

SPACE USE BY ROUND-TAILED MUSKRATS IN ISOLATED WETLANDS

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The round-tailed muskrat (*Neofiber alleni*) is a species of conservation concern that represents a monotypic genus with a restricted geographic distribution. Few data exist on space use to assist conservation efforts for this enigmatic species. We radiotracked 23 round-tailed muskrats in isolated freshwater wetlands in central Florida. Muskrats used lodges for diurnal rest sites when wetlands were inundated but switched to burrows during a seasonal dry period. Individuals shifted use among 10–15 rest sites within their home ranges. Body mass affected patterns of rest-site use; heavier individuals used fewer rest sites and were more likely to have a preferred site compared to lighter individuals. Estimates of home-range size averaged 1,263–2,071 m² and were at least an order of magnitude greater than existing estimates but less than expected given the body size of the species. Males may sometimes occupy nonoverlapping home ranges as predicted by theory. Small wetlands can support subpopulations of the round-tailed muskrat, which is a dispersal-limited species that exhibits metapopulation dynamics among wetlands.

Key words: dispersal, home range, movements, *Neofiber alleni*, rest site, round-tailed muskrat, space use, wetlands

Conservation of rare species requires an understanding of their basic natural history. Knowledge of space-use patterns and dispersal is especially critical. Use of rest sites by species is an important aspect of space use that can provide insights into degree of sociality (Brock and Kelt 2004), mating systems (Endries and Adler 2005), habitat preferences (Shibata et al. 2004), and habitat partitioning (Kalcounis-Rüppell and Millar 2002). Home-range size determines the scale of movements associated with normal activities, establishes space requirements, and is an input for many spatially explicit population models (e.g., Schumaker 1998) and for biodiversity conservation approaches (Allen et al. 2001). Dispersal capacity of a species influences spatial population structure (Harrison and Taylor 1997), landscape connectivity (Taylor et al. 1993), and the ability to respond to habitat loss and fragmentation.

The round-tailed muskrat (*Neofiber alleni*) is a species of conservation concern that represents a monotypic genus with a patchy distribution restricted to Florida and southern Georgia (Bergstrom et al. 2000; Lefebvre and Tilmant 1992). Round-tailed muskrats are semiaquatic, nocturnal herbivores that prefer shallow marshes with emergent vegetation (Birkenholz 1963; Lefebvre and Tilmant 1992). In inundated wetlands,

muskrats live in spherical to dome-shaped lodges (about 30 cm in diameter) that they construct of tightly woven plant material typically resting on a base of vegetation just above water level (Birkenholz 1963; Schooley and Branch 2005). Muskrats also build smaller, uncovered feeding platforms. When wetlands periodically dry out, and in sugarcane fields, round-tailed muskrats use burrows as rest sites instead of lodges (Lefebvre and Tilmant 1992). The species is described as colonial (Bergstrom et al. 2000; Lefebvre and Tilmant 1992), but spatial aggregation of individuals might simply reflect “forced coloniality” due to shortages of suitable habitat without development of sociality (Bergstrom et al. 2000; Hoogland 1995).

Only limited data exist on rest-site use and movement behavior for the round-tailed muskrat due to the difficulty of livetrapping this secretive mammal (Bergstrom et al. 2000; Birkenholz 1963). Birkenholz (1963) concluded that there was an average of 2 lodges for each individual, and this rule of thumb has been used to estimate population densities for the species (Bergstrom et al. 2000; Birkenholz 1963). An estimate of home-range size based on an adequate number of radiolocations exists for only 1 adult male that had a remarkably small range (130 m²—Bergstrom et al. 2000). No data exist on degree of range overlap for round-tailed muskrats, and the only evidence for territoriality is exclusive use of lodges by adults (Birkenholz 1963, but see Bergstrom et al. 2000). Dispersal ability of round-tailed muskrats is unknown.

Our goal was to fill in some of the knowledge gaps regarding space use by round-tailed muskrats to assist conservation

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efforts for the species, which was proposed as a Species of Special Concern by the Florida Committee on Rare and Endangered Plants and Animals (Lefebvre and Tilmant 1992). Our specific objectives were to describe and assess an improved trapping procedure, evaluate patterns of rest-site use in relation to individual characteristics and seasonal changes in water levels, estimate home-range size and overlap, and indirectly estimate dispersal capacity via predictive cross-species equations previously published for mammals.

MATERIALS AND METHODS

Study area.—We conducted our research on a 19,500-ha section in the southern half of Avon Park Air Force Range in central Florida (15 km east of Avon Park). Suitable habitat for round-tailed muskrats consisted of small (median = 0.9 ha, maximum = 73.4 ha), geographically isolated (Tiner et al. 2002) freshwater marshes. The study area included 457 of these depression marshes that in total covered <5% of the landscape. Nearest-neighbor distances between marshes averaged 312 m (85–1,435 m). Hence, the suitable habitat for round-tailed muskrats was naturally fragmented, which is typical of habitat within the core of the geographic range for the species. In other regions, round-tailed muskrats occur in more extensive and continuous wetland systems such as the Everglades in Florida (Lefebvre and Tilmant 1992) and Carolina bays in Georgia (Bergstrom et al. 2000).

