Distribution and Conservation of the Santa Rosa Beach Mouse

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Abstract: The Santa Rosa beach mouse (*Peromyscus polionotus leucocephalus*) occurs on a single barrier island in northwest Florida, but its distribution on the island is poorly known. In 1991–92 we searched for mouse tracks at 1-km intervals along the 78-km island and set traps at 23 locations. Beach mice occurred in beach and interior dune habitats across most (96%) of the undeveloped stretches (57 km) of the island. Beach mice were significantly less common in areas developed for residential or commercial use and tracks were found along just 7 of 21 km of developed land. We captured only 3 house mice (*Mus musculus*), all near buildings. Tracks of house cats (*Felis catus*) were significantly more common in developed areas. Predation by cats has likely reduced or eliminated beach mouse populations along developed beaches and at the undeveloped east end of the island. Habitat loss and house cats in 3 developed areas have apparently separated the beach mouse population into 4 isolated units. Conservation efforts should focus on maintaining existing habitat, controlling free-ranging house cats, and assessing the need for translocating mice among habitat fragments.

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Eight subspecies of the oldfield mouse (*Peromyscus polionotus*) occupy coastal dune habitats in Florida and Alabama (Hall 1981) and are collectively known as "beach mice." Most beach mouse subspecies are vulnerable to extinction because their ranges are small and isolated and because the coastal dune habitat they occupy is frequently developed for human use. One subspecies, the pallid beach mouse (*P. p. decoloratus*), is considered extinct and the only subspecies not listed as threatened or endangered by the federal or a state government (Wood 1992) is the Santa Rosa beach mouse (*P. p. leucocephalus*).

The Santa Rosa beach mouse occurs only on Santa Rosa Island, a narrow barrier island stretching nearly 78 km along the northwest coast of Florida. Howell (1920) collected beach mice on the island near Fort Walton Beach and noted the mice were abundant on beachfront sand dunes sparsely vegetated with sea oats

(*Uniola paniculata*). Blair (1946, 1951) found mice concentrated in dunes near the beach, but he also trapped them on interior dunes several hundred meters inland. Based on extrapolation from 1 study site, Blair (1946) estimated the island's population to be about 12,000 mice. Neither Howell (1920) nor Blair (1946, 1951) described specific locations where they found mice or indicated which parts of the island were surveyed for mice.

Specimens of *P. p. leucocephalus* were collected in the 1960s near East Pass, Fort Walton Beach, Navarre Beach, Fort Pickens, and east of Pensacola Beach (Bowen 1968; P. Borthwick, pers. commun.). Mice have recently been collected east of Fort Pickens (N. R. Holler, pers. commun.) and 10 km west of Fort Walton Beach (R. C. Lacy, pers. commun.).

Based on these collections and the availability of suitable habitat, biologists assumed that the Santa Rosa beach mouse is abundant and widely distributed on the island. However, no comprehensive survey for beach mice has been conducted on Santa Rosa Island and human use of the area has intensified. Much of the island remains largely undeveloped, but Fort Walton Beach, Pensacola Beach, and parts of Navarre Beach are now densely populated. Similar development of coastal habitats has been associated with the decline of other beach mouse populations (Holler 1992, Humphrey and Frank 1992). The restricted range of the Santa Rosa beach mouse, lack of a recent rangewide survey, history of decline in neighboring beach mouse subspecies, and increasing development of Santa Rosa Island all support the need for a survey of the distribution the Santa Rosa beach mouse and an assessment of conservation needs.

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Methods

Blair (1951) described habitats or vegetation types on Santa Rosa Island. Most of the island is covered by sparsely vegetated sand dunes and common plants include sea oats, rosemary (*Ceratiola ericoides*), goldenaster (*Chrysopsis* sp.), and Gulf bluestem (*Schizachyrium maritimum*). Beach dune habitat occupies a narrow strip along the gulf and typically consists of 1–3 dunes paralleling the beach. Interior and scrub dunes (Blair 1951) occur behind the beach dunes and are intermixed with lesser areas of forests and wetlands.

