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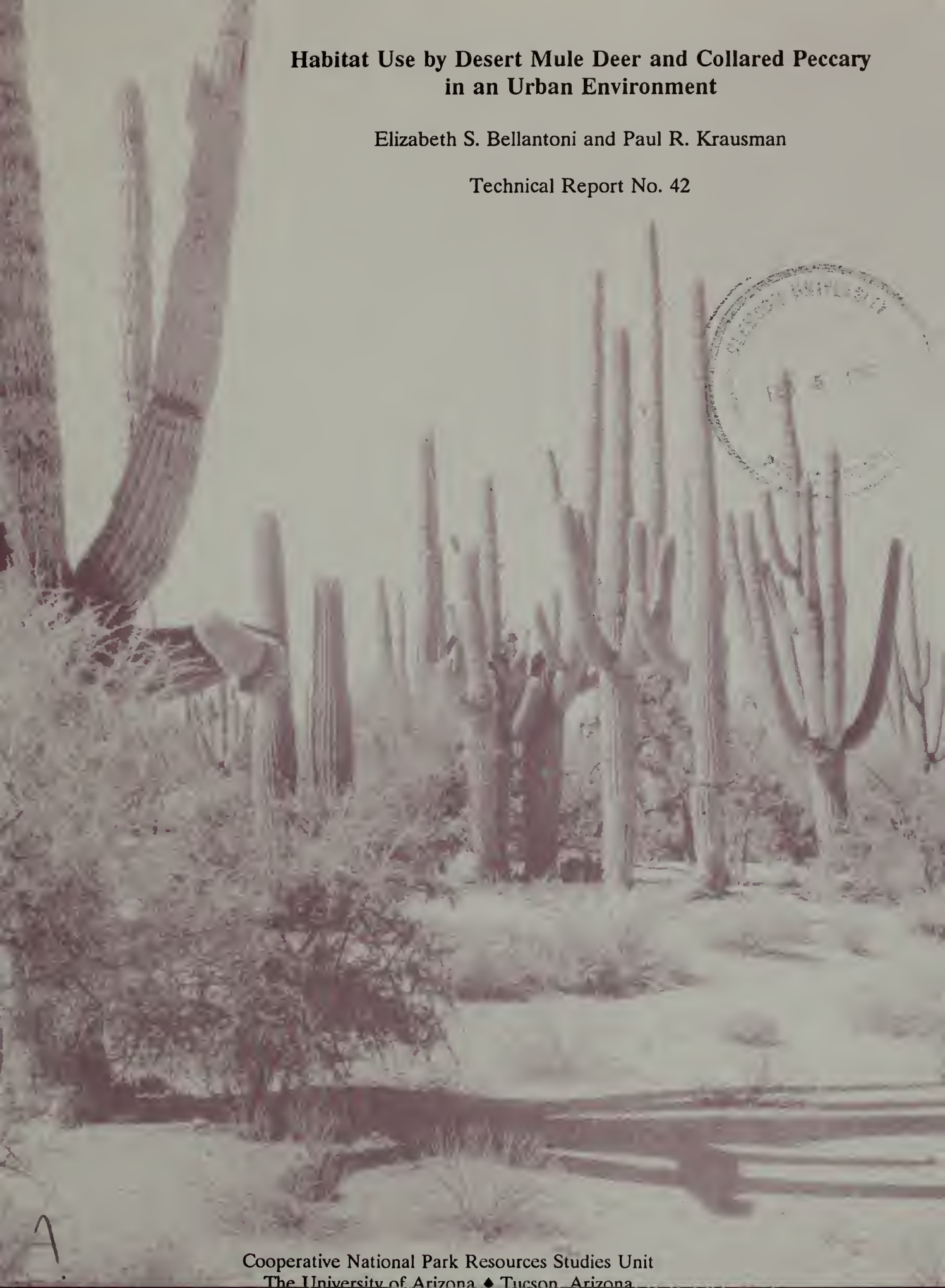
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Habitat Use by Desert Mule Deer and Collared Peccary in an Urban Environment

Elizabeth S. Bellantoni and Paul R. Krausman

Technical Report No. 42





COOPERATIVE NATIONAL PARK RESOURCES STUDIES UNIT

The University of Arizona, Tucson

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December 1991

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Cooperative National Park Resources Studies Unit
School of Renewable Natural Resources
The University of Arizona
Tucson, Arizona 85721

AUTHORS

Elizabeth S. Bellantoni¹, Graduate Assistant
Paul R. Krausman, Professor
Wildlife and Fisheries Science
School of Renewable Natural Resources
The University of Arizona
325 Biological Sciences East
Tucson, AZ 85721

UNIT PERSONNEL

Charles P. Stone, Acting Unit Leader
Peter S. Bennett, Research Ecologist
Michael R. Kunzmann, Ecologist
Katherine L. Hiatt, Biological Technician
Joan M. Ford, Administrative Clerk
Gloria J. Maender, Editorial Assistant

(602) 670-6885

(602) 621-1174

FTS 762-6885

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¹ Elizabeth S. Bellantoni is now a Resource Management Specialist at Saguaro National Monument, 3693 South Old Spanish Trail, Tucson, AZ 85730-5699.