Our wetlands were seasonal and dried out for a period during spring (March–May) and then were refilled mainly by summer rains (June–September). Marshes typically were shallow (water depth <50 cm) and contained concentric plant zones dominated by pickerelweed (*Pontederia cordata*), maidencane grass (*Panicum hemitomon*), or St. John's wort (*Hypericum fasciculatum*). Matrix habitat between the patchy wetlands included Florida dry prairie, pine flatwoods (*Pinus palustris*, *P. elliotii*) and plantations (*P. elliotii*), and oak scrub and hammocks (*Quercus* spp.).

Livetrapping procedures.—We livetrapped round-tailed muskrats periodically from 11 March 2003 to 25 May 2004 at 18 wetlands. In an attempt to increase capture success relative to previous studies, we designed an artificial platform–trap combination that we positioned near active lodges or natural platforms. Each plywood platform (30.5 × 61 cm) had 3 adjustable legs made of PVC pipes so that we could alter platform heights to keep them even with changing water levels. Legs were pushed into soft, wet soil to stabilize the platforms. When wetlands dried out, we put platforms directly on the ground. We placed 1 Tomahawk live trap (15 × 15 × 40 cm) near the back of the platform so that there was a haul-out area for muskrats in front of the trap opening. We covered the outside of each trap with wetland vegetation and baited the trap and haul-out area with slices of Golden Delicious apples or carrots. Each trap was connected to a platform via 2 clamps that prevented raccoons (*Procyon lotor*) from dislodging the trap.

We set traps in the evening, checked them at dawn, and kept them closed during the daytime. For all captured animals, we recorded age (juvenile, subadult, adult), sex, reproductive status (males = nonreproductive or scrotal testes; females = nonreproductive, pregnant, or lactating), and body mass. We marked individuals uniquely (Schooley et al. 1993) with passive integrated transponder tags (Biomark, Inc., Boise, Idaho). We set traps for round-tailed muskrats on 97 nights for a total trap effort of 3,961 trap-nights. Capture and handling procedures followed guidelines of the Animal Care and Use Committee (1998) of the American Society of Mammalogists and were approved by the University of Florida's Institutional Animal Care and Use Committee.

Radiotagging and tracking.—From 16 January to 12 July 2004, we radiocollared and tracked round-tailed muskrats at 2 marshes (1.2 and 10.7 ha) separated by 1.2 km. Both wetlands were high-quality habitat that had zones of dense maidencane grass, a preferred food for round-tailed muskrats (Birkenholz 1963). We fitted captured muskrats with radiotransmitters equipped with motion-sensitive mortality switches and whip antennae (SOM-2070 and SOM-2190 models, Wildlife Materials International, Murphysboro, Illinois) attached to cable-tie collars. Weights of complete radio packages (6.8–9.0 g) were <5% ($\bar{X} = 3.7\%$, $SD = 0.67\%$) of the body mass of muskrats. We radiotracked 23 round-tailed muskrats (8 scrotal males, 10 nonreproductive males, 5 nonreproductive females). We captured 19 of these individuals at the 10.7-ha wetland and 4 at the 1.2-ha wetland. All individuals were subadults or adults based on pelage and body mass (Birkenholz 1963).

We located individuals at most once per day (from 0800 to 1835 h) for ≤5 locations per individual each week. We did not determine locations via triangulation because we expected that technique would be inaccurate given the fine-scale movements anticipated for muskrats. Instead, we used a homing technique to locate animals directly in their daytime rest sites (lodges or burrows). We used a radio receiver and 3-element Yagi directional antenna to determine the general location of a radio signal. Then, we determined the specific location by replacing the Yagi antennae with a short (about 12 cm long) piece of wire, or sometimes no antennae, and by walking toward the strongest signal strength. A field experiment involving radiocollars hidden inside of muskrat lodges produced a mean difference between estimated and true locations of only 0.14 m ($SE = 0.14$, $n = 17$), and the correct lodge was identified in 94.1% of the trials. For each estimated location, we obtained spatial coordinates using a global positioning system (Trimble ProXR, Sunnyvale, California) with real-time differential correction (1–2-m accuracy). We marked each rest site with a unique number. Round-tailed muskrats used lodges as rest sites exclusively until 13 May, but as wetlands subsequently dried they switched to mainly using burrows.

