roosts can be missed due to cavity entrances located along the upper bole of trees. Several studies reported upper cavity use determined by relocating radio-tagged bats (Trousdale and Beckett 2004, Stevenson 2008, Rice 2009, Stuemke et al. in review). Because of the difficulty of observing upper canopy cavity entrance, no efforts were done in this study which could serve as important roosts. Though the acoustical survey also failed to detect either species, these results should not be used to exclude presence of either bat species. The effort did not focus on areas of high bat activity near water and was limited to only 2.5 hours of detection. In addition, RBEB echolocations are difficult to record due to the low intensity echolocation calls (Fenton 1982). Common bats anticipated to occur at high densities were detected.

Population estimates provide a reliable measure of the status and viability of species. However, rare, uncommon, or species with low densities can be difficult to obtain population estimates and trends. Such has been the case with RBEB and SEM due to the inability to provide a reliable estimate or index of the species or even detect occupancy across their range (Clark 2003). Information regarding species presence or absence in conjunction with measures of suitability of habitat conditions may provide indirect measures of population status and viability. RBEB are non-migratory and exist in groups of single individuals to a few hundred (Jones 1977). Because the species shows very little dispersal among populations (Paiggio et al. in press), isolated populations are more vulnerable to localized extirpation. The conservation of forest dwelling bats needs to consider forest patch size, density and degree of fragmentation across the landscape (Medlin et al. 2010). Twedt and Loesch (1998) have shown that the remainder of forest patches within the MAV are relative small and fragmented. As existing forest patches become smaller due to harvest or clearing for agriculture, the probability of local extirpation of small bat population increases. This may be the situation for all bats species at Dahomey NWR. Source populations may be too distant to replenish the population given the limited dispersal of these forest dwelling species.

The mechanism limiting RBEB and SEM on the refuge may be a function of the conditions surrounding the forest rather than a lack of suitable roost and foraging habitat. Agricultural practices regularly apply pesticides to limit crop damages. Though most chemicals are relatively safe label rates and does not cause direct effects to mammals, the indirect effects may be just as detrimental. RBEB are gleaners and forage on a diet composed heavily of Lepidoptera (Hurst and Lacki 1997). Multiple applications of insecticides through the growing season could easily affect the availability of prey items. The long-term implications may result in a steady and continued decline of bat species which rely on this insect forage base.

Management Recommendations

The rapid assessment to evaluate potential diurnal roosts for RBEB and SEM provides a reliable index of basal cavities. However, the small sample of suitable trees may preclude detection of the species at low densities and give a false indication of absence. This limitation can be partially overcome by conducting multiple inspections of suitable cavities or increasing the number sampled during warm months of high bat activity to increase detection probability. Likewise, the acoustical survey route designed to limit repeated detections of the same individual bat across an area may not detect RBEB due to its low volume call or if species has low densities. Future acoustical surveys should consider passive detection at 10-20 fixed locations for a limited period of 10-15 minutes each. This will allow for extended call sequences necessary for species characterization and capitalize on bats tendency to occupy areas near water sources or along flight corridors. The initiation of the acoustical survey at each site should vary between period to account for bat movement between roost sites and foraging locations.

Finally, given the lack of understanding of bat occupancy and habitat use by RBEB and SEM, a resolution of resource conflicts with avian conservation initiatives cannot be achieved through a compromise of management strategies. The relative increase in densities of selective birds (e.g., Swainson's warbler) through a process of recurring hardwood canopy disturbances (Wilson et al. 2007, Twedt and Somershoe 2008) within an area incapable of supporting viable populations, does not seem to outweigh the risks to rare or uncommon bats which are being considered for listing under the ESA. Therefore, a program to promote the development of old-growth forest conditions though a passive forest management program fosters a more comprehensive approach to avian and bat conservation along with the promotion of ecological integrity of the bottomland hardwood ecosystem.