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ABSTRACT

We examined movements and habitat use by the desert mule deer (*Odocoileus hemionus crooki*) and collared peccary (*Dicotyles tajacu*) in the Rincon Mountain District of Saguaro National Monument (SAGU) from February 1988 through December 1989. We determined ungulate use of vegetation association, aspect, slope class, slope position, and distance to housing from 596 and 277 radio-telemetry locations of 10 desert mule deer (5 M and 5 F) and 5 groups of collared peccaries, respectively. There was a significant difference ($P < 0.05$) in mean home-range size during late summer for desert mule deer ($M = 2.8 \text{ km}^2$, $F = 4.1 \text{ km}^2$). Of all habitat variables examined, only distance from housing during early summer and use of slope position during late summer differed ($P < 0.05$) between sexes. During late summer both sexes used moderately steep slopes (10-40%) with northern aspects. Movements and habitat use by desert mule deer were closely associated with the distribution of free-standing water during the driest seasons of the year. Deer responded to losses of ephemeral water sources in SAGU by leaving the monument to obtain water. Mean home-range size did not differ ($P > 0.05$) between urban and non-urban peccary herds (Urban = 1.03 km^2 , Non-urban = 1.00 km^2). Four of 5 herds supplemented their natural diet by visiting houses and/or restaurants on a daily or twice daily basis. The addition of water and supplemental food sources was a deliberate effort by homeowners to attract wildlife onto their property. The current pattern of habitat islands interspersed with low density housing ($< 1 \text{ house}/2\text{-}4 \text{ ha}$) is an effective and highly desirable buffer zone between the monument and the more heavily developed urban areas 3.2 km west of the monument.

INTRODUCTION

Boundaries of national parks and protected areas are usually politically defined. Bekele ([1980] cited in Harris [1984]) reported a positive correlation between area and the number of large mammal species for 14 national parks in the western United States. In national parks in western North America, the natural post-establishment loss of mammalian species indicates that these areas are not large enough to maintain populations of some wildlife species (Newmark 1987).

Urban development is the primary threat facing national parks in the United States (National Parks and Conservation Association 1979). These protected areas often provide critical habitat for a variety of species. Development on lands adjacent to national parks may irreversibly damage the natural resources of these areas.

As major changes in land use occur on lands bordering protected wildlands, information is needed to assess the implications that development will have on wildlife resources. This information is particularly important to growing cities and suburbs across the nation. In Arizona, the Tucson metropolitan area is developing and growing rapidly and formerly undeveloped lands are converted to urban environments. Major changes in land use patterns occur at the edges of the city. Urban development is particularly evident along the boundaries of the Rincon Mountain District (RMD) of Saguaro National Monument (SAGU).

Saguaro National Monument is an important recreational area for Tucson residents. When the RMD was established in 1933, the land adjacent to the monument was undeveloped (National Park Service 1986) and served as available wildlife habitat. As urbanization encroaches on monument borders, the amount of wildlife habitat outside the monument is rapidly disappearing, travel corridors providing access to and from SAGU are being eliminated, and fauna outside the monument is diminishing. Urbanization is also fragmenting the remaining wildlife habitat.

Habitat fragmentation can be a serious threat to the survival of large mammal populations because of their needs for space and habitat resources (e.g., forage, cover, and isolation). Wildlife in isolated habitats may suffer from reduced species viability and extinction from various causes (e.g., loss of critical resources, dispersal corridors, habitat heterogeneity, and genetic variability) (Wilcove et al. 1986). Wildlife movement patterns may also be affected by habitat fragmentation (Janzen 1986; Wilcove et al. 1986). Distribution of wildlife may be limited by roads, trails, and other human activity. Development occurring adjacent to SAGU may cause alteration in movement and activity patterns of those animals that range along monument borders.

The effects of urban development on desert mule deer (*Odocoileus hemionus crooki*) and collared peccary (*Dicotyles tajacu*) populations in the Southwest have not been reported

in the literature. The desert mule deer and collared peccary are among the most important big game species in Arizona (Arizona Game and Fish Department 1987). Both species attract a high level of public interest and concern among sportsmen and wildlife-oriented recreationists. At SAGU, these animals range beyond monument boundaries where urbanization is causing loss of habitat for both species.