Santa Rosa Island has long been used for military operations, but construction of roads and buildings has largely been limited to 3 small sections of the island. Pensacola Beach and Fort Walton Beach (known locally as Okaloosa Island) have been extensively developed, but parts of Navarre Beach are undeveloped. Although some roads and buildings are present throughout most of the island, we identified 4 areas as relatively undeveloped: Eglin East (east of Fort Walton Beach), Eglin West (between Fort Walton Beach and Navarre Beach), Gulf Islands East (between Navarre Beach and Pensacola Beach), and Gulf Islands West (west of Pensacola Beach).

The open sands of the dune habitats and presence of only 1 native mouse made searches for tracks the most efficient means of identifying occupied beach mouse habitat on the island. We determined the distribution of beach mice primarily by searching for mouse tracks along 78 transects located 1 km apart along the length of the island.

Each transect consisted of 2 parallel lines approximately 50 m apart and perpendicular to the beach. Transects extended across the island and varied in length according to island width. Habitat type was recorded along each transect and the number of mammal trails that crossed the transect were tallied by species and distance from the beach (in 50-m segments). If no mouse tracks were observed along a transect, the transect was searched on at least 1 other date. If subsequent surveys produced mouse tracks, those data were used in our analysis.

Comparison of tracking data was confounded because transects varied in length and because most developed areas contained little dune habitat except along the beach. Therefore, we also recorded tracks along a 50-m segment of beachfront

Table 1. Number (and median) of tracks of mice (*Peromyscus polionotus* or *Mus musculus*[a]) and house cats (*Felis catus*) found along 78 transects on Santa Rosa Island, Florida.

	N (median) of tracks				Transects with tracks		
Location	Mouse		Cat		Mouse	Cat	Total
Developed areas							
Fort Walton Beach	0	(0)	97	(8)	0	5	5
Navarre Beach	17	(2)	57	(7.5)	4	6	6
Pensacola Beach	132	(0)	128	(10.5)	4	10	10
Total	149	(0)	282	(8)	8	21	21
Undeveloped areas							
Eglin East	16	(3)	84	(10)	5	6	7
Eglin West	902	(40)	27	(1)	22	15	22
Gulf Islands East	1,091	(72)	17	(1)	16	10	16
Gulf Islands West	434	(15.5)	10	(0)	12	4	12
Total	2,443	(46)	138	(1)	55	35	57
All areas	2,592		420		63	56	78

[a] Traps were set by several transects, but only 1 house mouse was captured, near a transect within Pensacola Beach.

near 65 of the 78 transects. These standard length samples provided less biased comparison between developed and undeveloped portions of the island.

Transects were surveyed between October 1991 and February 1992. We searched for tracks at other locations on the island between August 1991 and July 1992. These additional searches covered the beach dune habitat along most of the length of the developed portions of the island. Because weather conditions can greatly influence sand conditions and affect visibility and durability of tracks, we searched for tracks only when the sand was smooth and little disturbed from the previous night.

We could not reliably distinguish beach mouse tracks from those of house mice, therefore, we set traps whenever we suspected house mice might be present. Traps were baited with rolled oats and set at 23 locations to ascertain which species was present. The number of traps (10–40) and number of nights trapped (1–5) varied with the size and location of the area, trapping success, and number of tracks seen. We also set traps at 3 locations for a concurrent study of beach mouse habitat use. Data from those locations are included to augment the number of locations where beach mice were found and to indicate the relative abundance of house mice.

Habitats were classified as beach, beach dune (adjacent and parallel to the gulf beach), interior or scrub dune, wetland (interdune swales and marsh), forest, fresh water, and developed land (roads, buildings, etc.). We estimated areas of different habitats on the island using a dot grid (Bryan 1943) and 1:12,500 scale aerial photographs. Each dot on the grid represented 1.56 ha on the photographs. Habitat areas were estimated on 16 sites, each 1 km wide, selected from a stratified random sample of the tracking transect locations. Thus each 5-km stretch of the island contained 1 sampling site and samples covered 20.6% of the length of the island.

Results and Discussion

Distribution

The Santa Rosa beach mouse occurred along approximately 62 linear km of Santa Rosa Island in 1991–92. We estimated that suitable beach mouse habitat (Blair 1951) covered 2,409 ha of which 442 ha was beach dunes and 1,967 ha was interior or scrub dunes. Forests, wetlands, and open beaches covered approximately 26% of the island and developed land occupied about 20%.

