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Habitat Factors Affecting Trap Success of Swamp Rabbits in Southeastern Arkansas During a Flooding Event

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Abstract.—Swamp rabbits (*Sylvilagus aquaticus*) are found in bottomland hardwood ecosystems that have canopy gaps dispersed throughout. During annual flooding of these ecosystems, swamp rabbits often are displaced to adjacent uplands or higher ground within the bottomlands. Trapping of swamp rabbits is reported to be best during times of flooding. We examined habitat characteristics at trap sites to identify the best suite of habitat characters to target when trapping for swamp rabbits during flooding conditions. We conducted trapping for swamp rabbits during a flooding event from 2 January 2007 to 3 February 2007. A total of 511 trap nights yielded 16 swamp rabbit captures, or an overall capture rate of 3.1%. We reduced the habitat data set using principal component analysis and identified habitat characteristics most important to trapping success using stepwise discriminant function analysis. Variables important for successful trapping of swamp rabbits were canopy cover, percent ground cover of leaves, distance to trees (i.e., tree density), number and stage of decomposition of stumps, diameter at breast height of trees, and distance to temporary water sources. Because some states list swamp rabbits as a species of concern, knowledge of habitat variables most often selected by swamp rabbits during a flooding event may assist with trapping for future studies concerning the species.

Key words:—Swamp rabbits, *Sylvilagus aquaticus*, trapping, bottomland hardwood ecosystems.

Introduction

Swamp rabbits (*Sylvilagus aquaticus*) are the least studied of the cottontail species (Chapman and Feldhamer 1981). Swamp rabbits generally inhabit bottomland hardwood forests (Sealander and Heidt 1990) with canopy gaps dispersed throughout. Habitat conditions in the center of the species' distribution have not been as well documented as habitat at the edge of its distribution (Terrel 1972). Swamp rabbit populations are in decline at the edge of their distribution, and habitat loss and change have been identified as the likely causes for this decline (Terrel 1972, Korte and Fredrickson 1977, Kjolhaug et al. 1987, Daliey et al. 1993). Better knowledge of habitat requirements, especially as they relate to flooding events, which increase mortality rates (Hastings 1954, Layne 1958, Conaway et al. 1960, Korte 1975), is needed to enable managers to enhance the quality of declining swamp rabbit habitat and increase population numbers.

When floods occur, adjacent uplands become an important refuge, but rabbits return to lower elevations after flood waters recede (Hastings 1954, Conaway et al. 1960, Smith and Zollner 2001). Floods commonly cause mortality (Hastings 1954), but displacement due to flooding can also have detrimental effects on swamp rabbits (Layne 1958, Conaway et al. 1960, Korte 1975). Displaced rabbits experience greater vulnerability to hunting (Layne 1958) and predator pressure (Korte 1975), decreased availability of food and cover (Korte 1975), and decreased natality due to adrenal stress syndrome and consequent total litter resorption (Conaway et al. 1960).

Few studies have looked at swamp rabbit habitat in the southern portion of the species' range and in Arkansas in particular (Zollner et al. 2000). With expectations of greater flooding events in the future due to global warming (Fowler and Hennessy 1995), there is a need to better understand the characteristics of the habitat selected during these times of stress. Trapping is an important means of assessing habitat use. Our objectives for this study were to describe habitat characteristics of trap sites and determine which habitat characteristics were most important for trapping success of swamp rabbits during a flooding event.

Materials and Methods

Our study was conducted along Brown's Creek, located in southwestern Drew County, Arkansas (N 33° 26' 6.5", W 91° 56' 37"). The study area was 83 ha in size and prone to flooding during winter rainfall events. Trapping was conducted from 2 January to 3 February 2007. The study area included 3 distinct cover types: bottomland hardwoods, agricultural land, and a 10-year-old hardwood cutover. Traps were placed in areas with swamp rabbit signs (i.e., pellets and tracks) in all 3 cover types: near a log or stump used as a latrine site or in the middle of runs used by rabbits. During trapping, flooding forced us to move traps from bottomland hardwood locations to the adjacent higher elevation bottomland hardwoods, hardwood cutovers, and agricultural edges. We used Tomahawk collapsible live traps (66 x 23 x 23 cm, Tomahawk Live Trap Co., Tomahawk, Wisconsin) covered with burlap to capture swamp rabbits. Traps were baited with a variety of baits, including apples, corn, lettuce, cabbage, and vanilla. The traps were checked daily.

