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Den Site Characteristics and Food Habits of the Red Fox (Vulpes vulpes) on Assateague Island, Maryland

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ABSTRACT

Aerial searches and ground surveys were used to locate red fox (*Vulpes vulpes*) excavations on Assateague Island, Maryland. Aerial searches were not successful since excavation entrances were concealed by vegetation and shadows from sand dunes. Red fox excavations on Assateague Island were located predominantly in shrub succession and *Hudsonia* dune habitats. Sand dunes within these habitats provided suitable denning sites. Average height and width measurements of fox excavations were significantly smaller in 1987 compared to 1985. These differences may be related to an increase in the number of juveniles. In 1985 and 1987, red fox excavations were predominantly oriented towards the northeast and northwest quadrants. Number of red fox denning areas increased from an estimated 8 to 11 between 1985 and 1987. Although the number of denning sites increased, the average distance between centers of denning areas decreased by 0.8 km. Red foxes on Assateague Island had a typically varied diet during summer 1987. Major components of the red fox diet as revealed by scat analysis included mammals (87.0%), crustaceans (64.8%), and birds (46.3%). Among the mammals, eastern cottontail rabbits (*Sylvilagus floridanus*) had the highest frequency of occurrence followed by meadow voles (*Microtus pennsylvanicus*) and white-footed mice (*Peromyscus leucopus*).

Key words: Red fox, *Vulpes vulpes,* Assateague Island, barrier island, denning habits, aerial searches.

INTRODUCTION

"Red fox are so variable in their behavior that any extrapolations leading to the management of foxes in one area based on studies from another should be viewed with caution" (Voigt and Macdonald, 1984). This statement based on the comparisons of red fox (*Vulpes vulpes*) populations in England and Canada, demonstrates the need for research to be conducted on individual red fox populations before developing management programs.

On 1 January 1985 the National Park Service prohibited trapping of red foxes within Assateague Island National Seashore, Maryland. Chincoteague National Wildlife Refuge, located just south of the Maryland/Virginia border (Fig. 1) still maintains a red fox trapping season. A study was initiated during summer 1985 to estimate the size of the red fox population on Assateague Island. Due to the

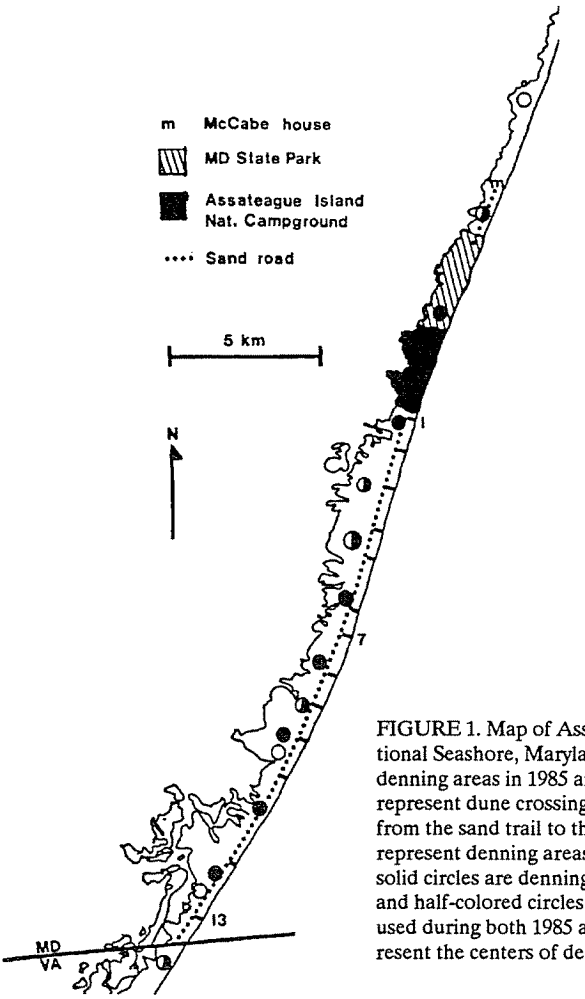

FIGURE 1. Map of Assateague Island National Seashore, Maryland showing red fox denning areas in 1985 and 1987. Numbers represent dune crossings permitting access from the sand trail to the beach. Open circles represent denning areas from 1985, while solid circles are denning areas used in 1987, and half-colored circles are denning areas used during both 1985 and 1987. Circles represent the centers of denning areas.

absence on Assateague Island of mortality factors, such as farm machinery, highways, and predation (Storm *et al.*, 1976; Pils and Martin, 1978), we believed this population would increase after trapping ceased.