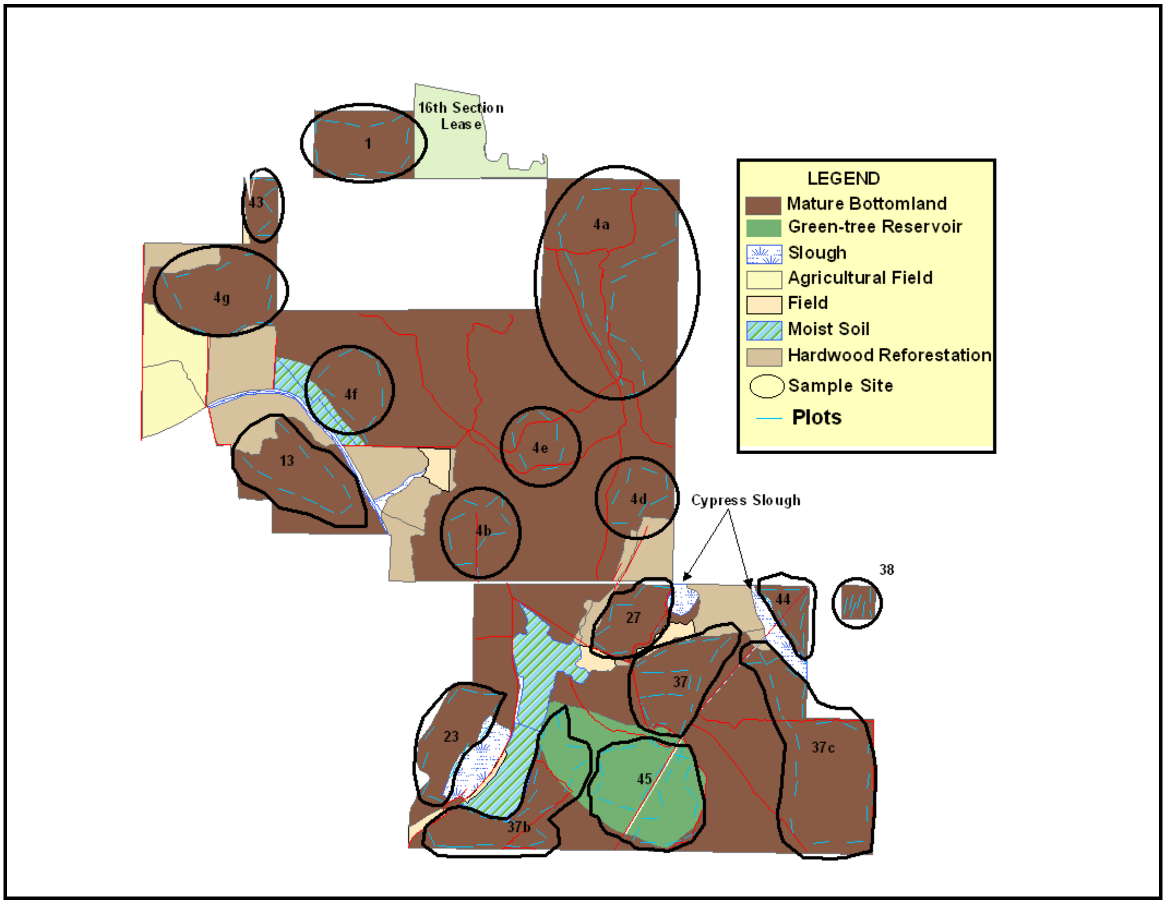

Figure 1. Location of sample sites for basal cavity trees, plot locations, and habitat cover classification on Dahomey National Wildlife Refuge during October 7-21, 2011.

Figure 2. Twenty-five mile acoustical survey route for detection of bats using an Anabat II detector along roads within Dahomey National Wildlife Refuge on November 8, 2011. Route initiated at the refuge office going north along Headquarters Road and ending at Bogue Pahlia on Mississippi Hwy 446.

c.

d.

a.

b.

