THE DISTRIBUTION OF SWAMP RABBITS IN SOUTHEAST MISSOURI

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ABSTRACT - We re-evaluate the distribution of the swamp rabbit (*Sylvilagus aquaticus*) in Southeast Missouri. We developed a list of 276 sites that were identified by the Missouri Department of Conservation as potential swamp rabbit habitat. Most of these sites were surveyed initially in 1992. We visited 245 of these sites in an effort to establish the presence or absence of swamp rabbits. Presence of swamp rabbits was based on scat deposition on down logs or stumps, presence of skulls or carcasses, sightings of live swamp rabbits, reports by trappers, or kills made by hunters. Logistic regression analysis was used to quantify the relationship between site area and likelihood of swamp rabbit presence. A patch size of approximately 48.6 ha was required to ensure a 50% likelihood of swamp rabbits in 1992, whereas in 2001 only 40.5 ha were required. No significant improvement in the distribution of swamp rabbits has occurred in Missouri since 1992.

INTRODUCTION

Swamp rabbits (*Sylvilagus aquaticus* (Bachman)) are associated with forested wetlands, especially swamps, floodplains, and lowland hardwood sites (Baccus and Wallace 1997, Bennitt and Nagel 1937, Chapman and Feldhamer 1981, McCollum and Holler 1994). Although swamp rabbits are not endangered in Missouri, they have been listed as rare (Nordstrom et al. 1977), or of special concern (Warren et al. 1986). There has been a significant loss of wetland habitat available for the species (Dailey et al. 1993, Kjolhaug and Woolf 1987, Korte and Fredrickson 1977, Sole 1994, Terrel 1972, Whitaker and Abrell 1986). In Missouri, the total area of available habitat is a small fraction of what it was 130 years ago. Korte and Fredrickson (1977) estimated that in 1870, there were 850,000 ha of lowland forests in Southeast Missouri. By 1970, this area had been reduced to 92,000 ha. Dailey et al. (1993) estimated that by 1992 there were only about 45,000 ha of bottomland hardwood forest available for swamp rabbits. Certainly, since 1992 there has been continued anthropogenic modification of this habitat, with little indication that the amount of available habitat will increase. In Kentucky, the swamp rabbit is still widely distributed throughout much of its historic range (Sole 1994). However, the species has been extirpated from parts of

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13 counties, and 1/3 of the sites occupied by swamp rabbits are woodlots < 40.5 ha. Terrel (1972) noted that in Indiana only about 10% of the original habitat for swamp rabbits remains, and he was pessimistic about the prospects for the species. Whitaker and Abrell (1986) suggested that Terrel (1972) overestimated the abundance of swamp rabbits in Indiana, and noted continued loss of swamp rabbit populations in 1984–85.

Based on interviews with landowners, the fact that swamp rabbits are relatively rare is apparent to many residents in the southeastern portion of Missouri. In our surveys, landowners noted that they had not seen swamp rabbits in 10, 20, and even 30 years.

In light of extensive habitat loss, it is important that we develop a better understanding of 1) the status of the remaining populations, including their locations, sizes, and demographic and genetic viability, 2) the distribution of the available remaining habitat, 3) the viability of dispersal corridors between habitat fragments, 4) the habitat features that are important to swamp rabbits, and 5) how removal of individuals from small or isolated habitat patches affects population viability. This paper provides some insight to the distribution of current populations of swamp rabbits in Missouri, and lays the groundwork for a more comprehensive study of swamp rabbit habitat requirements.

METHODS

In conjunction with the Missouri Department of Conservation, we compiled a list of 276 sites containing potential swamp rabbit habitat. All but 18 of these sites were surveyed initially in 1992 (see Dailey et al. 1993). Sites were selected based on historical evidence (Bennitt and Nagel 1937, Korte and Fredrickson 1977) and using National Wetland Inventory maps. Bottomland hardwood forests with ≥ 25% canopy cover of woody vegetation, hydric soils, periodic flooding, and an area of ≥ 16 ha in 1989 were used.

