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Recent Trends and Future Outlook for the Swamp Rabbit (*Sylvilagus aquaticus*) in Illinois

Michael S. Barbour, Alan Woolf, and Joel W. Porath
Cooperative Wildlife Research Laboratory and Department of Zoology
Southern Illinois University
Carbondale, Illinois 62901-6504

ABSTRACT

Declines in forested bottomlands cause concern about the status of swamp rabbits (*Sylvilagus aquaticus*) in Illinois. We identified potential swamp rabbit habitat using the Illinois Land Cover database, applying size and distance criteria to areas classified as forested wetland, swamp, or shallow water wetland. Potential habitat was searched 1995-1997 for fecal pellets on raised objects indicating swamp rabbit presence, and the resulting distribution compared to that found in a 1985 survey. We found swamp rabbits occupied 33 of 69 sites searched in 14 of 20 counties. While there were changes in occupancy status of individual sites between the 1985 and our survey, the overall distribution appears to have been stable over the intervening years. We believe the swamp rabbit in Illinois exists as a mainland-island metapopulation and remains vulnerable to habitat loss and stochastic events that can cause local extirpation. We recommend a proactive management strategy focusing on existing habitat that identifies and manages resource rich habitat patches (sources) and establishes connectivity with smaller patches and lower quality habitat that now serve as "islands" or are unoccupied. A public-private partnership should be included because there are important sites in private ownership.

INTRODUCTION

The swamp rabbit (*Sylvilagus aquaticus*) has a distribution in the United States that extends from the Gulf Coast west to include eastern Oklahoma and Texas; east through Alabama, northern Georgia, and a small portion of western South Carolina, and northward to include southern Illinois, southwestern Indiana, and western Kentucky and Tennessee (Whitaker and Hamilton 1998). In Illinois, the swamp rabbit's range likely has never extended beyond approximately 38º north latitude.

The swamp rabbit's distribution coincides with that of forested floodplains, bottomlands, and swamps associated with large bodies of water. This close association of the swamp rabbit with forested wetland habitats is a hallmark of the species and a major consideration in assessing the species status and risk of extirpation. Its range has diminished southward in association with loss of the forested bottomlands that define its habitat needs (Chapman et al. 1982).

The swamp rabbit is a species of concern to wildlife biologists because of habitat loss throughout much of its range, especially along the northern periphery. Kjolhaug et al. (1987) concluded the swamp rabbit was less common and had a more restricted distribution in Illinois than historical records indicated. Similar habitat losses and subsequent swamp rabbit declines and restricted distributions were reported in Indiana (Mumford and Whitaker 1982), Kentucky (Nelson 1974), and Missouri (Korte and Fredrickson 1977, Dailey et al. 1993).

We reviewed the findings of Kjolhaug et al. (1987) and searched additional sites to document changes in status of the swamp rabbit in Illinois between searches conducted in 1984-1985 and 1995-1997. Further, we defined potential habitats in Illinois more accurately than was accomplished in the prior study because of changes in the research tools available. Our purpose was to provide current information to guide management aimed at maintaining the swamp rabbit as a secure component of Illinois' fauna.

METHODS

Potential Habitat Definition

Potential swamp rabbit habitat was identified in 23 southern Illinois counties using the Illinois Land Cover (ILC) database (Illinois Department of Natural Resources 1996). The ILC database contained a raster image of land cover/land use for the entire state that was projected to Universal Transverse Mercator (UTM) and clipped for the 23 southern counties. All pixels classified as forested wetland, swamp, or shallow water wetland were identified, and the resulting image was converted to a shapefile for further analysis using ArcView software (Environmental Systems Research Institute, Redlands, CA).

The initial image of potential habitat contained many patches that acted as 1 functional site, but were represented in the image by multiple polygons that either shared adjacent borders or were close enough to be a simple functional site. We merged polygons that were adjacent to or within 150 m of each other to form 1 polygon. We assumed that small isolated sites were biologically insignificant and eliminated all sites <5 ha and those sites <50 ha that were >5 km from sites >100 ha. A more conservative estimate of potential habitat was obtained by identifying small (<50 ha) patches within 2 km of large patches and eliminating the remaining small sites.

We ground-truthed the resulting image to identify misclassified areas. Corrections also were made to the shapes of the remaining areas based on observations while ground-truthing the image and interpretation of current aerial photography. The selection criteria were then reapplied to produce the final image of potential habitat.

Search Criteria and Techniques

The number of sites to search was reduced by consolidating adjacent sites and eliminating isolated sites. Geographically isolated 5-25 ha areas were excluded from the search. Using these criteria, we identified 77 sites totaling 45,934 ha to be searched from the areas defined as potential swamp rabbit habitat.