Analysis of space use.—We were interested in whether the number of rest sites used by muskrats was related to individual characteristics and to use of different rest-site types associated with changes in water levels. As predictor variables, we evaluated body mass (at 1st capture), sex–reproductive status (scrotal males, nonreproductive males, nonreproductive females), and rest-site type (lodges, lodges plus burrows). The rest-site–type variable reflected seasonal changes in wetland conditions because individuals that used only lodges were radiotracked solely while wetlands were inundated, whereas individuals that used lodges plus burrows were radiotracked across the wet season–dry season transition. Number of rest sites used was related positively to number of radiolocations (see Results), so we included number of radiolocations as a covariate in all models (Shibata et al. 2004). All 23 individuals were used for the analyses. We developed a candidate set of generalized linear models (PROC GENMOD—SAS Institute Inc. 2002) that included combinations of predictor variables, and then used a model-selection procedure based on Akaike information criterion (AIC_c) to rank models and evaluate importance of predictor variables (Burnham and Anderson 2002). We present results as AIC_c differences ($\Delta_i = AIC_{ci} - \text{minimum } AIC_c$). The best model has $\Delta_i = 0$, and models with $\Delta_i \leq 2$ are considered competitive models (Burnham and Anderson 2002). We also report Akaike weights (w_i), which are normalized relative likelihoods that model i is the best model.

We conducted all home-range analyses with the Animal Movement extension (Hooge and Eichenlaub 2000) for the Spatial Analyst module of ArcView GIS (Version 3.2, ESRI, Redlands, California). We estimated home-range size using the 100% minimum convex polygon

(MCP) method (Hayne 1949). Area-observation curves using 100 bootstrap replicates for each sample size indicated that about 25 radiolocations were necessary to estimate home-range size using the MCP model (Branch and Schooley 2005). Most individuals had inadequate sample sizes due to high mortality rates. Five males (3 nonreproductive, 2 scrotal) had a sufficient number of radiolocations (≥ 25) to estimate home-range size without adjusting for number of locations.

Because we relocated individuals in their diurnal rest sites and not while they were foraging, our home-range estimates probably were biased low. Birkenholz (1963) reported that most foraging occurs within about 6 m of a lodge. For the 5 males with adequate sample sizes, we modified our raw estimates of ranges by adding a circular buffer (6-m radius) to each lodge location and then recalculated MCP home-range sizes and report these as “buffer-adjusted estimates.”

We used AIC_c-based model selection to evaluate whether body mass and reproductive status were predictors of MCP home-range size. We did not evaluate rest-site type as a predictor so as to maintain a tolerable balance between number of predictor variables and number of observations. We used raw estimates of ranges, restricted our evaluation to individuals with ≥ 10 radiolocations, and included number of radiolocations as a covariate in all models (Shibata et al. 2004). We also limited our statistical analyses to 13 males (8 nonreproductive, 5 scrotal) because only 2 females had ≥ 10 radiolocations.

Dispersal estimates.—We used cross-species equations to predict dispersal distances for round-tailed muskrats based on average body mass (Sutherland et al. 2000) and home-range size (Bowman et al. 2002) obtained from this study. This indirect approach is 1 practical way to obtain approximate estimates of dispersal potential for a species for which actual dispersal data are extremely difficult to obtain. However, realized dispersal distances for species also will depend on other factors, especially landscape structure (Schooley and Wiens 2004).

RESULTS

Capture success.—We captured 48 individual muskrats a total of 167 times. The sex ratio of captured animals was heavily biased toward males (69%). We captured only 7 juveniles (59–109 g). Our basic estimate of capture success ($[\text{number of captures}/\text{number of trap-nights}] \times 100$) was 4.2%. In contrast, Bergstrom et al. (2000) reported a capture rate of only 0.5%. Our estimate of capture success adjusted for sprung traps (Beauvais and Buskirk 1999) was 4.5%. Trapping success differed among seasons with the greatest success from February to May ($>7.5\%$ adjusted rate) compared to relatively low success from June to August ($\leq 2.2\%$).

Radiotracking and dispersal.—The mean number of radiolocations per individual was 14 ($SD = 10.2$, maximum = 39, $n = 23$). Fifteen individuals had ≥ 10 relocations. We monitored individuals for an average of 23 days ($SD = 19.1$, maximum = 62, $n = 23$). As expected, number of radiolocations per individual was correlated positively with number of days monitored ($r = 0.98$, $P < 0.001$, $n = 23$). Only 1 individual seemed to have lost its radio package; we found it in a wetland with no sign of a carcass nearby. We detected no movements of the 23 radiomarked muskrats away from the 2 wetlands where they had been captured and released. This pattern of residency was based on a total of 317 radiolocations that represented 525 muskrat-days of monitoring.