A survey crew of 15 upper-level and graduate biology students was assembled, and given an initial training session at a conservation area with a large population of swamp rabbits (Donaldson Point Conservation Area, New Madrid County, MO). Because presence of swamp rabbits can be assessed on the basis of latrines (Zollner et al. 1996), the students were instructed on the appearance of swamp rabbit pellets, likely deposition sites, and methods for evaluating habitat components and completing the data sheets. Of the 15 students, 5 provided the majority of the surveys for the privately owned sites. Federally and state-owned sites were surveyed by personnel of the Missouri Department of Conservation.

Of 276 sites, it was possible to visit 245 sites, and survey 228 between January 2001 and early April 2001. Seventeen sites were flooded, permission by landowners was denied at 18 sites, and 13 sites were not accessible. One flooded site was surveyed via kayak, and a swamp rabbit carcass recovered. Also, 9 sites were surveyed but had been cleared or converted to residential use since the 1992 survey. None of the cleared or converted sites contained swamp rabbit sign.

We obtained a copy of the raw data for the 1992 survey from the Missouri Department of Conservation. The area of each study site was derived from the 1992 survey results. Sites that were 40.5 ha (100 acres) or less were surveyed by one person for one hour, sites between 40.5 and 405 ha were surveyed for two hours, and sites > 405 ha were surveyed for three hours. Each hour of survey was divided into four 15-minute intervals, and each interval was used to search a different section of the study site. During each 15-minute survey interval, logs and stumps were searched for the presence of pellets. Pellets were collected and placed in plastic collection bags.

To determine suspect sites, that is, those from which pellets may not have been swamp rabbits, weights of collected pellets were compared with a 99% confidence interval for known swamp rabbit pellets. In the lab, pellets were removed from their collection bags, placed in uncapped, individually labeled 30 dram vials, and allowed to air-dry for ≥ 3 days. Pellets from each collection bag were counted and weighed as a group to the nearest 0.001 g using a Metler electronic balance. Mean dry weight of the pellets from each collection bag was then determined by dividing pellet mass by pellet number. The 99% confidence interval was constructed using pellets collected at Donaldson Point Conservation Area. Mean pellet weights for any site falling outside the confidence interval were earmarked for additional investigation. Field notes from these sites were reviewed to determine if the pellets might in fact be those of eastern cottontails (*Sylvilagus floridanus*), gray and fox squirrels (*Sciurus carolinensis* and *S. niger*), or white-tailed deer (*Odocoileus virginianus*). If pellets were collected next to a log or stump rather than on top, and if the pellet mass fell below the 99% CI, they were classified as non-swamp rabbit pellets.

We used a weighted logistic regression to determine the probability of swamp rabbit presence in relation to site area. To accomplish this, a logit transformation of the form:

$$p' = \ln\left(\frac{p}{1-p}\right) \quad (1)$$

(where p is the probability of encountering swamp rabbit scat on a site)

was performed, such that

$$p' = \beta_0 + \beta_1 X \,. \qquad (2)$$

Here, X is defined as study site area based on the 1992 survey. Consequently, the regression model becomes:

$$E(Y) = \frac{e^{(\beta_0+\beta_1 X)}}{1+e^{(\beta_0+\beta_1 X)}} \,. \qquad (3)$$

With this formulation, the dependent axis is the expected probability of occurrence of the swamp rabbits, and varies from 0 to 1. Separate regressions were computed for the 1992 and 2001 survey years, using data from 208 sites common to both survey years.

RESULTS

The mean dry pellet weight for Donaldson Point was 0.192 g, and the 99% confidence interval for these pellets ranged from 0.131 g to 0.253 g. As shown in Figure 1, a considerable number of mean pellet weights fell below 0.13 g. In fact, the distribution of pellet weights appears to be bimodal with one peak at about 0.185 g and a second peak at about 0.125 g. By comparison, mean pellet weights for fox squirrels were about 0.04 g (based on pellets collected throughout the survey), and mean pellet weights for cottontail rabbits were about 0.125 g. Thus, it is possible that the first peak in Figure 1 represents cottontail pellets, not swamp rabbit pellets. It seems unlikely that cottontail rabbits would deposit