We found mouse tracks along a greater proportion (96%) of transects in undeveloped portions of the island than in developed areas (Table 1; Chi square = 33.12, $P < 0.001$). Transects in undeveloped areas also contained more mouse tracks than transects in developed areas (Table 1; Mann-Whitney test, $P < 0.001$). This might be expected because undeveloped areas covered larger stretches of sand for tracking. However, track data from along 50-m sections of beach near 65 of the transects provided a less-biased comparison and also showed significantly more mouse tracks along undeveloped areas (Mann-Whitney test, $P = 0.03$).

The distribution and abundance of mouse tracks varied among the 3 developed areas (Table 1). Beach mice were absent within Fort Walton Beach,

although at the western boundary we found tracks and captured beach mice on Eglin Air Force Base. Nearly all mouse tracks in Pensacola Beach were found along dune preserves in the western third of the developed area and trapping confirmed that beach mice were present. Navarre Beach is much less densely populated than the other developed areas and it contains remnant parcels of interior dune habitat. We tracked or captured beach mice on beach and interior dunes across most of Navarre Beach. However, we found no evidence that beach mice crossed the most highly developed area at the east end of Navarre Beach near Transect 35. The beach mouse population may be fragmented into 4 isolated units separated by the developed sections of the island.

Within the undeveloped portions of the island, occupied beach mouse habitat covered approximately 22.0 km in the Eglin West area, 16.6 km in Gulf Islands East, and 12.1 km in Gulf Islands West. Only the Eglin East area contained transects with no evidence of beach mice (Table 1). We found mouse tracks on 49 of 50 transects in the other undeveloped areas, but 2 of 7 transects in the Eglin East area produced no mouse tracks despite repeated searches. Transect 2 in Eglin East was the only trapping location in an undeveloped area where we failed to capture beach mice.

The relative importance of the beach dunes as beach mouse habitat varies among locations depending largely upon the availability of suitable habitat behind the beach dunes (Blair 1951, Humphrey and Barbour 1981, Holliman 1983, Extine and Stout 1987, Holler and Rave 1991). We could not compare tracks among most habitats because the area of suitable tracking surface (i.e., open sand) varied among habitats. However, mice were not restricted to the beach dunes. Of 63 transects that contained mouse tracks, 70% had tracks on both beach dunes and interior dunes and 14% had tracks only on interior dunes. We also trapped beach mice and found their tracks along the litter and wrack line of the beach on the north side of the island, several hundred meters from the beach dunes.

House Mice

Because we could not distinguish beach mice tracks from those of house mice, we set traps at 23 locations for a total of >12,500 trapnights. Only 3 house mice were captured in the developed portions of the island. All were captured within 30 m of a building, and 2 were nearest a vacant building. Two recent studies of beach mice on the island covered several other locations and recorded hundreds of additional trapnights without capturing house mice (N. R. Holler and R. C. Lacy, pers. commun.). We trapped no house mice in the undeveloped portions of the island, thus we are confident that all undeveloped areas where we found mouse tracks represent occupied beach mouse habitat. The scarcity of house mice on the island in 1991–92 suggests they were not reproducing in the beach dune habitat.

At other locations, house mice have been found occupying beach mouse habitat and biologists have speculated that house mice may compete with beach mice for resources (Humphrey and Barbour 1981, U.S. Fish and Wildl. Serv. 1987, Holler and Rave 1991, Humphrey and Frank 1992). Holliman (1983), however,

found no house mice within occupied beach mouse habitat in Alabama and the occurrence of house mice in some locations has been irregular (Holler 1992, James 1992). The few house mice we found on Santa Rosa Island suggests that house mice were not excluding beach mice from potential habitat, even in developed areas. Nonetheless, house mouse numbers can increase rapidly and this species' role in excluding beach mice from dune habitats, particularly the altered habitat along developed portions of the island, should not be dismissed.