Our objectives were to (1) describe movements of desert mule deer and collared peccaries along the boundaries of the RMD of SAGU and adjacent private lands, (2) describe habitat use by desert mule deer and collared peccaries relative to sex, season, activity, vegetation association, aspect, slope class, slope position, water availability, and distance to housing, and (3) compare observations of home range and habitat use by desert mule deer and collared peccaries in an urban environment to similar data reported for these species in other southwestern habitats. These data will provide information that can be used by city planners, developers and park managers to make informed decisions regarding urban growth and its effect on desert ungulates.

STUDY AREA

The study area encompassed the RMD of SAGU at elevations below 1,219 m and west of Universal Transverse Mercator latitudinal component 5,300,000 m (Fig. 1). Elevations ranged from 792 to 1,219 m. Level terrain (<10% slope) accounted for 68% of the study area and was predominant below 914 m. The northern and western borders of the study area were major county roadways located 1.6 km north (Speedway Boulevard) and 3.2 km west (Houghton Road) of northwestern and western monument boundaries. Rincon Mountain District is located on the eastern edge of Tucson and is bordered on the east and portions of the north and south sides by Coronado National Forest. Residential developments border sections of the western, southwestern, and northwestern boundaries of the monument.

Major predators within the study area include mountain lion (*Felis concolor*), bobcat (*Lynx rufus*), and coyote (*Canis latrans*). Vegetation is classified as Sonoran desertscrub and is characterized by vegetation associations within the Arizona Upland Subdivision (Brown 1982). Dominant plant associations are primarily within the palo verde (*Cercidium* spp.)-cacti series. Plant names follow Lehr (1978).

Tucson has an arid climate with a mean annual precipitation of 28 cm (Sellers and Hill 1974). The majority of rainfall occurs in late summer as geographically isolated thunderstorms and in winter as widespread, regional storms. Although data for 1988 did not differ significantly from the yearly average, 1989 was the fourth driest year on record with 16.5 cm of precipitation (J. Mazur, pers. com., 1990). Daily maximum temperatures at monument headquarters during 1988-89 ranged from 21° C in January to 42° C in July, and daily minimum temperatures ranged from -2° C in January to 20° C in July (Saguaro National Monument, unpubl. data, 1988-89).

With the exception of a small water catchment located behind the visitor center, perennial water sources on the desert floor of SAGU are limited to occasional seeps, springs, and tanks. Most ephemeral water sources disappear by late spring. The occurrence of free-standing water within SAGU increases with elevation in the Rincon Mountains. Outside the monument, water is readily available year-round. The majority of these water sources are located on residential property and are placed there intentionally for the benefit of wildlife.