Search procedures were established such that sites were searched during the same time of year with similar methods as Kjolhaug et al. (1987). Staff and personnel from the Cooperative Wildlife Research Laboratory conducted searches during December 1995-April 1996, January-March 1997, and November-December 1997. Because of time limitations, areas >25 ha were prioritized for search effort. Areas <25 ha were searched as time permitted, but with greater frequency when located near larger tracts of suitable habitat. Because size and shape of most areas were highly variable, search patterns were modified to suit each individual site, and in most cases search patterns were non-random. When potential swamp rabbit habitat meandered with a creek, stream, or river, the search was conducted by following the corridor on both sides of the water system (e.g., down one side and back the other side). Searches of large tracts of potential habitat focused on areas with the best microhabitat (e.g., brushy tangles, open canopy/thick underbrush borders). If the tract of habitat was small, we tried to thoroughly search the entire area for presence of swamp rabbit sign.

Presence and relative swamp rabbit abundance were determined by observations of fecal pellets on raised objects (usually logs, stumps, or moss mounds) (Terrel 1972, Korte 1975, Kjolhaug 1986, Whitaker and Abrell 1986, Zollner et al. 1996). Similar to Kjolhaug (1986), relative swamp rabbit abundance was subjectively classified as high, moderate, low, or absent based on localized abundance of sign. When re-examining Kjolhaug's data, we could not precisely identify the areas he searched, and his abundance classification was entirely subjective. We classified relative abundance according to the following number of pellet logs found within a localized area of the habitat patch: > 20 pellet logs = high, 10-19 pellet logs = moderate, 1-9 pellet logs = low, and 0 pellet logs = absent. When swamp rabbit sign was found on any portion of the site, the entire site was classified as inhabited and assigned the highest occupancy status found on the site.

Areas searched were delineated on United States Geological Survey 1:24,000 scale 7.5 minute topographic maps and identified by specific county, topographic map name and sections, and legal description. Topographic maps were then used to delineate searched areas on 1993 black and white aerial photographs (scale 1:40,000, Markhurd Corporation, Minneapolis, MN) to further characterize sites. The aerial photographs were scanned using TNTMips (Map and Image Processing System, Lincoln, NE) and georeferenced to UTM North American Datum 1927. Images were imported into ArcView to digitally map the site boundary and for further processing. ArcView was used to calculate the area of the site, and information from the search of the site was entered into the site database table. County plat books were used to determine ownership of areas searched.

RESULTS

Potential Habitat

The initial image created after merging polygons <150 m from nearby habitat was composed of 5,263 polygons; however, 96% were <50 ha. Elimination of small and isolated (>5 km) pixels and ground truthing produced an estimate of 141 sites with 57,259 ha of potential habitat in 20 southern Illinois counties. Three counties (Edwards, Hardin, White) contained no potential habitat. When small sites >2 km distant from other habitat blocks were eliminated, only 111 sites totaling 55,591 ha of potential habitat remained. Size of the habitat blocks ranged from 25 to 4,415 ha. Sites were described in more

detail by Woolf (1998) and Woolf and Roseberry (1999), and the data was archived on CD-ROM for distribution by the Cooperative Wildlife Research Laboratory, Southern Illinois University at Carbondale.

Distribution and Relative Abundance

Kjolhaug et al. (1987) reported that swamp rabbits were restricted to the southernmost portions of the state with populations occurring in 22 sites in 8 counties (Alexander, Franklin, Jackson, Johnson, Massac, Pope, Pulaski, and Union) along the Bay Creek, Big Muddy, Cache, Mississippi, and Ohio River drainages (Fig.1). In contrast, we found rabbits occupying 33 of 69 sites in 14 of 20 counties searched. We could not search 8 potential sites because land owners denied access to their property. Swamp rabbits were associated with Bay Creek, Big Muddy, Cache, Kaskaskia, Mississippi, Ohio, and Saline River drainages (Fig. 1). However, presence was not certain, or had a very tenuous classification in 3 counties. Gallatin County was classified as occupied on the basis of a single site where large pellets were found on the ground, but not on an elevated object. In Williamson County, only 1 pellet on 1 log led to classification as occupied, and Jackson County was classified occupied based on only 1 pellet on 1 log in each of 2 sites.

Within the study area, we did not detect evidence of swamp rabbits in suitable patches located in Hamilton, Jefferson, Lawrence, Perry, Wayne, and Wabash counties (Fig.1). All sites along the Wabash and Little Wabash rivers were unoccupied, with the possible exception of the 1 site along the Wabash River on which the occupancy status was uncertain. All sites along the Ohio River were either unoccupied or occupied at low abundances except for 1 site in Pulaski County near the confluence of the Ohio and Mississippi rivers, which had a high relative abundance.