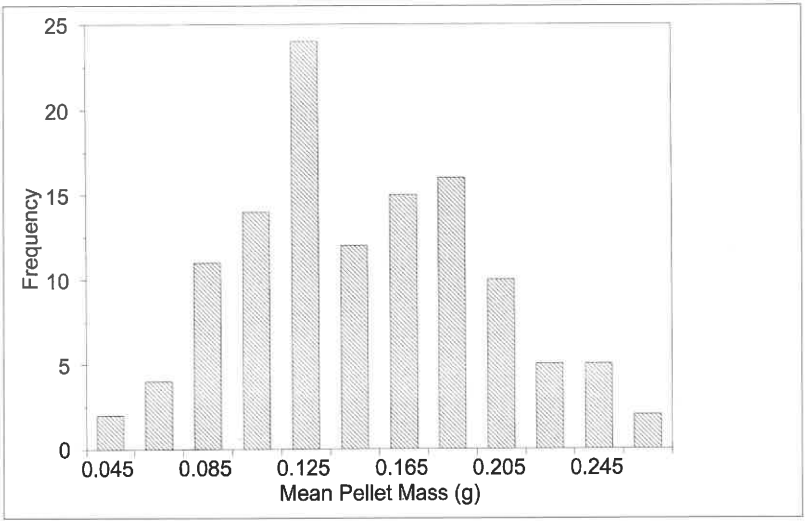

Figure 1. Distribution of mean pellet weights for the entire set of sites visited during 2001.

their pellets on stumps or logs (Chapman et al. 1980, Zollner et al. 1996). Thus, some small pellet weights reported here may be a consequence of weathering or erosion of old pellets, or perhaps may have been produced by young rabbits. Field notes for Cape Girardeau County in particular reveal that some pellets were collected next to logs rather than on them. The surveyors assumed that the pellets had rolled off the logs (see McCollum and Holler 1994). However, it is possible that cottontail rabbits deposited these small pellets.

Swamp rabbits were found on more sites in 2001 than in 1992. Of the 208 sites common to both surveys, 43.8% showed evidence of swamp rabbits in 1992 (91 sites), whereas 50.5% (105 sites) showed sign of swamp rabbits in 2001. Bollinger, Oregon, and Scott Counties showed no change in the number of sites with swamp rabbits; neither Perry nor Jefferson Counties had sites with swamp rabbits. Cape Girardeau, Dunklin, New Madrid, and Ripley Counties had fewer sites with swamp rabbits, while the remaining counties showed increases (Table 1).

Both logistic regression models (Fig. 2) were significant at the .01 level, and explained about half of the variance in the data (1992: R^2 = 0.494, 2001: R^2 = 0.478). However, the models for 1992 (p' = -0.19148 + 0.00155X) and 2001 (p' = -0.11049 + 0.00165X) did not differ significantly with respect to slope or intercept. In 1992, a forest patch of about 48.6 ha was necessary for a 50% likelihood of containing swamp rabbits. In 2001, the area necessary for the same likelihood was 40.5 ha.

Table 1. Comparison of overall results for the 1992 and 2001 swamp rabbit surveys. The columns headed by 1992 and 2001 contain the number of common sites with evidence for swamp rabbits. The upper portion of the table lists counties where the number of sites with swamp rabbits increased since 1992, followed by counties with no change, and fewer sites with swamp rabbits.

County	No. of sites common to both surveys	1992	2001
Increased			
Butler	26	16	17
Mississippi	35	13	25
Pemiscot	18	8	12
Ste. Genevieve	3	0	1
Stoddard	21	6	8
Wayne	6	1	2
No Change			
Bollinger	11	1	1
Jefferson	5	0	0
Oregon	3	3	3
Scott	11	6	6
Perry	9	0	0
Decreased			
Cape Girardeau	12	1	0
Dunklin	16	13	11
New Madrid	14	9	8
Ripley	18	14	11

The regression for 2001 was estimated assuming that site area did not differ from 1992. This assumption was clearly violated because some sites had been cleared and others reduced significantly in size. Thus, the regression is biased. However, because the 2001 areas are probably overestimated, and because the regression slope for 2001 equals that for 1992, the bias inherent in the analysis does not change the overall result. That is, the relationship between swamp rabbit occurrence and site area did not differ from 1992 to 2001.