These studies were undertaken in order to augment existing knowledge on the Assateague Island red fox population and to help the National Park Service formulate a management plan for this species. In this paper den-site characteristics and population estimates from two study years were compared to evaluate changes in these aspects of insular red fox ecology. In addition, we report on the first analysis of fox food habits from the Atlantic barrier islands.

STUDY AREA

The study area consisted of 25.4 km^2 of Assateague Island National Seashore, Worcester Co., Maryland. The study area extended from Ocean City Inlet on the northern end of Assateague Island southward 0.8 km beyond the Virginia border,

and included 0.4 km^2 of the Chincoteague National Wildlife Refuge, immediately south of the State Line (Fig. 1). This area is bounded by the Atlantic Ocean on the east, and Chincoteague and Sinepuxent bays on the west. From east to west across the island the typical sequence of terrestrial communities was: high energy beach, primary dunes, *Hudsonia* dunes, shrub succession, pine woods, and wetlands, with fresh water ponds interspersed within individual communities in the interior of the island (Hill, 1986).

MATERIALS AND METHODS

The first year of the study extended from 20 May to 18 August 1985, while the second year extended from 20 May until 30 August 1987. Five low level (approximately 30.5 m above M.S.L.; 70 ± 10 kts.) aerial searches to locate red fox excavations were flown during April (1), May (3), and August (1) 1985. Flights were made in a Cessna-150 by a pilot and one observer, who was experienced with the appearance of fox excavations. Two transect paths were flown per flight; North to South and South to North over the entire study area.

Ground surveys were undertaken by one to six people to locate fox excavations throughout the study area between 20 May - 23 July 1985 and 20 May - 20 July 1987. Survey and measurement techniques were identical in both years. Excavations were considered active based on the presence of fox tracks and whether the entrance was cleaned out (Sheldon, 1950). Excavations were further classified as dens (depth >1.0 m), pseudo-dens (depth 0.5-1.0 m), and digs (depth <0.5 m) (Bashore and Krim, 1986). Only dens and pseudo-dens were analyzed in this study, because digs were usually related to caching or other non-denning activities. Orientation of entrance openings (in degrees) was determined by using a Warren-Knight forester's compass. Hourly records of wind speed and direction for both 1985 and 1987 were obtained from NASA, Wallops Island, Virginia, 32 km southwest of Assateague Island. Entrance height and width were measured using expandable kitchen corn tongs. These were inserted 45 cm into the opening, expanded to the height or width of the tunnel, held in position as they were extracted, and placed on a meter stick to obtain measurements. The 45 cm depth was chosen to minimize bias caused by sand blown into or fallen at the entrance. Collapsed excavations could not be measured.

In North America, red fox families traditionally consist of a pair of foxes (one adult male and female) and their pups, and occupy well-defined contiguous territories (Scott, 1943). Sargeant *et al.* (1975) assigned dens within 1.6 km of each other to the same fox family. Bashore and Krim (1986) defined a red fox denning area as a section of Assateague Island which contained at least one active den in association with other dens, pseudo-dens, and digs. Denning areas were identified by plotting fox excavations on vegetation maps. When plotted, these excavations often took the form of distinctive clusters, which usually occurred within 1.6 km of each other. Denning areas lacking distinct clusters were determined by drawing a circle (1.6 km in diameter) from the center of a major group of excavations.

In 1987, relative coverage of open ground, grasses and forbs, shrubs, and trees was estimated for a 10 m radius circle centered on the excavation. This was determined by running four transect lines (10 m in length) from the excavation opening, and were oriented to cover the four ordinal directions. The length of

transect passing under the dripline of a tree was measured to determine relative coverage of trees. The portion of transect length intercepted by plants or by a perpendicular projection of their foliage was measured for grasses, forbs, and shrubs. The amount of open ground (non-vegetated) which intercepted the transect also was measured (Brower and Zar, 1977).