The majority of occupied sites (60.6%) had low relative rabbit abundances (Table 1). Only 13 sites were classified as having either a high (10) or moderate (3) relative abundance. With the exception of 1 site along Ewing Creek in Franklin County classified as a moderate abundance, all sites on which populations were regarded to have a high or moderate abundance were restricted to 5 of the southernmost counties (Alexander, Johnson, Massac, Pope, and Pulaski) along Bay Creek and the Cache, Mississippi, and Ohio rivers.

Trend

We searched 45 sites previously searched by Kjolhaug (1986). While there were changes in the occupancy of individual sites, the overall distribution appears to have been stable over the intervening 10 years. Seventeen sites searched were unoccupied and 19 sites were occupied by swamp rabbits in both studies. Thus, there was no change in 80% of common sites searched. We did not find evidence of rabbits on 2 sites where Kjolhaug (1986) found swamp rabbits; 1 site in Massac County and 1 in Union County. Conversely, we found swamp rabbits on 6 sites in Alexander, Massac, Pulaski, Saline, Union, and Williamson counties that Kjolhaug (1986) reported as unoccupied.

DISCUSSION

Swamp rabbits and their habitat exhibit a patchy distribution in southern Illinois clustered along the Cache, Mississippi, and Ohio rivers and along a few of the interior rivers (Big

Muddy, Kaskaskia, Saline) and their tributaries. Our searches found that Alexander, Johnson, Massac, Pope, and Pulaski counties supported several secure, site-specific swamp rabbit populations. Sign in Franklin, Gallatin, Jackson, Monroe, Randolph, Saline, St. Clair, Union, and Williamson counties suggested low abundance and limited distributions.

An earlier study (Kjolhaug 1986) reported a minimum area of 12,485 ha was occupied by swamp rabbits. We found swamp rabbits occupying about 27,545 ha, but the difference is a reflection of larger searched areas in our study. Further, estimates of area occupied should not be taken literally because of the methods used to define occupancy. Our estimate of hectares of habitat occupied is an overestimate because if sign was detected on a site, the entire site was classified as occupied. However, habitat on these sites was heterogenous and portions of many occupied sites were unsuitable habitat. Nevertheless, the 33 sites where we found swamp rabbits did represent nearly twice as much area (27,545 ha) of potential habitat as did the 36 unoccupied sites (14,096 ha).

The differences in site occupancy between the searches reported by Kjolhaug (1986) and found in this study provide clues to the influences of habitat structure and changes. Two areas occupied in the past study and unoccupied in the present study were mature forest stands that provided marginal habitat then (Kjolhaug 1986) and remained mature stands with scarce understory vegetation at the time of our searches. They also were inundated for a prolonged period of time during major flood events in 1993 and 1995. Further, these sites were fragmented bottomland remnants surrounded by agriculture and probably supported low population levels at best. If the 1993 and 1995 floods extirpated swamp rabbits from these locations as we suspect, lack of connectivity with sites in the vicinity still supporting substantial swamp rabbit populations would have precluded repopulation. Conversely, we found swamp rabbits on 6 sites where Kjolhaug (1986) did not find evidence of rabbits. However, 2 of the sites were flooded or recently flooded when searched by Kjolhaug (1986), possibly causing these site's occupancy status to be misclassified. One of these areas was along the Mississippi River, connected but distant from an established population, but the other was very isolated and unlikely to have been recolonized. Three of the remaining 4 areas experienced some form of disturbance to the forest canopy in the previous 5 years that created more favorable habitat. Sources of disturbance identified were tornado blowdowns, selective or clear-cut logging, and flood-caused tree kills that opened the canopy producing thick stands of underbrush. Also, the 1993 and 1995 flood events killed trees in some areas that created better swamp rabbit habitat than existed previously. We speculate that swamp rabbits moved from surrounding areas into these improved habitats. The 3 sites with disturbance were connected to established populations by waterways; however, 1 of these sites was distant from any existing population. The remaining site was isolated and not connected to any existing populations; however, this was 1 of the sites on which the occupancy status was very tenuous (1 pellet on 1 log). All sites that changed occupancy status between the 2 studies only supported low populations, with the exception of 1 of the sites possibly misclassified by Kjolhaug (1986). These changes suggest the influence of habitat quality on occupancy and may reflect the transitory nature of swamp rabbit populations on these areas.