Rest-site use.—Individual round-tailed muskrats used 2–15 different rest sites ($\bar{X} = 5.9$, $SD = 3.95$, $n = 23$). Number of rest

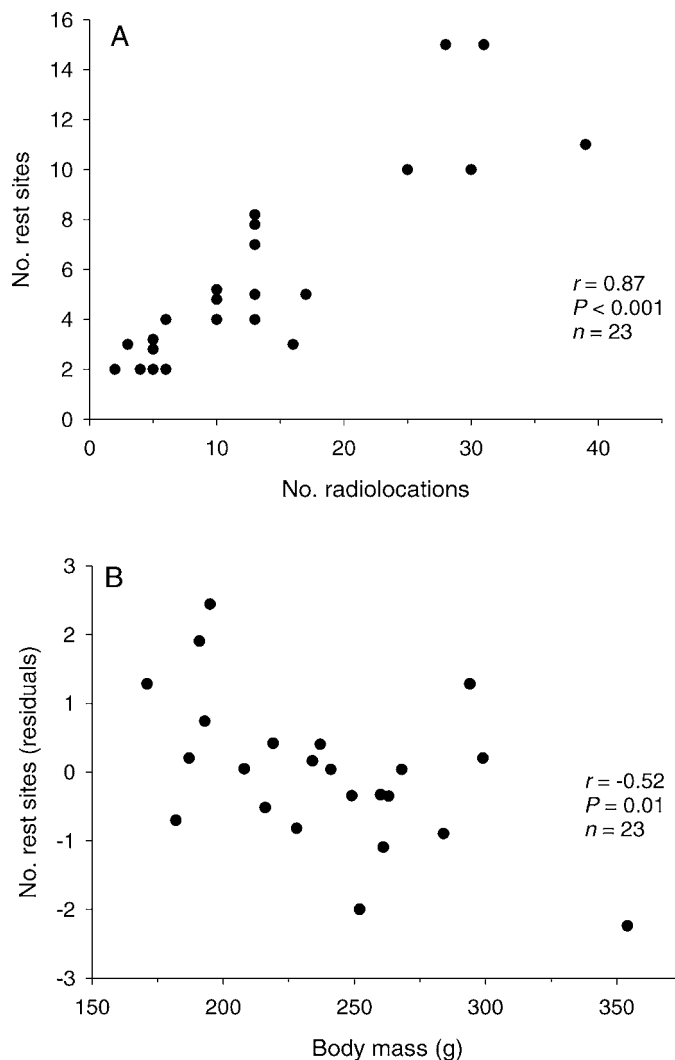


FIG. 1.—A) Relationship between number of rest sites used by round-tailed muskrats and number of radiolocations. B) Association between number of rest sites used (corrected for number of radiolocations) and body mass of individuals.

sites used was related positively to number of radiolocations (Fig. 1A). The best model ($R^2 = 0.83$) for predicting number of rest sites included the radiolocations covariate and body mass (Table 1). After correcting for number of radiolocations, heavier individuals used fewer rest sites than did lighter individuals (Fig. 1B). Sex-reproductive status and rest-site type had no detectable effects on number of rest sites (Table 1).

Some individuals had a primary rest site ($\geq 50\%$ of radiolocations at a single rest site), whereas others used several sites with similar intensity. For instance, 1 male used 4 lodges, but most (10 of 13) of his radiolocations were in a single lodge. In contrast, another male used 15 different lodges or burrows, and 3 rest sites received similar use (4–6 days each). For individuals with ≥ 10 radiolocations, heavier individuals (\geq median body mass) were more likely (50%) to have primary rest sites than were lighter individuals (0%; Fisher's Exact Test, $n = 15$, $P = 0.077$).

TABLE 1.—Ranking of regression models evaluating factors influencing number of rest sites used (males and females) and home-range size (males only) for round-tailed muskrats. Explanatory variables included number of radiolocations, body mass, rest-site type (lodges or lodges plus burrows), and reproductive status (non-reproductive male or scrotal male). K = the number of explanatory variables plus 2, AIC_c is an Akaike information criterion, $\Delta_i = AIC_{ci} - \text{minimum } AIC_c$, and w_i values are Akaike weights. A 95% confidence set for the top model is presented for each response variable.

| Response variable and models | K | Log-likelihood | AIC _c | |
|--------------------------------------|---|----------------|------------------|-------|
| | | | Δ_i | w_i |
| No. of rest sites | | | | |
| Locations, body mass | 4 | -43.61 | 0.00 | 0.655 |
| Locations, body mass, rest-site type | 5 | -43.49 | 3.07 | 0.141 |
| Locations | 3 | -47.10 | 4.02 | 0.088 |
| Locations, rest-site type | 4 | -45.82 | 4.42 | 0.072 |
| Home-range size | | | | |
| Locations | 3 | -98.48 | 0.00 | 0.509 |
| Locations, reproductive status | 4 | -96.60 | 0.57 | 0.382 |
| Locations, body mass | 4 | -98.10 | 3.57 | 0.085 |