Captured rabbits were immobilized with an injection of 10 mg/kg of ketamine hydrochloride and 2 mg/kg of xylazine hydrochloride. After rabbits were immobilized, their eyes were covered and total length, tail length, hind foot length, ear length, and mass (g) measurements were taken. Age (juvenile or adult) of each animal was estimated by weight, and gender was determined. Monel ear tags were placed in both ears (Seber 1982, National Band and Tag Company, Kentucky) and a radio collar was fitted to adults as part of another study. Rabbits were given time to recover from sedation and were released at the site of capture. Capture and release of swamp rabbits followed guidelines of the American Society of Mammalogists (Animal Care and Use Committee 1998) and were approved by the University of Arkansas at Monticello Institutional Animal Care and Use Committee (Approval #2006-2).

We quantified habitat at each trap site by measuring vegetation and other physical characteristics. For each site, we measured mean canopy cover using a concave densitometer. Five densitometer measurements were averaged for each trap site; one measurement was taken over the trap, and the other 4 measurements were taken 5 m from the trap in each cardinal direction.

We measured mean horizontal visibility using a density board (Wagner et al. 2000). Density board measurements were taken in each cardinal direction 10 m from each trap and averaged. We measured horizontal visibility from ground level to 0.5 m and from 0.5 m to 1 m. Downed logs and stumps within 10 m of each trap site were counted and measured. Decay class (Brown et al. 1998), diameter, and presence of moss and rabbit fecal pellets were noted (Fowler and Kissell 2007). Latrines within 10 m of each location were counted and measured. Number of pellets present and type of latrine (stump, log, or ground) were recorded. Latrine sites were characterized as sites with at least 1 fecal pellet, and pellets within 1 m were considered 1 latrine site (Zollner et al. 1996).

Using ArcMap (ESRI, Redlands, CA), we measured the distance to both permanent and temporary water. The distance to temporary water was measured during a flood event using a Global Positioning System unit. These data were then entered into our GIS. Tree density and composition were measured using the point-quarter method (James and Shugart 1970). The closest tree in each quarter was identified to species, and diameter at breast height (dbh, cm) and distance (m) were measured. Shrub density and composition were measured using the same methods as tree density and composition, except the nearest shrub in each quarter was identified to species, and distance (m) and height (m) were measured.

Ground cover was quantified by ocular estimation using 4 1-m^2 sampling quadrats and 6 coverage classes at each site. Percent coverage for grasses/sedges, bare ground, vines, forbs, leaf litter, and other were recorded for each 1-m^2 quadrant. The 6 coverage classes (Daubenmire 1959) were 0-5%, 6-25%, 26-50%, 51-75%, 76-95%, and 96-100%. Quadrats were measured in the 4 cardinal directions, 5 m away from each trap site. We recorded the presence of several browse species, crossvine (*Bignonia capreolata*), briar (*Smilax spp., Rubus spp.*), grasses (*Graminae*), sedges (*Carex spp.*), poison ivy (*Toxicodendron radicans*), and cane (*Arundinaria gigantea*), within 10 m of each trap.

We analyzed habitat variables using principal component analysis (PCA) to reduce the data set. Habitat variables not normally distributed were transformed using a natural log transformation or arcsine square root transformation for count and percentage data, respectively. Identification of important habitat variables was based on eigenvalues of the PCA. Because each trap was not operated an equal number of nights, PCA was weighted by trap nights. Vectors having eigenvalues ≥ 1 were used in stepwise discriminant function analysis (SDFA). Principal component scores were calculated for each trap and used as raw data for SDFA to assess which principal components differentiated successful trap sites from unsuccessful trap sites. Model entry and retention of variables was based on significance levels set at 0.15. A t-test was used to determine differences in selected principal components of habitat between traps that were successful and traps that were unsuccessful in capturing swamp rabbits; t-tests were conducted at $\alpha = 0.05$. All statistics were conducted using Statistical Analysis Software (SAS, Cary, North Carolina).