All excavations from the two years were plotted on a vegetation map (1:8640 scale) (Hill, 1984) and on a U.S. Department of Agriculture Soil Survey map (1:15840 scale) (Hall *et al.*, 1973). Chi-square tests were performed to determine if red fox excavations were distributed randomly among seven habitat types. To compute expected values, the areal percent for each habitat was multiplied by the total number of excavations located. To meet the assumptions of the chi-square test (Zar, 1984), two habitat types (non-vegetated plus washes and pans) were combined.

Red fox scat collected between May - August 1987 was analyzed to determine food habits. The scat was washed and broken up, floated in a sieve of clean water to separate it further and dried at 50° C for at least 24 hours (Lockie, 1959; Green *et al.*, 1986). Scat contents were separated into eight major categories: mammals, birds, crustaceans, fish, insects, plants, molluscs, and unknown. Where possible mammal remains were identified to genus or species by analyzing bone fragments, teeth, and hair present in the scat.

Statistical analyses followed the procedures of Zar (1984) and were performed using BIOSTAT I (Pimentel and Smith, 1985).

RESULTS

Three potential fox excavations were observed during the two afternoon flights and no sightings occurred during morning flights. One sighting was verified as a shallow dig (depth < 50 cm) in a sparsely vegetated sand dune. The second possible excavation was not located during a ground search four days later, while the third sighting was verified as a previously located pseudo-den in a sparsely vegetated primary dune.

In 1985, 61 red fox excavations were located from ground searches. Of these, 49 (80.3%) were classified as dens (16 active; 33 inactive) and 12 (19.7%) were pseudo-dens (3 active; 9 inactive). In 1987, 96 fox excavations were located. Of these, 70 (72.9%) were classified as dens (41 active; 29 inactive) and 26 (27.1%) were pseudo-dens (6 active; 20 inactive). Pseudo-dens were found both in association with dens and other pseudo-dens and isolated from other fox excavations. Dens and pseudo-dens with one opening were common on Assateague, 43 of the 61 excavations in 1985 and 75 of 96 excavations in 1987 had only one opening.

Height and width measurements of fox excavations from 1985 were compared to those from 1987 (Table 1). Some excavations had collapsed before height and width measurements could be made. Active pseudo-dens were not analyzed due to small sample sizes in both 1985 (n = 3) and 1987 (n = 4). There were significant differences between years in the heights and widths of all three excavation types (active and inactive dens, and inactive pseudo-dens), with sample means in 1987 smaller than those in 1985. Average height and width dimensions of active dens in 1985 were 23 x 25 cm and in 1987 were 20 x 22 cm. In 1985, 32 (54.2%) excavations were oriented towards the northwest, 14 (23.7%) faced southwest, 12 (20.3%) faced

northeast, and 1 (1.7%) faced southeast. In 1987, fox excavations were oriented predominantly towards the northeast (n = 34; 36.9% of the total) and northwest (29; 31.5%), with fewer being oriented toward the southwest and southeast (19; 20.7% and 10; 10.9%, respectively). Directional orientation of excavations differed significantly between 1985 and 1987 ($X^2 = 12.25$, $P < 0.01$). Between 1985 and 1987 there was a significant increase in the frequency of excavations oriented towards the southeast ($Z = -3.54$, $P < 0.01$). However, in 1987, 68.4% of the excavation entrances were oriented towards the northeast and northwest quadrants. No significant correlations were observed between wind direction and excavation orientation or between winds above 20 mph, representing major storms, and excavation openings in either 1985 or 1987.

In 1985, 31 excavations were located in shrub succession, 19 in *Hudsonia* dune habitat, 7 in dunegrass and 1 in woodland communities. A Chi-square analysis was not performed on the data from 1985 because after combining two habitat types, the data still did not conform to the assumptions of the Chi-square test (Zar, 1984) (*i.e.* more than 20% of expected frequencies were less than 5.0). Fox excavations were distributed non-randomly among habitat types in 1987 (Table 2) ($X^2 = 781.8$, $df = 6$, $P < 0.001$). Of the 96 excavations located, 59 were in the *Hudsonia* dune habitat, with 31 in shrub succession, while woodland and dunegrass communities supported fewer numbers (4 excavations, and 2 excavations, respectively). In order to meet the assumptions of the Chi-square test (Zar, 1984), data from two similar habitats having small numbers of excavations (non-vegetated plus washes and pans) were combined. Between 1985 and 1987 there was a significant increase in the use of *Hudsonia* dune habitat for red fox excavation location ($Z = -2.30$, $P < 0.05$). There was also a corresponding significant decrease ($Z = 1.73$, $P < 0.05$) in red fox use of shrub succession habitat for excavation location.