We never detected >1 individual using the same rest site simultaneously; however, of the 119 total rest sites used by 23 round-tailed muskrats, 13.4% were used by >1 individual on different days. Multiple individuals used lodges (15.2%, $n = 79$) and burrows (10.0%, $n = 40$) with a similar frequency ($\chi^2 = 0.615$, $d.f. = 1$, $P = 0.433$). Most instances of multiple use of rest sites involved only 2 individuals (93.8%); 1 burrow was used by 3 individuals on different days. Eleven cases of multiple use involved the same sex (2 males), but only 5 of those cases included individuals known to be alive when the spatial overlap occurred. In 4 of 5 situations with dual use of a rest site by 2 males, the site was used only once during monitoring by at least 1 of the individuals (i.e., not a primary site), and the site was on the perimeter of the home range for 1 or both individuals.

Home-range size.—For the 5 males with ≥ 25 locations (Fig. 2), home-range size averaged 1,263 m² ($SE = 304$) and ranged from 129 to 1,974 m². Our buffer-adjusted estimate of home-range size for the same 5 males averaged 2,071 m² ($SE = 430$, $n = 5$). Substantial overlap of MCP home ranges occurred for 2 individuals (Fig. 2), but 1 of these muskrats used 2 discrete areas within his MCP range so that spatial overlap of rest sites between individuals was minimal.

For males with >10 radiolocations, home-range size was correlated positively with number of radiolocations ($r = 0.73$, $P = 0.005$, $n = 13$). The best model ($R^2 = 0.53$) for predicting home-range size of males included only the radiolocations covariate (Table 1). A model that also included reproductive status was competitive and had a higher log-likelihood (Table 1), suggesting this predictor variable had some effect on home-range size. Reproductive males with scrotal testes had larger home ranges (least-squares mean = 945 m², $SE = 144.4$, $n = 8$) than did nonreproductive males (least-squares mean = 458 m², $SE = 182.7$, $n = 5$).

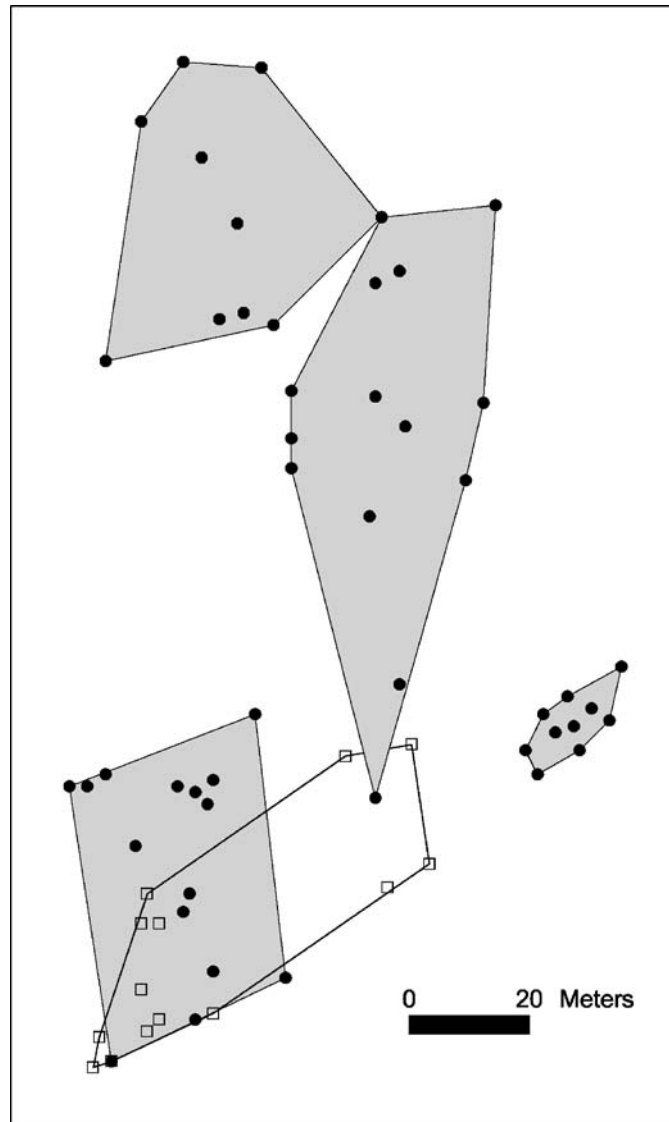


FIG. 2.—Home ranges of 5 male round-tailed muskrats modeled using the minimum convex polygon method. Each symbol (filled circle or unfilled square) represents a diurnal rest site (lodge or burrow). Estimated home ranges of 2 individuals overlapped considerably, but the individual indicated by an unshaded polygon had 2 separate activity areas.