We recognize that we are working on the swamp rabbit's distribution edge (Whitaker and Hamilton 1998). Distribution fluctations along this edge would be expected, and that

may account for individual site occupancy changes between the 2 studies. However, human alterations of the landscape and hydrology have been so extensive that they likely pose a greater threat to swamp rabbit persistence than the random fluctuations expected along a species distribution edge.

We believe that the swamp rabbit in Illinois exists as a mainland-island metapopulation as described by Harrison (1991). The fragmented bottomland habitat in southern Illinois includes some large habitat patches (mainlands) that are responsible for net population recruitment, while small patches (islands) support only a few individuals with limited resources and low survival rates that hinder successful recruitment. While these "island" populations likely have little influence on metapopulation persistence (Harrison 1991), they could provide important stepping stones for connecting the "mainlands". Due to the patchy distribution of habitat, swamp rabbit populations remain vulnerable to habitat loss and stochastic events such as flooding that can cause local extirpation.

Flooding can be both beneficial and harmful to swamp rabbits depending on the extent, duration, and timing of the flood event and the surrounding landscape mosaic. Extensive and prolonged flooding can reduce swamp rabbit survival and reproduction, particularly if there is no secure upland cover nearby for them to move to, potentially causing local extirpations. However, flooding also is one of the disturbance events which can kill overstory trees, creating canopy gaps and thereby enhancing the habitat.

MANAGEMENT IMPLICATIONS

While it appears that swamp rabbits have maintained a stable distribution over the past decade, the status of the species in Illinois should be viewed with concern. Although the number of occupied sites remained relatively constant between Kjolhaug's (1986) survey and ours, nearly 61% of the sites only supported populations of low abundance. These low abundance populations spread out over such a large area are vulnerable to localized extirpations. Whitaker and Hamilton (1998) noted that swamp rabbits were extirpated, or nearly so, from bottomland habitats in Indiana and speculated that the cause was conversion of adjacent higher areas to farmland. This is so in Illinois, but the reality is that land use is unlikely to change.

We recommend a proactive management strategy that focuses on existing occupied and unoccupied habitats. We recognize that further study is needed on swamp rabbit dispersal and population dynamics in "island" populations to determine if they might be acting as "sinks". However, the management strategy we advocate is to identify resource rich habitat patches (mainlands), properly manage them, and establish connectivity with smaller patches and lower quality habitat that now serve as "islands", or are unoccupied. Emphasis should be placed on connecting to "islands" which could serve as stepping stones between "mainlands". Although about 68% of occupied sites are in public ownership (and 40% of potential habitat identified; A. Woolf, unpublished data), important sites are in private ownership, hence, a public-private partnership should be created to manage Illinois swamp rabbits. Riparian zone management of waterways to connect habitat patches will require landowner cooperation that can be encouraged with existing conservation stewardship and incentive programs, easements, and other similar programs. This important cornerstone of a management plan should be politically and economically

feasible, and enhances water quality and watershed management in a broad context. The latter benefit should facilitate inter-agency cooperation and collaboration to develop and implement a management plan.

A critical component of a plan to maintain swamp rabbits as a viable component of Illinois's fauna is need to manage the habitat patches. Kjolhaug and Woolf (1988) and home range studies in progress (A. Woolf, unpublished data) underscore the importance of early successional stage habitat to swamp rabbit food and cover needs. However, support is lacking to manage public lands for species that require such habitats. Unless resource agencies can actively manage habitats (or at least habitat patches) now occupied by swamp rabbits, habitat quality will surely diminish. Dependance on natural events (e.g., windstorms, insect damage, floods, and others) to create canopy openings and patches of early-succession vegetation will leave swamp rabbit persistence to chance. Given their limited distribution and vulnerable status in Illinois, we believe that proactive adaptive management is a more reasonable strategy.

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Table 1. Number (n), acreage (ha), and minimum and maximum patch size (ha) of sites occupied by swamp rabbits at different relative abundances in southern Illinois, 1995-1997.

Abundance[a]	n	% of occupied sites	Total acreage	Patch size Minimum	Patch size Maximum
Low	20	60.6	18,514.5	25.7	2,926.2
moderate	3	9.1	1,839.0	48.5	1,435.6
high	10	30.3	3,016.7	159.1	891.5

[a] Relative swamp rabbit abundance was classified as high, moderate, low, and absent according to the following number of pellet logs found per site: ≥20 pellet logs = high; 10-19 pellet logs = moderate; 1-9 pellet logs = low; 0 pellet logs = absent.

Figure 1. Swamp rabbit distribution in southern Illinois as indicated by a survey conducted 1995 - 1997. Habitat patches are indicated, but not all habitat patches within occupied counties were occupied.