House Cats

Bowen (1968) warned that predation by house cats (*Felis catus*) might eliminate beach mouse populations from developed beaches and subsequent authors have reiterated his concern (Humphrey and Barbour 1981, Holliman 1983, Holler and Rave 1991, Humphrey and Frank 1992). On Santa Rosa Island, wherever cat tracks were abundant, mouse tracks were not (Table 1). We found cat tracks on 35 (61%) of the transects in undeveloped areas and on all 21 transects in developed areas (Chi square = 11.21, $P < 0.001$). Furthermore, the number of cat tracks was higher on transects in developed areas than in undeveloped areas (Mann-Whitney test, $P < 0.001$). Cat tracks comprised 14% of all cat and mouse tracks found, but they accounted for 65% of the tracks in developed areas and only 5% of the tracks in undeveloped areas (Table 1).

The inverse relationship between cat and mouse tracks might be a result of predation by house cats, but it can also be explained if habitat alterations that adversely affect mouse populations are, coincidentally, beneficial to cats. Circumstantial evidence from our tracking transects on the Eglin East area supports the idea that house cats are major predators of beach mice. A stretch of highway traverses the Eglin East area and a few isolated military buildings are present, but otherwise the land is undeveloped and the dune habitats are largely intact. Despite the absence of commercial or residential development, we found few mouse tracks and the only 2 transects in undeveloped areas that contained no mouse tracks (Table 1). Conversely, cat tracks were abundant (Table 1), and on 1 occasion we saw 5 cats at one time.

The number of mouse tracks found per transect in Eglin East was significantly lower than for the other 3 undeveloped areas (Mann-Whitney test, $P < 0.001$), but was not different from the number found in the 3 developed areas ($P = 0.386$). In contrast, the number of cat tracks per transect on Eglin East was significantly greater than for the other undeveloped areas ($P = 0.004$), but not different from the developed areas ($P = 0.894$). Because the habitat at Eglin East is largely undisturbed and similar to that on other undeveloped portions of the island, predation by cats is the most likely cause for the low numbers of mouse tracks.

The abundance of cats in Eglin East is probably related to the presence of 2 recreational beaches and facilities along an otherwise isolated beach. Although these recreational sites have disturbed little dune habitat, they are a source of food for cats and they are also a site for abandoning unwanted pets (C. J. Petrick, pers. commun.).

Management Implications

Habitat loss has not affected the Santa Rosa beach mouse as severely as it has other subspecies of beach mice because about 80% of Santa Rosa Island has not been subject to intensive development. Most of the island and nearly all of the remaining beach mouse habitat is managed by Gulf Islands National Seashore (National Park Service) and Eglin Air Force Base (Department of Defense). Maintaining the habitat protection these agencies already provide is critical to the conservation of the Santa Rosa beach mouse. Local governments control smaller, but important, parcels of land within Fort Walton Beach, Navarre Beach, and Pensacola Beach. Many of these sites provide public access to the beach, but they also provide current or potential beach mouse habitat. Protection of the beach dune habitat at these sites should be encouraged.

House cats are predators on beach mice, but their impact on populations has not been directly demonstrated. We found cats or their tracks in the most remote portions of the island, and in developed areas cat tracks outnumbered mouse tracks. We assume cats are the primary reason beach mice are absent from the dunes along Fort Walton Beach and most of Pensacola Beach. Cats are likely responsible for the scarcity of beach mice at the undeveloped east end of the island. Removal of cats from public lands on the island would likely be beneficial to beach mouse populations and should be encouraged. Eradication of cats from the Eglin East area is particularly important. Eradication efforts may need to be repeated periodically, perhaps each fall prior to the usual increase in beach mouse numbers in winter. Regulations and educational efforts would help reduce the number of abandoned or free-ranging house cats on both public and private lands.

Intensive development within 3 sections of the island has eliminated mice from most of these areas and created barriers that effectively separate the beach mouse population into isolated units. If major storms, predators, disease or some other catastrophe were to destroy any of the 4 isolated populations on the island, the developed areas would likely prevent recolonization of the depleted area. Gene flow among the 4 beach mouse populations is currently restricted or nonexistent and the long-term effect on the populations is undetermined. Capturing and translocating individuals between populations may be useful, and the costs and benefits of routine or emergency translocations should be assessed.

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