DISCUSSION

Our study represents the most complete picture to date of space use by round-tailed muskrats, a distinctive component of the mammalian fauna of North America. Individual muskrats will use 10–15 different rest sites as demonstrated by our data for males with ≥ 25 radiolocations. This result is consistent with the observation by Bergstrom et al. (2000) of a male that used 10 lodges in Carolina bay habitat, and it indicates that the established rule of thumb of 2 lodges per individual (Birkenholz 1963) is either incorrect, or that patterns of rest-site use vary geographically. Round-tailed muskrats could be viewed as central-place foragers that periodically shift their central places within their home ranges. Males also might switch among rest sites to facilitate monitoring of females for breeding opportunities.

Despite the extreme change in environmental conditions of wetlands during our study—including complete drying that forced muskrats to shift use from lodges to burrows—we detected no seasonal differences in number of rest sites used by individuals. However, patterns of rest-site use were related to body masses of individuals. Lower-weight individuals used more rest sites and were less likely to have a preferred rest site, compared to heavier individuals. If these lighter individuals also were younger, this result suggests that young muskrats still were in the process of establishing and exploring home ranges and that space-use patterns are age-dependent in this species.

Our estimates of mean home-range size for male round-tailed muskrats (rest sites = 1,263 m², buffer-adjusted estimates = 2,071 m²) were 10 times greater than the single existing estimate derived from radiotelemetry (Bergstrom et al. 2000) and 25 times greater than the estimate that Allen et al. (2001) used to calculate a minimum critical area for the species in their modified gap analyses. Compared to other wetlands at our study area, our 2 focal wetlands were high-quality sites with zones of thick maidencane grass. Our judgment of habitat quality is based on a strong relationship between maidencane cover and the probability a wetland is occupied by muskrats (Branch and Schooley 2005). If home-range size is inversely related to resource abundance (e.g., Herfindal et al. 2005; Smith and Shugart 1987) then ranges might be even larger in low-quality habitat. Nevertheless, round-tailed muskrats in small, isolated wetlands have smaller home ranges than would be expected for herbivorous mammals of their body size (5,290–8,524 m²; Harestad and Bunnell 1979; Kelt and Van Vuren 2001; Swihart et al. 1988). Home-range sizes of muskrats might differ in other landscapes given the substantial variation in habitat structure that exists within the geographic range of the species.

According to Ostfeld's (1985) conceptual model for territoriality in arvicoline rodents, male round-tailed muskrats should be territorial. The model proposes that female territoriality is resource-based; females should be nonterritorial in species like muskrats that rely on relatively evenly distributed resources such as grasses. In contrast, male territoriality should be female-based; males should be territorial when females are nonterritorial, clumped in space, and defensible (Ostfeld 1985). Whether male round-tailed muskrats exhibit territoriality is uncertain, but some degree of exclusive space use by individuals occurs at several levels. First, we detected no concurrent use of rest sites by different individuals. Instances of shared use of rest sites separated in time were relatively infrequent and typically involved rest sites that were not preferred ones and that were located on the periphery of ranges. Birkenholz (1963) reported exclusive use of lodges, but Bergstrom et al. (2000) documented simultaneous sharing of a lodge by 2 reproductive adult males (genetic relationship unknown). Second, home ranges for the 5 males with ≥ 25 radiolocations indicated only 1 case of substantial overlap between 2 individuals (Fig. 2), and 1 of those males used 2 distinct areas so that actual overlap of locations was minor. Third, for 10 male muskrats from the larger wetland with ≥ 10 radiolocations, estimated core areas of ranges (50% probability polygons from fixed kernel model—Worton 1989) did not overlap except for 2 individuals that did not coincide in time (Branch

TABLE 2.—Predictions of median and maximum dispersal distances for round-tailed muskrats (*Neofiber alleni*) based on published cross-species equations for mammals.

| Dispersal distance | Prediction for <i>Neofiber</i> (m) | Predictor | Source |
|--------------------|------------------------------------|------------------------------|------------------------|
| Median | 671 | Body mass | Sutherland et al. 2000 |
| Median | 249 | Home-range size ^a | Bowman et al. 2002 |
| Median | 319 | Home-range size ^b | Bowman et al. 2002 |
| Maximum | 1,309 | Body mass | Sutherland et al. 2000 |
| Maximum | 1,422 | Home-range size ^a | Bowman et al. 2002 |
| Maximum | 1,820 | Home-range size ^b | Bowman et al. 2002 |

^a Raw estimate using minimum convex polygon method.

^b Buffer-adjusted estimate using minimum convex polygon method.

and Schooley 2005). Some of our core areas probably were underestimated, but the pattern is intriguing nonetheless.