DISCUSSION

Swamp rabbits continue to persist in Southeast Missouri, despite continued loss of habitat. Although 9 sites that contained swamp rabbits in 1992 have since been cleared, reduced in size, or converted to residential use, swamp rabbits were found on 50 sites where they were presumed absent in 1992. In fact, of the 208 sites common to both the 1992 and 2001 surveys, 91 (44%) contained swamp rabbits in 1992, whereas 105 (50%) contained swamp rabbit sign in 2001. Dailey et al. (1993) reported swamp rabbits on 114 of 274 sites (42%) in 1992 (they surveyed 258 sites); we found swamp rabbits on 115 of 219 total sites (53%). There are several possible explanations for this, including differences in the way the 1992 and 2001 surveys were conducted. Also, two major flooding events since 1992 may have facilitated swamp rabbit dispersal. Regardless, the total area of available habitat has been reduced since 1992.

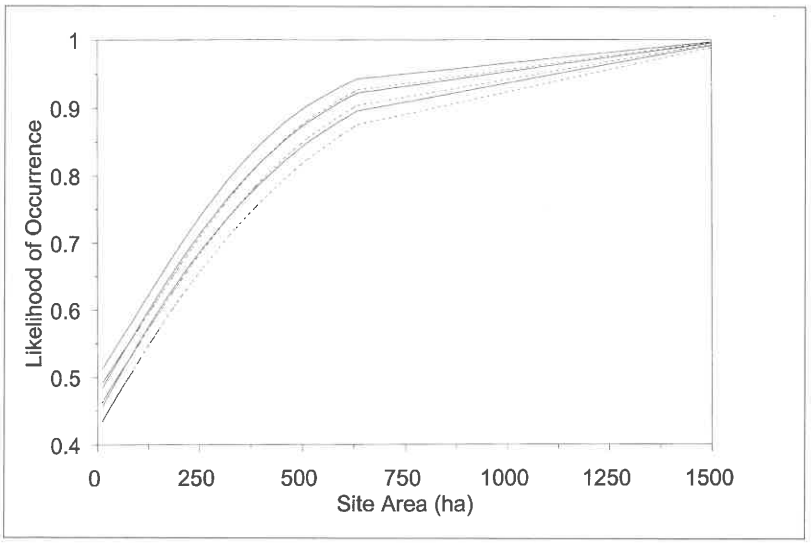

Figure 2. Logistic regression results for the combined 1992 and 2001 swamp rabbit surveys. The dashed lines represent the predicted, and upper and lower 95% confidence intervals for the 1992 survey. The black lines represent the predicted, and upper and lower 95% confidence intervals for the 2001 survey.

Although Bennitt and Nagel (1937) reported the northernmost locality for swamp rabbits in Missouri was a site in St. Genevieve County, Dailey et al. (1993) found swamp rabbits only as far north as Perry County. We found some pellets in Perry County, but these were outside the 99% confidence limits for swamp rabbit pellet mass, and likely were cottontail pellets. Similarly, all pellets collected farther south in Cape Girardeau County were classified as cottontail pellets on the basis of mass. Thus, it appears that swamp rabbits have been extirpated from both Perry and Cape Girardeau Counties.

Not surprisingly, the logistic regression analysis revealed a significant likelihood/area relationship. Allen (1985) suggested that an area of at least 100 ha was required to support a viable population of swamp rabbits. In Kentucky, nearly 1/3 of the swamp rabbit sign found by Sole (1994) was in woodlots < 100 ha. Dailey et al. (1993) noted that in Missouri, the mean size of a privately owned forest tract was only 8 ha compared to 331 ha for publicly owned forest tracts. Furthermore, 2/3 of the swamp rabbit sign they found was on private land. Because lands adjacent to forested tracts containing swamp rabbits provide refugia during floods, and because privately owned tracts are smaller and more fragmented than publicly owned tracts, swamp rabbits in Missouri are vulnerable to continued anthropogenic activities.

Relatively small forest tracts had a high probability of supporting swamp rabbits, and in 2001 there was a tendency for smaller tracts to be suitable. As forest patch size increased, the chance of encountering swamp rabbit sign increased in both 1992 and 2001. However, the accuracy of the 2001 area estimates is undetermined because some of the sites were cleared or partially cleared between 1992 and 2001. The viability of populations on small tracts is unknown. Perhaps they are replenished by recruitment from larger populations, like those at Mingo National Wildlife Refuge and Duck Creek Conservation Area in Butler and Stoddard Counties, and Donaldson Point Conservation Area in New Madrid County. However, the dispersal abilities of swamp rabbits are unknown.