There were an estimated eight breeding pairs of foxes (16 individuals) on Assateague Island in 1985. This increased to an estimated 11 pairs (22 individuals) in 1987. Because Assateague is a narrow barrier island oriented parallel to the coasts of Maryland and Virginia, denning sites were located from north to south in basically a straight line (Fig. 1). Therefore, measurements between the centers of adjacent denning areas were made continuously from north to south. The average distance between centers of adjacent denning areas decreased from 3.4 km in 1985 to 2.6 km in 1987.

In 1985, 51 excavations (83.6% of the total) were located in soils with a dominant sandy texture (coastal beach soils), while 9 excavations (14.8%) were in soil with a loamy sand texture (klej soil). During 1987, 93 excavations (96.9% of the total) were located in sandy soils, while 3 excavations (3.1%) were found in a soil with a sandy loam texture. There was a significant increase in the use of sandy textured soil for the location of fox excavations from 1985 to 1987 ($Z = -2.42$, $P < 0.01$).

Results from the analysis on the amount of barren ground and vegetative cover surrounding fox excavations were varied (Table 3). Open ground and shrubs were the only ground covers which showed significant differences among the different excavation types. ANOVA tests were performed on the average length of transect intercepted by barren ground and vegetative covers, while percent cover is recorded in Table 3. Although ANOVA tests revealed significant differences, the

TABLE 1. Comparison of average height and width measurements (in cm) of red fox excavations within Assateague Island National Seashore, Maryland, from 1985 and 1987. Active pseudo-dens from 1985 and 1987 were not included in the analysis due to the small sample sizes (3 and 4, respectively).

Excavation Type	1985	1987	Statistic
Active Dens			
Height	23	20	U = 288
	(n=13)	(n=32)	P < 0.05
Width	25	22	t =2.116
	(n=13)	(n=32)	P < 0.05
Inactive Dens			
Height	19	17	t =2.593
	(n=15)	(n=17)	P < 0.02
Width	25	21	U = 192
	(n=15)	(n=17)	P < 0.02
Active Pseudo-dens			
Height	23	25	
	(n=3)	(n=4)	
Width	23	27	
	(n=3)	(n=4)	
Inactive Pseudo-dens			
Height	24	16	t =3.820
	(n=9)	(n=10)	P <0.002
Width	27	20	t =4.227
	(n=9)	(n=10)	P <0.001

results of multiple range tests were ambiguous. In analyzing the amount of shrub cover, active and inactive dens, as well as active pseudo-dens grouped together, however, inactive dens and active pseudo-dens also grouped with inactive pseudo-dens. This could have resulted from the low sample sizes in both active and inactive pseudo-dens (4 and 19, respectively). The amount of open ground showed less ambiguity. Inactive pseudo-dens grouped with inactive dens and active pseudo-dens, but active dens also grouped with active pseudo-dens. Again this could be the result of only having four active pseudo-dens in the analysis.

Prey remains were often observed in the vicinity of red fox excavations. The most common prey item was the eastern cottontail rabbit (*Sylvilagus floridanus*), although skate (*Raja erinacea*) and blue fish (*Pomatomus saltatrix*) were fairly common. The skate and bluefish were probably left on the beach by fishermen and scavenged by foxes. A pony (*Equus caballus*) leg was also discovered outside a fox den, most likely from a carcass found by the foxes. Remains of other prey items found at fox excavations included muskrat (*Ondatra zibethicus*), meadow vole (*Microtus pennsylvanicus*), and willet (*Catoptrophorus semipalmatus*).

Based on the analysis of 56 scats, the diet of red foxes on Assateague Island, during the 1987 study, consisted primarily of mammals, crustaceans, and birds (Table 4). Of the identified mammals consumed, the eastern cottontail rabbit had the highest frequency of occurrence (44.4%), followed by the meadow vole (31.5%) and white-footed mouse (*Peromyscus leucopus*) (24.1%). From field observations

TABLE 2. Number and distribution of red fox excavations among habitats on Assateague Island National Seashore, Maryland from 1985 and 1987. Aerial extents of each habitat are from Bashore and Krim (1986). Numbers in parentheses are percent of total yearly sample.