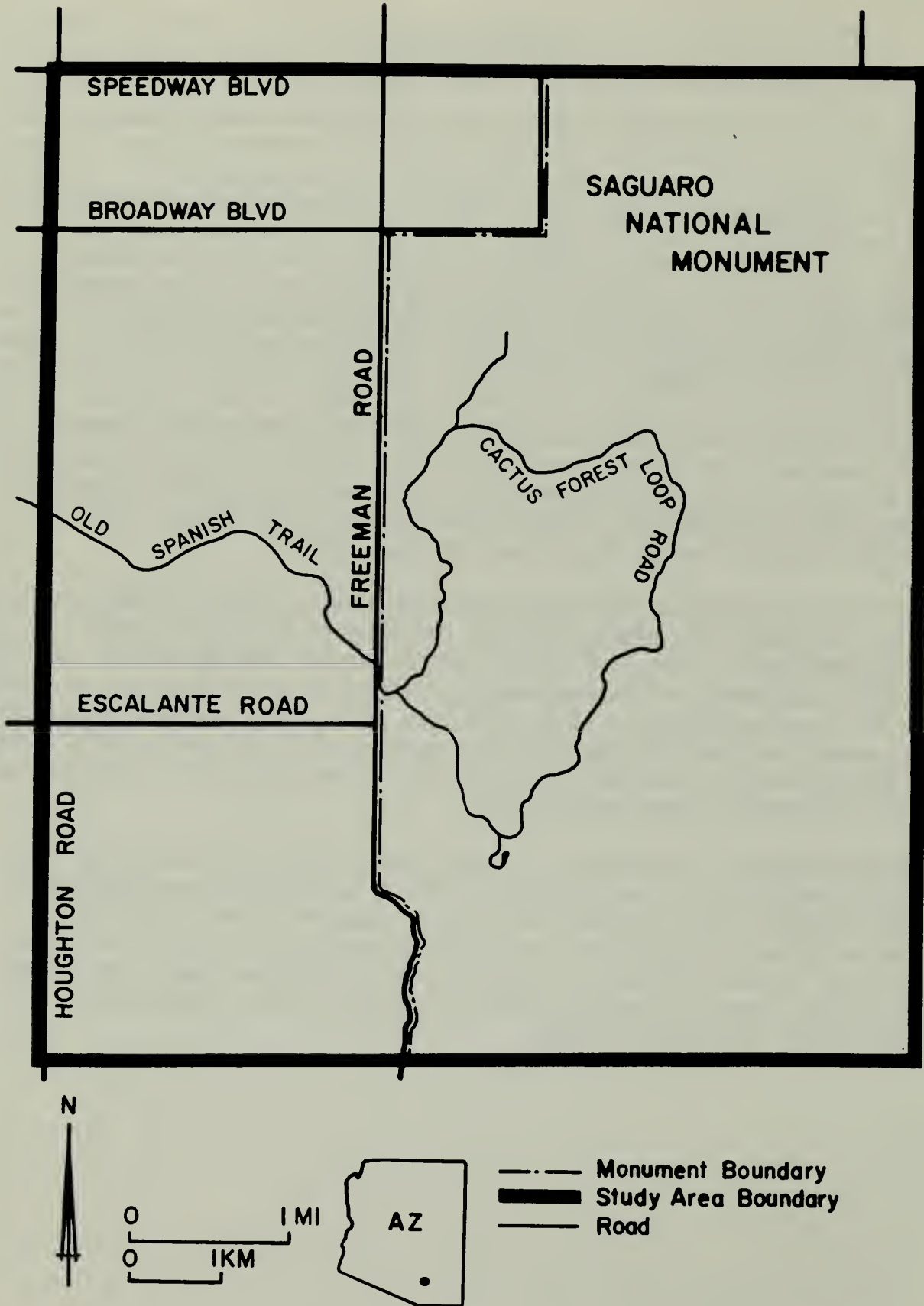


Figure 1. Location of study area in the Rincon Mountain District, Saguaro National Monument, Tucson, Arizona.

METHODS

We captured 10 desert mule deer (5 M and 5 F) in the RMD of SAGU during February and March 1988. Deer were captured with a drive net or net-gun (Krausman et al. 1985b) and immobilized with xylazine hydrochloride (HCl) and ketamine HCl administered intramuscularly (DelGiudice et al. 1989). Immobilizing drugs were reversed with tolazoline HCl administered intravenously. We fitted deer with color-coded radio collars prior to release. Between February 1988 and January 1989, we captured 5 collared peccaries (1/herd) with a net-gun or box trap. Collared peccaries were handled using methods similar to those described for desert mule deer.

Between February 1988 and September 1989, we used radio telemetry and obtained visual observations of each collared animal every 7-10 days. We obtained additional telemetry locations every 7-14 days from fixed-wing aircraft (Cessna 182) between September and December 1989. We made observations from the ground primarily during diurnal hours, generally during early morning and evening when animals were most active. The data we recorded for each observation included location, vegetation association, slope class (<10, 10-40, >40%), slope position (flats/wash/bench [$<10\%$ slope], slopes, and ridges), aspect (nearest cardinal point), distance to housing, and animal activity. Because of small sample size, behaviors other than foraging and bedding were omitted from analysis. Additional data collected by several homeowners documented presence and frequency of collared animals on their property.

We used the harmonic mean (Dixon and Chapman 1980) and minimum convex polygon (MCP) (Southwood 1978) methods to calculate seasonal home-range size. For the harmonic mean method, we used a 75% isopleth (that represented the area where an animal spent 75% of its time within its home range) to identify core areas of use and compared this information to similar data reported for other studies. Desert mule deer data were analyzed seasonally by sex. Only deer located ≥ 9 times/season were used in the analysis. Seasonal categories were based on temperature and precipitation patterns as described by Ordway and Krausman (1986). Because preliminary data analysis indicated no seasonal differences in home-range use, we analyzed collared peccary data on an annual basis by herd. We present minimum convex polygon estimates (area defined by the outermost locations recorded for an animal within its home range) for comparison to other studies.

For deer data, we transformed the harmonic mean and MCP estimates to their natural logarithm and achieved homogeneity of variances. Analysis of variance was used to test for differences in these estimates between sexes and among seasons. For MCP estimates, we examined differences in home-range size among seasons using Student-Newman-Keuls (SNK) multiple range test (Norusis 1988:B-159). We tested collared peccary data for differences in home-range size between years and herd classes (i.e., herds using urban versus non-urban environments) using the Mann-Whitney test (Norusis 1988:B-177).

We evaluated differences in habitat use between sexes by season (between herd classes for years combined for collared peccaries) using crosstabulation analysis (Norusis 1988: B-93). Overall differences in habitat use for foraging and bedding behavior were analyzed on an annual basis because of small sample size. To satisfy the assumptions of the test statistic, we combined categories within a particular habitat component (e.g., slope class and aspect) to create 5 broad use classifications: vegetation association based on dominant plant cover (creosote series, palo verde-cacti series, and mesquite series); aspect (level ground [$<10\%$ slope] versus aspects with $\geq 10\%$ slope); slope class ($<10\%$ slope versus $\geq 10\%$ slope); slope position (flats/wash/bench [$<10\%$ slope] versus mid-slope and higher positions); and housing distance (within 100 m versus beyond 100 m of housing).