Results

Sampling was conducted for 511 trap nights during flooded conditions. Twelve swamp rabbits (3 female and 9 male) were captured; 4 were captured twice for a total of 16 captures. Trap success was 3.1%. Eleven trap sites were successful, and 31 trap sites were unsuccessful in capturing swamp rabbits.

The first 3 eigenvalues accounted for 51.2% (Table 1) of the variation in habitat characteristics at trap sites, and the first 7 eigenvalues were important in distinguishing habitat characteristics (Table 1). Principal components 1, 2, 3, and 6 were found to discriminate between successful and unsuccessful traps for the capture of swamp rabbits (Table 2). PC1 represented canopy cover, distance to trees, and percent ground cover of leaves. PC2 characterized the stage of stump decomposition and the number of stumps. PC3 and PC6 represented tree size (dbh) and distance to temporary water, respectively.

A significant difference existed between successful and unsuccessful trap sites for all habitat characteristics represented by PC1. No habitat variable was found to differ significantly between successful and unsuccessful trap sites for PC2 or PC3. Distance to temporary water was found to be significantly different between successful and unsuccessful traps (Table 3).

Discussion

Trap success for swamp rabbits is usually quite low (Toll et al. 1960, Korte 1975) with only 1% or 2% success being common. Our trap success was similar at 3.1%. Trap success is usually greatest during winter with rates as high as 29.2% being reported in Louisiana on a site that was selectively logged and burned 2 years prior to trapping (Mullin 1982). Trap success

Table 1. Eigenvalues from principal component analysis and their representative individual and cumulative proportions representing habitat characteristics related to swamp rabbit trap success during a flooding event in southeastern Arkansas in winter 2007.

	Eigenvalue	Proportion	Cumulative
1	6.277	0.251	0.251
2	4.326	0.173	0.424
3	2.203	0.088	0.512
4	2.045	0.082	0.594
5	1.941	0.078	0.672
6	1.426	0.057	0.729
7	1.120	0.045	0.774
8	0.970	0.039	0.812
9	0.815	0.033	0.845
10	0.736	0.029	0.874

Table 2. Selected principal components from stepwise discriminant function analysis used to explain successful and unsuccessful trap sites for swamp rabbits during a flooding event in southeastern Arkansas in winter 2007.

	F Value	P-value
PC1	10.24	0.003
PC2	5.97	0.020
PC3	4.48	0.041
PC6	2.58	0.117

Table 3. T-test results of habitat variables used to explain principal component analysis for successful and unsuccessful trap sites for swamp rabbits during a flooding event in southeastern Arkansas in winter 2007.

		Mean		
Variable	Principal Component	Successful Traps	Unsuccessful Traps	P
Canopy cover (%)	1	31.2 (18.7)	51.2 (15.2)	0.002
Distance to trees (m)	1	12.8 (6.8)	7.4 (4.3)	0.028
Ground cover of leaves (%)	1	33.1 (20.8)	51.0 (18.1)	0.016
Number of stumps	2	3.0 (2.2)	1.5 (1.5)	0.097
Class of stump decomposition	2	4.4 (1.9)	3.4 (2.5)	0.150
Tree size (diameter at breast ht)	3	21.2 (10.6)	24.9 (15.1)	0.461
Distance to temporary water (m)	6	114.1 (62.1)	69.1 (66.3)	0.004

would be expected to increase during times of flooding if home ranges are restricted. Kjolhaug and Woolf (1988) described the reduction of 2 home ranges during periods of inundation. By contrast, Zollner et al. (2000) found home ranges not to change significantly during periods of inundation. Given our relatively low trap success, it is unlikely swamp rabbit home ranges became restricted during our flooding event. While it is possible the flooding of the entire bottom changed the use of the area such that more of the adjacent upland was used, and hence a greater density resulted, we had no data to support this.