Figure 2. Photographs of basal cavities on Dahomey National Wildlife Refuge: a) basal cavity in 8-inch DBH sweetgum, b) basal cavity in 16-inch DBH cedar elm, c) basal cavity in >30-inch DBH willow oak deemed suitable, and d) basal cavity in willow oak obstructed by an eastern wood rat nest.

Table 1. Estimate of basal cavities/acre by tree species and diameter class, and number of trees observed with cavities for all plots (n=211) and sample sites (n= 17) combined on Dahomey National Wildlife Refuge collected during October 7 – 26, 2011.

	DBH < 14 inch			DBH ≥ 14 inch		
Tree Species	Mean	SD	n	Mean	SD	n
American Elm	0.01	0.11	3	0.004	0.07	1
Bitter Pecan	0.004	0.07	1	0.04	0.20	9
Blackgum	0.01	0.10	2			
Box Elder	0.004	0.07	1			
Cedar Elm	0.06	0.27	12	0.05	0.24	11
Cherrybark Oak	0.004	0.07	1	0.004	0.07	1
Eastern Cottonwood				0.004	0.07	1
Green Ash	0.15	0.43	31	0.09	0.33	18
Hickory[a]				0.004	0.07	1
Honey Locust				0.01	0.10	2
Nuttall Oak	0.02	0.15	5	0.03	0.23	7
Oak – unknown snag				0.004	0.07	1
Overcup Oak				0.04	0.22	9
Shagbark Hickory	0.01	0.10	2	0.01	0.1 0	2
Sugarberry	0.14	0.43	18	0.10	0.33	30
Swamp Chestnut Oak				0.02	0.15	5
Swamp Laurel Oak	0.004	0.07	1			
Sweetgum	0.05	0.23	10	0.09	0.35	29
Sycamore	0.004	0.07	1	0.004	0.07	1
Water Oak	0.01	0.10	2	0.004	0.07	1
Willow Oak				0.06	0.26	13
Total	0.48	0.79	102	0.57	0.78	123

[a] Either Mockernut or Pignut Hickory

Table 2. Estimate of basal cavities/acre by sample sites and two diameter classes pooled for all tree species on Dahomey National Wildlife Refuge collected during October 7 – 26, 2011.

Sampling Site	No. Plots	DBH<14 $\bar{X}$	DBH $\geq$ 14 $\bar{X}$	Combined $\bar{X}$
1	11	0.45	0.18	0.64
4a	25	0.20	0.60	0.80
4b	10	0.80	0.90	1.70
4d	7	0.00	0.29	0.29
4e	7	0.29	0.00	0.29
4f	9	0.89	0.78	1.67
4g	10	1.00	0.80	1.80
13	10	0.20	1.10	1.30
27	9	0.89	0.67	1.67
37	17	0.65	0.53	1.18
37b	21	0.48	0.57	1.05
37c	20	0.35	0.45	0.80
38	7	0.71	1.00	1.71
43	6	0.33	0.00	0.33
44	9	0.22	0.78	1.00
45	22	0.59	0.64	1.23
Pooled	211	0.48	0.59	1.07

Table 3. Tree species, number sampled, mean DBH, and number suitable of ancillary basal cavity trees inspected within 17 sample sites on Dahomey National Wildlife Refuge from October 7 – 26, 2011.

Tree Species	No. Trees	Mean	Range	Suitable[b]
American Elm	2	22	20-24	2
Bitter Pecan	5	27	20-38	5
Cedar Elm	1	26		1
Cherrybark Oak	1	16		1
Nuttall Oak	8	37	14-50	7
Oak – snag[a]	1	42		1
Overcup Oak	6	33	22-46	5
Sugarberry	1	28		1
Swamp Chestnut Oak	1	34		1
Sweetgum	3	27.5	24-30	2
Water Oak	2	42	38-46	1
Total	31	31	14-50	27

[a] Species was either a Nuttall or willow oak.

[b] Suitable trees had a DBH $\geq$ 14 inches and an inside chamber height $\geq$8 feet.

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