We determined habitat component availability by nonmapping techniques (Marcum and Loftsgaarden 1980). We determined vegetation association, aspect, slope class, slope position, and distance from housing for 385 random points within the study area for comparisons with habitat components used by desert mule deer and collared peccaries.

We used Chi-square analysis (Zar 1974) and the Bonferroni Z-test (Marcum and Loftsgaarden 1980) to determine significant differences between use and availability of specific vegetation associations and habitat components. Preference was determined only for habitat components with observed use. Desert mule deer data were grouped by sex and season for analysis. Collared peccary data were combined for years, and herds were grouped according to herd class. Behavioral data for both species were grouped by activity and evaluated against habitat components.

RESULTS

MOVEMENTS AND HOME-RANGE SIZE

Desert Mule Deer

We located desert mule deer 596 times during the study. Analysis of variance indicated no significant difference ($P > 0.05$) for mean home-range size between sexes and among seasons for the harmonic mean estimates (Table 1). There was a significant difference ($P < 0.05$) for MCP estimates among seasons, although this difference was not significant between sexes. Closer examination of MCP estimates using SNK multiple range test indicated that there was a significant difference ($P < 0.05$) in mean home-range size during late summer for both sexes ($M = 2.8 \text{ km}^2$, $F = 4.1 \text{ km}^2$). During the late summer fawning period, females increased their movements. Females moved to higher elevations during late summer, with 3 females using the same general fawning area. Fawning sites generally ranged between 150-300 m above the desert floor and were located close to perennial water. Males also increased their home range and moved to higher elevations during late summer.

Individual variation is apparent in how some deer used areas outside the monument. Although some deer (e.g., no. 442) used available habitat outside the monument all year (Fig. 2), others (e.g., no. 341) did not move out of the monument until ephemeral water sources began to disappear in late spring (Fig. 3). Other deer remained within the monument by day, often bedded in the vicinity of the boundary. Because the majority of deer sightings on residential property occurred between the hours of dusk and dawn (B. Burkholder, unpubl. data, 1988-89), it is likely that some radio-collared animals moved out of the monument only during this period.

Home range increased for 4 of 5 males during the breeding season (Dec-Jan). Two males that had never been observed out of the monument previously were seen during this period in residential areas with females. Both males returned to the monument at the end of the breeding season.

Collared Peccary

We located collared peccary herds 277 times during the study. Mean home-range size between collared peccary herd classes (urban = 1.03 km^2 , non-urban = 1.00 km^2) and between years was similar ($P > 0.05$) (Table 2).

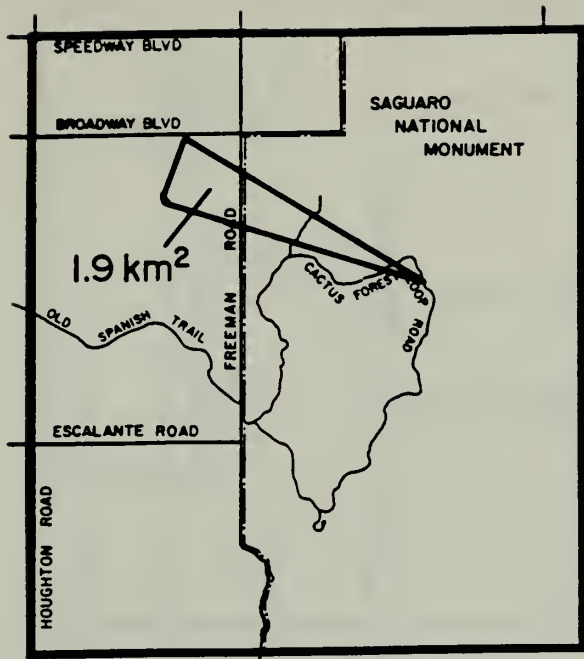
All radio-collared urban peccaries weighed between 28-30 kg when caught. Detailed records kept by several homeowners who provided supplemental food sources for collared peccaries indicate that these animals became readily habituated to urban environments and had been visiting some homes and restaurants daily for years. Four

Table 1. Harmonic mean and minimum convex polygon (MCP) estimates of mean seasonal home-range size (km²) of desert mule deer in the Rincon Mountain District of Saguaro National Monument, Tucson, Arizona, 1988-89.