A significant difference in trap success was found for PC1 variables, which included percent canopy, leaf ground cover, and distance to trees from traps. Canopy cover measurements in this study may seem high given this study occurred during leaf-off; however, cane and shrub densities were extremely high on the site and likely influenced results. Percent canopy cover was significantly less at successful trap sites than at unsuccessful trap sites. This is not surprising given that areas with less canopy cover are reportedly used more by swamp rabbits (Terrel 1972, Korte 1975, Allen 1985). Korte (1975) found trap success correlated with less canopy cover. Sunlight penetrating to the forest floor allows for more herbaceous plant and shrub growth, providing food and cover for swamp rabbits. Canopy cover of 25-60% is considered optimum for swamp rabbits (Allen 1985). We found that less amounts of canopy correlated with trap success of rabbits. During spring-summer (April 15 – Oct 1) Zollner et al. (2000) found latrine sites positively correlated with percent canopy cover. Only form and browse sites were correlated with less canopy cover. Swamp rabbits commonly defecated around and on traps in our study. This may indicate rabbits were using successful trap locations for browse and resting sites rather than as latrines.

Korte (1975) found distance to trees significantly greater at successful trap sites. He found trees 7-13 m away from successful trap sites, whereas only 4-6 m away from unsuccessful trap sites. We found similar distances in this study. He suggested that distance to trees increased solar energy penetrating to the forest floor, which increased plant production and ultimately increased the site's attractiveness to swamp rabbits.

The third variable in PC1, percent leaf ground cover, was significantly lower at successful trap sites than unsuccessful trap sites. This result may be due to the presence of many of the other ground cover categories, none of which individually stood out as important. Where less ground cover of leaves occurred, there were likely more forage items known to be used by swamp rabbits, such as grasses, forbs, and vines.

Latrine sites, typically as an indicator of use or occurrence, have been studied extensively for swamp rabbits (Zollner et al. 1996, Scheibe and Henson 2003, Fowler and Kissell 2007). Latrine sites have been quantified and described most often as logs (Lowe 1958, Terrel 1972, Zollner et al. 1996), likely because logs are more common in bottomland hardwood stands and are used to a high degree (Fowler and Kissell 2007). Stumps, by comparison, have not been found to be an important factor for trap success of swamp rabbits. However, use of stumps as latrine sites has been reported to be greater than use of logs in at least two studies. Fowler and Kissell (2007) attributed this phenomenon to the fact that stumps are higher and flatter, and therefore it is less likely that pellets will roll off and decay more quickly. We found stumps and their degree of decomposition important factors for determining the success of trapping. While stumps have been measured in other studies (Whitaker and Abrell 1986), statistics describing stumps used by swamp rabbits are still scarce.

Diameter at breast height of trees indicates the size of trees, and larger trees are expected to provide greater canopy coverage, which decreases the amount of light reaching the forest floor for understory vegetation growth; reduced understory vegetation limits the amount of forage and cover for swamp rabbits and is less than optimal habitat (Allen 1985). Trees ≥ 36 cm dbh have been reported to be representative of high-use areas (Allen 1985). We found no differences in tree dbh between successful and unsuccessful trap sites. Likewise, Korte (1975) found no differences in tree dbh between successful (x = 27.0 cm) and unsuccessful (x = 27.0 cm) trap sites. These differences likely indicate study sites vary greatly, and measurement is not at a scale sufficient to detect differences in this parameter. While our study site was used to a high degree by swamp rabbits, we had no comparative data for non-flood-prone periods or other seasons.

The presence of water is a key life-history component of swamp rabbit habitat (Sealander and Heidt 1990). Water is used by swamp rabbits for escape from predators (Sealander and Heidt 1990) except during periods of flooding, when swamp rabbits move to adjacent uplands (Zollner et al. 2000) in an attempt to avoid expanding flood waters. Our results support the hypothesis that swamp rabbits respond to flooding by moving to adjacent uplands, as trap success increased with an increase in distance from temporary water.

Based on trapping, swamp rabbits displaced during flooding events used different habitat characteristics than those previously reported for distance to trees (Terrel 1972, Korte 1975, Allen 1985). These differences may be attributed to site-specific conditions or may be related to behavior (e.g., latrine use) that changes over space and time. These data were collected over a short time period and results should be viewed with caution. By the nature of flooding events, duration is short and many flooding events will need to be sampled to better understand the variations in habitat used during these events.

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