We detected no dispersal from 2 isolated wetlands by round-tailed muskrats, which mainly were subadult and adult males. However, our concurrent, broad-scale study of wetland occupancy demonstrated that muskrats recolonize vacant wetlands, and the species exhibits metapopulation dynamics among wetlands (Branch and Schooley 2005). Hence, dispersal either is by age–sex classes not sampled in our study (e.g., juvenile males), or it occurs during other seasons and environmental conditions. Given the lack of empirical data on dispersal distances, estimates based on interspecific equations (Table 2) should be valuable, although movement distances of mammals can vary with landscape pattern (Dooley and Bowers 1998; Long et al. 2005; Wolff et al. 1997). Sutherland et al. (2000) estimated allometric relationships between body size and dispersal distance for mammals; however, Bowman et al. (2002) concluded that home-range size is a better predictor of dispersal capacity than is body size, because species have an inherent ability to move (independent of body size) that is reflected by home-range size. Estimates of median dispersal distances for round-tailed muskrats ranged from 249 to 671 m (Table 2). We also estimated dispersal capacity indirectly by examining distances between 46 recolonized wetlands and the closest source wetlands (Branch and Schooley 2005). The median recolonization distance was 452–472 m, depending on how sources were defined, which provides empirical estimates within the range from theoretical predictions. Moreover, most of the observed colonization distances ($\geq 96\%$) were less than the maximum dispersal distances predicted by home-range size (Table 2; Branch and Schooley 2005). Overall, these data delimit the probable spatial scales of dispersal and provide insights into how the species might respond to further loss and fragmentation of its wetland habitat.

Round-tailed muskrats inhabit small home ranges within isolated wetlands in central Florida. Therefore, even small wetlands may contain enough individuals to function as breeding subpopulations within a larger metapopulation (Gibbs 1993; Semlitsch and Bodie 1998), especially if quality of the wetland habitat is high. Small wetlands also might act as stepping-stones during dispersal of round-tailed muskrats, a species expected to be dispersal-limited (Branch and Schooley 2005). Conservation actions for round-tailed muskrats should

consider multiple-wetland networks and not just individual wetlands independent of their landscape context.