Habitat Type	1985	1987	Percent of Total Area
Shrub succession	31 (50.8)	31 (32.3)	15.3
Hudsonia dunes	22 (36.1)	59 (61.5)	4.5
Dune grass	7 (11.5)	2 (2.1)	10.0
Woodland	1 (1.6)	4 (4.2)	6.7
Fresh water marsh	0	0	14.9
Tidal marsh	0	0	35.4
Non-vegetated plus Washes and Pans	0	0	13.2
Totals	61	96	

during summers 1985 and 1987, rabbits appeared abundant on the island. The status of the meadow vole and white-footed mouse was unknown during this study.

DISCUSSION

Aerial surveys were not useful for locating red fox excavations on Assateague Island because most excavation entrances were concealed by vegetation or dune shadows. All fox excavations on Assateague Island were believed to have been dug by red foxes. This is in contrast with Pils and Martin (1978), who noted that red foxes in Wisconsin modified dens dug by badgers and woodchucks.

In 1987, both adult and juvenile red foxes were flushed from pseudo-dens; however, no foxes were flushed from excavations in 1985. Pseudo-dens may function as resting places for both adults and juveniles. Scott (1943) reported that red foxes in the northern Great Plains utilized nearby dens as outlying retreats, and Kolosov (1935) found that 70% of dens located in Russia were temporary retreats. These were shallow, short excavations having few, if any, branches and may have been similar to pseudo-dens found on Assateague.

There were significant differences between years in the heights and widths of all excavations types, with means in 1987 smaller than those in 1985. These differences may be related to the fact that more juveniles foxes were observed in 1987 compared to 1985. The average dimensions in 1987 were smaller than those reported by Storm *et al.*, (1976) in Illinois (28 x 23 cm), and in Iowa (25 x 23 cm), and by Pils and Martin (1978) in Wisconsin (28 x 23 cm). These differences may also be related to an increase in juveniles in 1987. More juveniles seen in 1987 may indicate a shift in the age structure of the population.

Directional orientations of red fox excavations differed significantly between 1985 and 1987. Although there was a significant increase in the frequency of

TABLE 3. Percentage composition of vegetative cover surrounding red fox excavations on Assateague Island National Seashore, Maryland in 1987. Letters represent results of multiple range tests and encompasses values that did not differ statistically ($P < 0.05$).

Excavation Type	Open	Grass	Shrub	Tree
Active Dens (N = 34)	56.9a	31.8	10.9a	0.4
Active Pseudo-Dens (N = 4)	47.4ab	23.3	27.7a	0.8
Inactive Dens (N = 27)	44.3b	30.6	23.1a	2.0
Inactive Pseudo-Dens (N = 19)	41.7b	27.6	29.9	0.8

excavations oriented towards the southeast from 1985 to 1987; excavations were still predominantly oriented towards the northeast and northwest quadrants in 1987. If directional orientation of excavations is related to thermal considerations, it would seem reasonable for excavations to be oriented towards cooler northern directions during summer months. It has been hypothesized that arctic foxes select favorable microclimate conditions in which to construct dens (Chesemore, 1969; Smits *et al.*, 1988). Red foxes on Assateague Island may also select microclimate conditions favorable for construction of fox dens.

Shrub succession and *Hudsonia* dune habitats were the two most important sites for red fox excavations on Assateague Island. These two habitats supported 96.2% of the total excavations in 1985 and 93.6% in 1987. Between 1985 and 1987 there was a significant increase in the use of *Hudsonia* dune habitat for red fox excavation location. Although this shift was significant, it probably does not constitute a major habitat change, since *Hudsonia* dune community usually occurs within the shrub succession habitat (Hill, 1984). In many places these two habitats merged together and one side of a dune was characterized by shrub succession habitat while the other side was predominantly *Hudsonia* dune habitat.

Between 1985 and 1987 the red fox population increased from an estimated eight breeding pairs to an estimated 11 breeding pairs. The average distance between centers of adjacent denning areas decreased from 3.4 km in 1985 to 2.6 km in 1987. This suggested that suitable red fox denning sites may not have been limited in 1985.