Korte and Fredrickson (1977) attributed the near demise of the swamp rabbit in Missouri to loss of habitat. Furthermore, swamp rabbits are susceptible to extended flooding (Heuer and Perry 1976) and increased habitat fragmentation (Baccus and Wallace 1997). Because many of the sites occupied by swamp rabbits are private property and are relatively small, management options to ameliorate anthropogenic activities are limited. The agricultural land, small towns, and roads that often surround private sites may represent significant barriers to dispersal. As noted by Korte and Fredrickson (1977:76), "The needs of the species are incompatible with modern intensive agricultural practices that restrict preferred habitat to small woodlots and narrow streamside belts." It may be that persistence of swamp rabbits in Missouri, as in other states, will depend on efforts to increase habitat continuity (Baccus and Wallace 1997). In light

of current trends in human population growth, it seems unlikely that the status of the swamp rabbit will improve in the near term.

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LITERATURE CITED

Allen, A.W. 1985. Habitat suitability index models: swamp rabbit. U.S. Fish and Wildlife Service Biological Report 82(10.107). 20 pp.

Baccus, J.T. and M.W. Wallace. 1997. Distribution and habitat affinity of the swamp rabbit (*Sylvilagus aquaticus*: Lagomorpha: Leporidae) on the Edwards Plateau of Texas. Occasional Papers, Museum of Texas Tech University, Number 167. 14 pp.

Bennitt, R. and W.O. Nagel. 1937. A survey of the resident game and furbearers of Missouri. University of Missouri Studies XII 2:92–99.

Chapman, J.A., J.G. Hockman, and M.M. Ojeda C. 1980. *Sylvilagus floridanus.* Mammalian Species 136:1–8.

Chapman, J.A., and G. Feldhamer. 1981. *Sylvilagus aquaticus.* Mammalian Species 151:1–4.

Dailey, T.V., T.M. Vangilder, and L.W. Burger, Jr. 1993. Swamp rabbit distribution in Missouri. Proceedings of the Annual Conference of Southeast Associations of Fish and Wildlife Agencies 47:251–256.

Heuer, E.T., Jr., and H.R. Perry, Jr. 1976. Squirrel and rabbit abundances in the Atchafalaya Basin, Louisiana. Proceedings of the Annual Conference of Southeastern Association of Fish and Wildlife Agencies 30:552–559.

Kjolhaug, M.S. and A. Woolf. 1987. Current status and distribution of the swamp rabbit in Illinois. Transactions of the Illinois Academy of Science 80:299–308.

Korte, P.A., and L.H. Fredrickson. 1977. Swamp rabbit distribution in Missouri. Transactions, Missouri Academy of Science 10&11:72–77.

McCollum, R.C., and N.R. Holler. 1994. Comparative use of floodplains by swamp rabbits. Journal of the Alabama Academy of Science 65:263–275.

Nordstrom, G.R., W.L. Pflieger, K.C. Sadler, and W.H. Lewis. 1977. Rare and endangered species of Missouri. Missouri Department of Conservation, Jefferson City. 129 pp.

Sole, J.D. 1994. Assessing swamp rabbit distribution in Kentucky. Proceedings of the Annual Conference of Southeast Association of Fish and Wildlife Agencies 48:145–151.

Terrel, T.L. 1972. The swamp rabbit (*Sylvilagus aquaticus*) in Indiana. The American Midland Naturalist 87:283–295.

Warren, M.L., W.H. Davis, R.R. Hannan, M. Evan, D.L. Batch, B.D. Anderson, B. Palmer-Ball, Jr., J.R. MacGregor, R.R. Cicerello, R. Athey, B.A. Branson, G.J. Fallo, B.M. Burr, M.E. Medley, and J.M. Baskin. 1986. Endangered, threatened, and rare plants and animals of Kentucky. Transactions of the Kentucky Academy of Science. 47:83–98.

Whitaker, J.O., Jr., and B. Abrell. 1986. The swamp rabbit, *Sylvilagus aquaticus*, in Indiana, 1984–1985. Proceedings of the Indiana Academy of Science 95:563–570.

Zollner, P.A., W.P. Smith, and L.A. Brennan. 1996. Characteristics and adaptive significance of latrines of swamp rabbits (*Sylvilagus aquaticus*). Journal of Mammalogy 77:1049–1058.