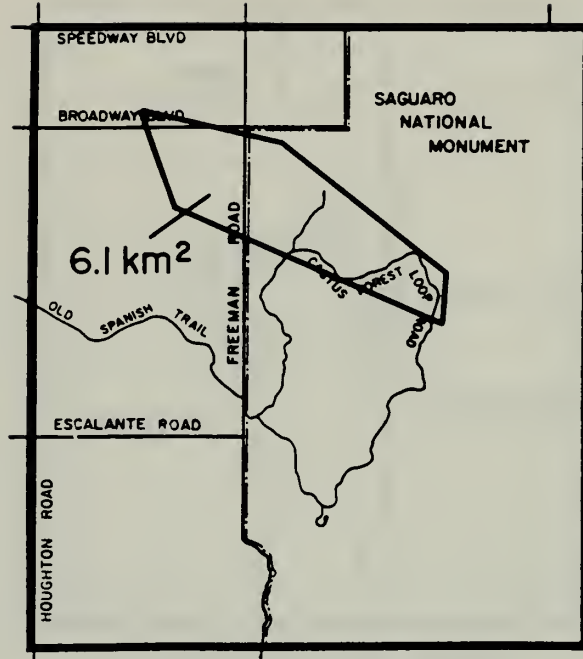
	Season ^a															
	Spring			Early summer			Late summer			Winter						
	\bar{X}	SE	No. deer locations	\bar{X}	SE	No. deer locations	\bar{X}	SE	No. deer locations	\bar{X}	SE	No. deer locations				
<u>Females</u>																
75% isopleth ^b	0.5	0.3	3	32	0.6	0.2	7	90	0.9	0.1	7	100	0.2	0.1	3	33
MCP	3.3	1.4	3	32	2.0	0.5	7	90	4.1	0.6	7	100	2.1	0.7	3	33
<u>Males</u>																
75% isopleth ^b	0.4	0.1	5	63	0.3	0.1	6	72	0.6	0.2	9	111	0.7	0.3	5	57
MCP	2.3	0.4	5	63	1.6	0.4	6	72	2.8	0.4	9	111	3.9	1.0	5	57

^a Spring = 1 Feb-30 Apr; early summer = 1 May-Jul 15; late summer = 16 Jul-31 Oct; and winter = 1 Nov-31 Jan.

^b Area where an animal spent 75% of its time within its home range.



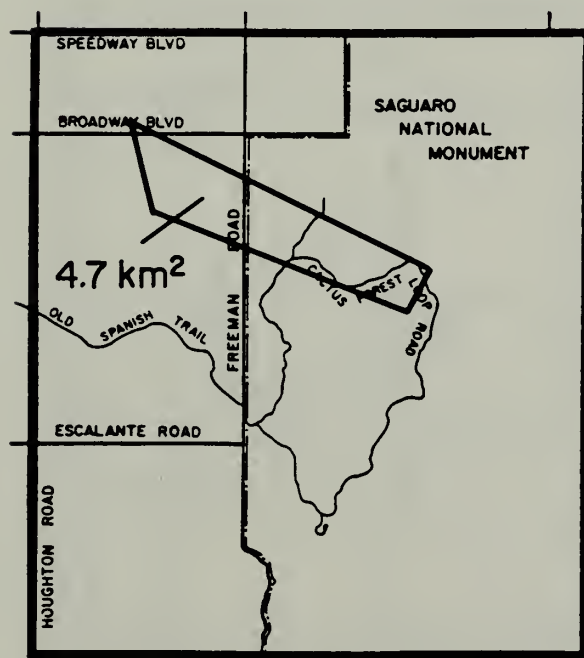
Winter (1 Nov – 31 Jan)



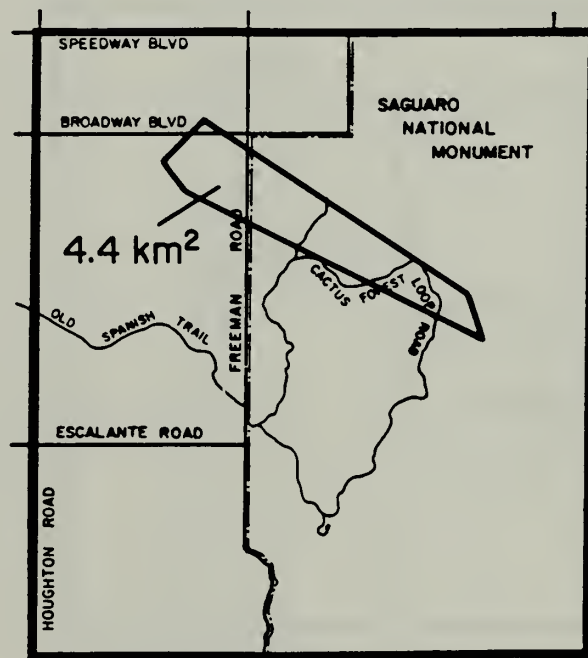
Spring (1 Feb – 30 Apr)