Red foxes have been reported to exhibit a universal preference for digging dens in sandy loam soils (Soper, 1942; Sheldon, 1950; Storm *et al.*, 1976; Pils and Martin, 1978) and well-drained soils (Scott and Selko, 1939; Layne and McKeon, 1956; Stanley, 1963). Sandy or loamy sand textured soils also appeared to be important factors influencing the location of fox excavations on Assateague Island. These two types of soils permit rapid water drainage and ease in digging excavations. They also were above the water table (Hall *et al.*, 1973), which may be an important factor in determining excavation location on Assateague. There was a significant increase in the use of sandy-textured soil for the location of fox excavations from 1985 to 1987. The sandy loam soil (klej) was restricted to an area west of the primary dunes from dune crossing 10 southward to approximately 1.0 km south of dune crossing

TABLE 4. Percent frequency of occurrence for prey items found in red fox scat on Assateague Island, Maryland. Results were based on the analysis of 56 scats found between May and August 1987.

	PERCENT FREQUENCY
MAMMALS	87.0
Rabbit	44.4
Meadow Vole	31.5
White-footed Mouse	24.1
Unknown	35.2
CRUSTACEANS	64.8
BIRDS	46.3
PLANT	42.6
INSECTS	31.5
FISH	9.3
MOLLUSCS	1.9
UNKNOWN (Organic)	37.0

11 (Fig. 1). Although the increase in the use of sandy-textured soil was statistically significant, it may not represent a major change in red fox preference. The change probably occurred due to a slight shift in the location of a denning area from 1985 to 1987. This shift moved the denning area location from the site where klej soil was restricted to an area just to the north.

Active dens are significantly different from both inactive dens and inactive pseudo-dens in the amount of open ground surrounding them. The large amount of barren ground associated with active dens may reflect the need for increased visibility while raising young. Less vegetation may also have resulted in higher wind velocities and thus fewer numbers of biting insects (Keiper and Berger, 1982) surrounding the excavations. Biting insects, which are abundant on Assateague, may influence red fox excavation location on Assateague Island.

Life expectancy of red fox excavations on Assateague was unknown, but due to constant sand shifting, it appeared that excavations in unprotected areas cover over within days or weeks. However, excavations in protected areas with shrub cover last several years. During the ground search in 1985, a researcher broke through the surface of a dune and discovered an old fox den, although no evidence of a den opening was present.

Although red fox food habits have been studied extensively in southern Wisconsin and Iowa (Errington, 1935, 1937), Michigan (Hamilton *et al.*, 1937), Maryland (Hockman and Chapman, 1983), Missouri (Korschgen, 1959), England (Southern and Watson, 1941), Ireland (Robertson and Whelan, 1987), central Alberta (Dekker, 1983), and Newfoundland (Dodds, 1955; Maccarone and Montevechi, 1981), studies on the food habits of red foxes on Atlantic barrier islands are apparently non-existent.

Red fox diets have been documented to consist largely of lagomorphs and rodents depending on their abundance (Errington, 1935; Scott, 1943; Wood, 1954; Dodds, 1955; Korschgen, 1959; Hockman and Chapman, 1983; Robertson and Whelan, 1987). Insects and fruit show seasonal fluctuations with the peak occurring

in summer and autumn (Ewer, 1973). *Microtus* appears to be an important food source for red fox in other regions of its distribution (Errington, 1935; Heit, 1944; Scott and Klimstra, 1955). Heit (1944) studied fox food habits in a salt marsh in Maryland and found *Microtus* to be the most frequent prey item in the scat, although the larger muskrat appeared to be the major food item in terms of total energy intake. Although muskrats were not found in the scat analysis, remains were found outside of red fox excavations. This suggests that muskrats were also consumed by red foxes on Assateague.

Dueser and Porter (1986) found that these species were common to abundant on Assateague Island during June - July 1978. Because this present study included analysis of only 56 red fox scats collected between May and August 1987, the results should not be viewed as representing the complete diet of red foxes on Assateague Island.

MANAGEMENT IMPLICATIONS

Fox den searches by fixed winged aircraft are not recommended for use on east coast barrier islands. Ground surveys, although manpower intensive, allowed us to readily locate fox excavations. Search activities may be expedited by scrutinizing sand dune habitats, since nearly all excavations were found in these areas. Information regarding red fox denning behaviors is important in developing management plans and protection of critical barrier island fox habitat.

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