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LITERATURE CITED

- ALLEN, C. R., L. G. PEARLSTINE, AND W. M. KITCHENS. 2001. Modeling viable mammal populations in gap analyses. *Biological Conservation* 99:135–144.
- ANIMAL CARE AND USE COMMITTEE. 1998. Guidelines for the capture, handling, and care of mammals as approved by the American Society of Mammalogists. *Journal of Mammalogy* 79:1416–1431.
- BEAUVAIS, G. P., AND S. W. BUSKIRK. 1999. Modifying estimates of sampling effort to account for sprung traps. *Wildlife Society Bulletin* 27:39–43.
- BERGSTROM, B. J., T. FARLEY, H. L. HILL, JR., AND T. HON. 2000. Ecology and conservation of a frontier population of the round-tailed muskrat (*Neofiber alleni*). *Occasional Papers of the North Carolina Museum of Natural Sciences* 12:74–82.
- BIRKENHOLZ, D. E. 1963. A study of the life history and ecology of the round-tailed muskrat (*Neofiber alleni* True) in north-central Florida. *Ecological Monographs* 33:255–280.
- BOWMAN, J., J. A. G. JAEGER, AND L. FAHRIG. 2002. Dispersal distance of mammals is proportional to home range size. *Ecology* 83:2049–2055.
- BRANCH, L. C., AND R. L. SCHOOLEY. 2005. Wetlands assessment in a landscape context on Avon Park Air Force Range: surveys for wading birds and round-tailed muskrats (*Neofiber alleni*). Department of Defense, Final Report.
- BROCK, R. E., AND D. A. KELT. 2004. Conservation and social structure of Stephens' kangaroo rat: implications from burrow-use behavior. *Journal of Mammalogy* 85:51–57.
- BURNHAM, K. P., AND D. R. ANDERSON. 2002. *Model selection and multimodel inference: a practical information-theoretic approach*. Springer-Verlag, New York.
- DOOLEY, J. L., JR., AND M. A. BOWERS. 1998. Demographic responses to habitat fragmentation: empirical tests at the landscape and patch scale. *Ecology* 79:969–980.
- ENDRIES, M. J., AND G. H. ADLER. 2005. Spacing patterns of a tropical forest rodent, the spiny rat (*Proechimys semispinosus*), in Panama. *Journal of Zoology (London)* 265:147–155.
- GIBBS, J. P. 1993. Importance of small wetlands for the persistence of local populations of wetland-associated animals. *Wetlands* 13:25–31.
- HARESTAD, A. S., AND F. L. BUNNELL. 1979. Home range and body weight—a reevaluation. *Ecology* 60:389–402.
- HARRISON, S., AND A. D. TAYLOR. 1997. Empirical evidence for metapopulation dynamics. Pp. 27–42 in *Metapopulation biology: ecology, genetics, and evolution* (I. A. Hanski and M. E. Gilpin, eds). Academic Press, San Diego, California.
- HAYNE, D. W. 1949. Calculation of size of home range. *Journal of Mammalogy* 30:1–18.
- HERFINDAL, I., J. D. C. LINNELL, J. ODDEN, E. B. NILSEN, AND R. ANDERSEN. 2005. Prey density, environmental productivity and home-range size in Eurasian lynx (*Lynx lynx*). *Journal of Zoology (London)* 265:63–71.
- HOOGE, P. N., AND B. EICHENLAUB. 2000. *Animal movement extension to ArcView*. Version 2.0. Alaska Science Center, Biological Science Office, United States Geological Survey, Anchorage, Alaska.
- HOOGLAND, J. L. 1995. *The black-tailed prairie dog: social life of a burrowing mammal*. University of Chicago Press, Chicago, Illinois.
- KALCOUNIS-RÜPPELL, M. C., AND J. S. MILLAR. 2002. Partitioning of space, food, and time by syntopic *Peromyscus boylii* and *P. californicus*. *Journal of Mammalogy* 83:614–625.
- KELT, D. A., AND D. H. VAN VUREN. 2001. The ecology and macroecology of mammalian home range area. *American Naturalist* 157:637–645.
- LEFEBVRE, L. W., AND J. T. TILMANT. 1992. Round-tailed muskrat (*Neofiber alleni*). Pp. 276–286 in *Rare and endangered biota of Florida*. Vol. I. Mammals (S. R. Humphrey, ed.). University Press of Florida, Gainesville.
- LONG, E. S., D. R. DIEFENBACH, C. S. ROSENBERY, B. D. WALLINGFORD, AND M. D. GRUND. 2005. Forest cover influences dispersal distance of white-tailed deer. *Journal of Mammalogy* 86:623–629.
- OSTFELD, R. S. 1985. Limiting resources and territoriality in microtine rodents. *American Naturalist* 126:1–15.
- SAS INSTITUTE INC. 2002. *SAS for Windows*, Version 9.0. SAS Institute Inc., Cary, North Carolina.
- SCHOOLEY, R. L., AND L. C. BRANCH. 2005. Survey techniques for determining occupancy of isolated wetlands by round-tailed muskrats. *Southeastern Naturalist* 4:745–756.
- SCHOOLEY, R. L., B. VAN HORNE, AND K. P. BURNHAM. 1993. Passive integrated transponders for marking free-ranging Townsend's ground squirrels. *Journal of Mammalogy* 74:480–484.
- SCHOOLEY, R. L., AND J. A. WIENS. 2004. Movements of cactus bugs: patch transfers, matrix resistance, and edge permeability. *Landscape Ecology* 19:801–810.
- SCHUMAKER, N. H. 1998. *A user's guide to the PATCH model*. United States Environmental Protection Agency, Environmental Research Laboratory, Corvallis, Oregon. EPA/600/R-98/135.
- SEMLITSCH, R. D., AND J. R. BODIE. 1998. Are small, isolated wetlands expendable? *Conservation Biology* 12:1129–1133.
- SHIBATA, F., T. KAWAMICHI, AND K. NISHIBAYASHI. 2004. Daily rest-site selection and use by the Japanese dormouse. *Journal of Mammalogy* 85:30–37.
- SMITH, T. M., AND H. H. SHUGART. 1987. Territory size variation in the ovenbird: the role of habitat structure. *Ecology* 68:695–704.
- SUTHERLAND, G. D., A. S. HARESTAD, K. PRICE, AND K. P. LERTZMAN. 2000. Scaling of natal dispersal distances in terrestrial birds and mammals. *Conservation Ecology* 4(1):16. [online].
- SWIHART, R. K., N. A. SLADE, AND B. J. BERGSTROM. 1988. Relating body size to the rate of home range use in mammals. *Ecology* 69:393–399.
- TAYLOR, P. D., L. FAHRIG, K. HENEIN, AND G. MERRIAM. 1993. Connectivity is a vital element of landscape structure. *Oikos* 68:571–573.
- TINER, R. W., H. C. BERGQUIST, G. P. DEALESSIO, AND M. J. STARR. 2002. Geographically isolated wetlands: a preliminary assessment of their characteristics and status in selected areas of the United States. United States Department of the Interior, Fish and Wildlife Service, Northeast Region, Hadley, Massachusetts.
- WOLFF, J. O., E. M. SCHAUBER, AND W. D. EDGE. 1997. Effects of habitat loss and fragmentation on the behavior and demography of gray-tailed voles. *Conservation Biology* 11:945–956.
- WORTON, B. J. 1989. Kernel methods for estimating the utilization distribution in home-range studies. *Ecology* 70:164–168.

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