--- Monument Boundary
 ■ Study Area Boundary
 — Road

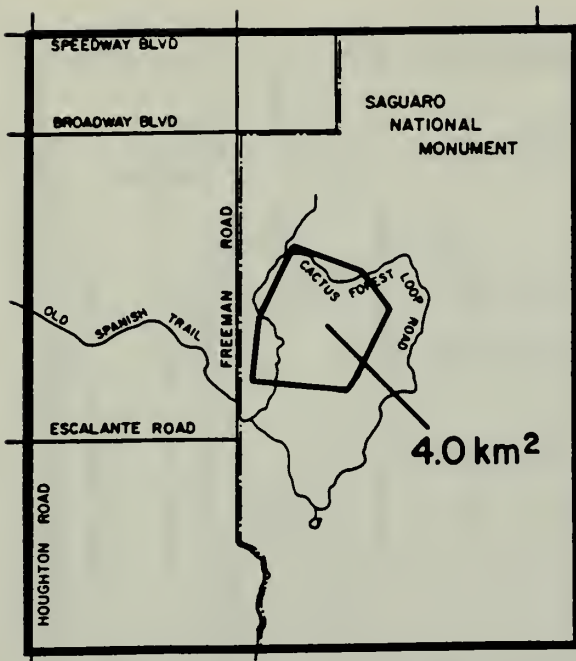


Early summer (1 May – 15 Jul)

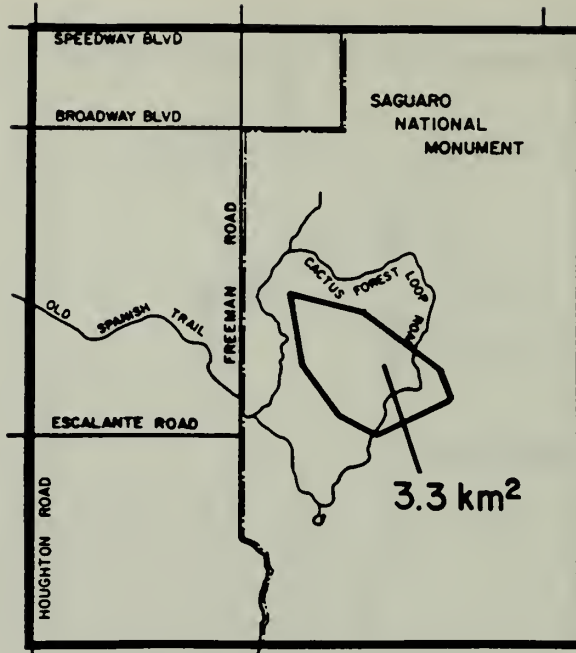


Late summer (16 Jul – 31 Oct)

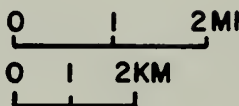
Figure 2. Minimum convex polygon (MCP) estimates of seasonal home-range size (km^2) for a desert mule deer female (no. 442), Saguaro National Monument, Tucson, Arizona, winter 1988-late summer 1989.



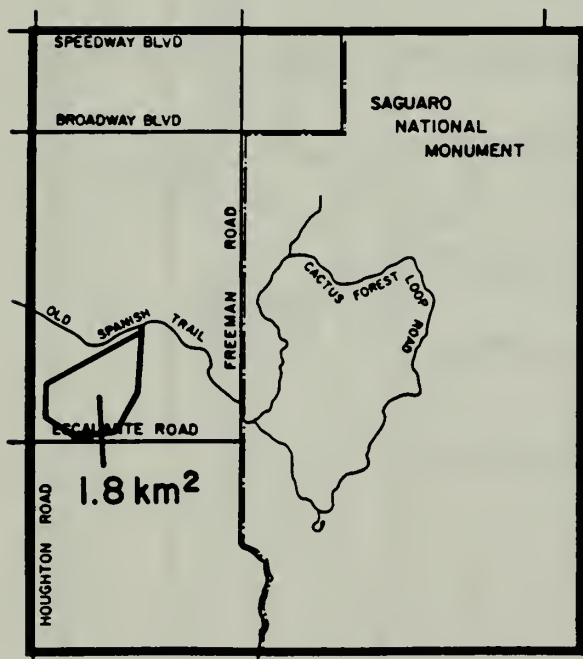
Winter (1 Nov - 31 Jan)



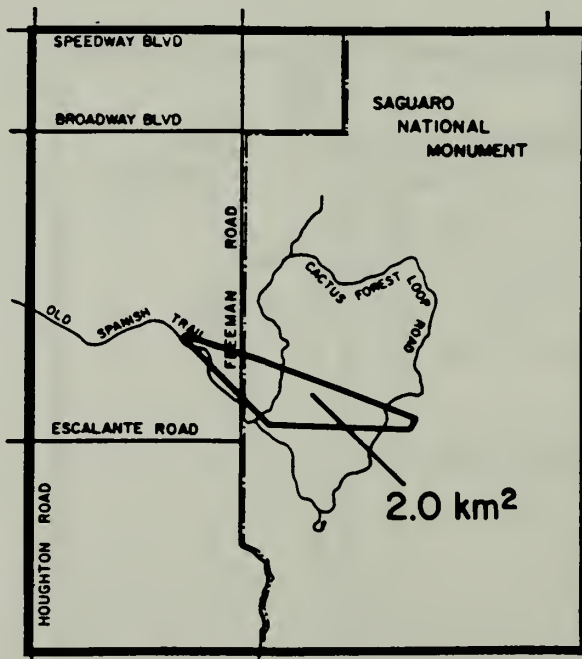
Spring (1 Feb - 30 Apr)



--- Monument Boundary
 ■ Study Area Boundary
 — Road



Early summer (1 May - 15 Jul)



Late summer (16 Jul - 31 Oct)

Figure 3. Minimum convex polygon (MCP) estimates of seasonal home-range size (km^2) for a desert mule deer male (no. 341), Saguaro National Monument, Tucson, Arizona, winter 1988-late summer 1989.

Table 2. Harmonic mean and minimum convex polygon (MCP) estimates of annual home-range size (km²) of collared peccary in the Rincon Mountain District of Saguaro National Monument, Tucson, Arizona, 1988-89.

	460 ^a	No. home ranges	560 ^a	No. home ranges	672 ^{a,b}	No. home ranges	801 ^a	No. home ranges	921 ^{a,b}	No. home ranges
<u>1988^c</u>										
75% isopleth ^d	0.3	30	0.3	33			0.05	39		
MCP	1.0	30	0.9	33			0.5	39		
<u>1989^c</u>										
75% isopleth ^d	0.2	34	0.4	39	0.7 (0.2) ^e	26 (21)	0.04	53	0.3	45
MCP	0.8	34	1.1	39	2.3 (1.3) ^e	26 (21)	0.4	53	1.2	45

^a Herd no.

^b Radio-collared in Jan 1989.

^c Based on seasonal year (1 Feb-31 Jan).

^d Area where a herd spent 75% of its time within its home range.

^e Collared animal left herd in mid-Jul; home range calculated for collared animal after leaving herd.

radio-collared herds (nos. 460, 672, 801, 921) (Fig. 4) frequented urban areas and supplemented their natural diet by visiting some homes and/or restaurants on a daily or twice daily basis. Food items most often consisted of table scraps, bird seed, bread, and dog food. A fifth radio-collared herd (no. 560), located within the interior of the monument loop road but not using urban areas, exhibited movements and habitat use typical of a free-ranging wild herd.

One urban peccary herd (no. 801) had the smallest home range of any herd reported in the literature (Table 3). This herd, comprised of 2 animals, lived inside the monument boundary within 200 m of a residential area. The radio-collared female, well-known to neighborhood residents for >4 years, became so accustomed to humans that she could be hand fed.

Another radio-collared individual from an urban herd (no. 672) had the farthest dispersal movement of any collared peccary reported in the literature. In early March of 1989, this adult female moved into a densely populated area (22nd Street and Prudence Road) over 8.0 km west of the monument boundary. Although she and an adult male, presumably from the same herd, were later captured and returned to the monument, the radio-collared animal moved again in mid-July. She was relocated over 16.0 km southwest of the monument boundary (I-10 and Valencia Road) again in the company of an adult male. In this new habitat she was repeatedly seen at a recreational vehicle campground where she was again supplementing her diet with human-provided foods.

HABITAT USE

Vegetation Associations Available

Vegetation associations are based on type descriptions (Brown 1982; Arizona Game and Fish Department 1983) described by A. E. Goldsmith and W. W. Shaw (pers. com.). Of the nine associations identified in the study area, eight are on the desert floor, and one is predominately in mountainous terrain. Vegetation associations on the desert floor include creosote (*Larrea tridentata*)-acacia (*Acacia greggii*)-palo verde (*Cercidium microphyllum*)-ocotillo (*Fouquieria splendens*)-zinnia (*Zinnia acerosa*), palo verde-mixed shrub-mixed cacti-zinnia/burroweed (*Isocoma tenuisecta*) found only within a residential area outside the monument, jojoba (*Simmondsia chinensis*)-mixed scrub, palo verde-creosote-desert broom (*Baccharis sarothroides*)-brittlebush (*Encelia farinosa*)-ocotillo, palo verde-saguaro (*Carnegiea gigantea*)-brittlebush, palo verde-acacia-mixed cacti-mixed scrub-grass, and xeroriparian areas and related vegetation associations (e.g., mesquite [*Prosopis juliflora*]-mixed short tree and mesquite-wolfberry [*Lycium* spp.]-mixed scrub, and mesquite-acacia-palo verde-mixed cacti-mixed scrub). Palo verde-saguaro-mixed cacti-mixed scrub is located primarily in mountainous terrain.

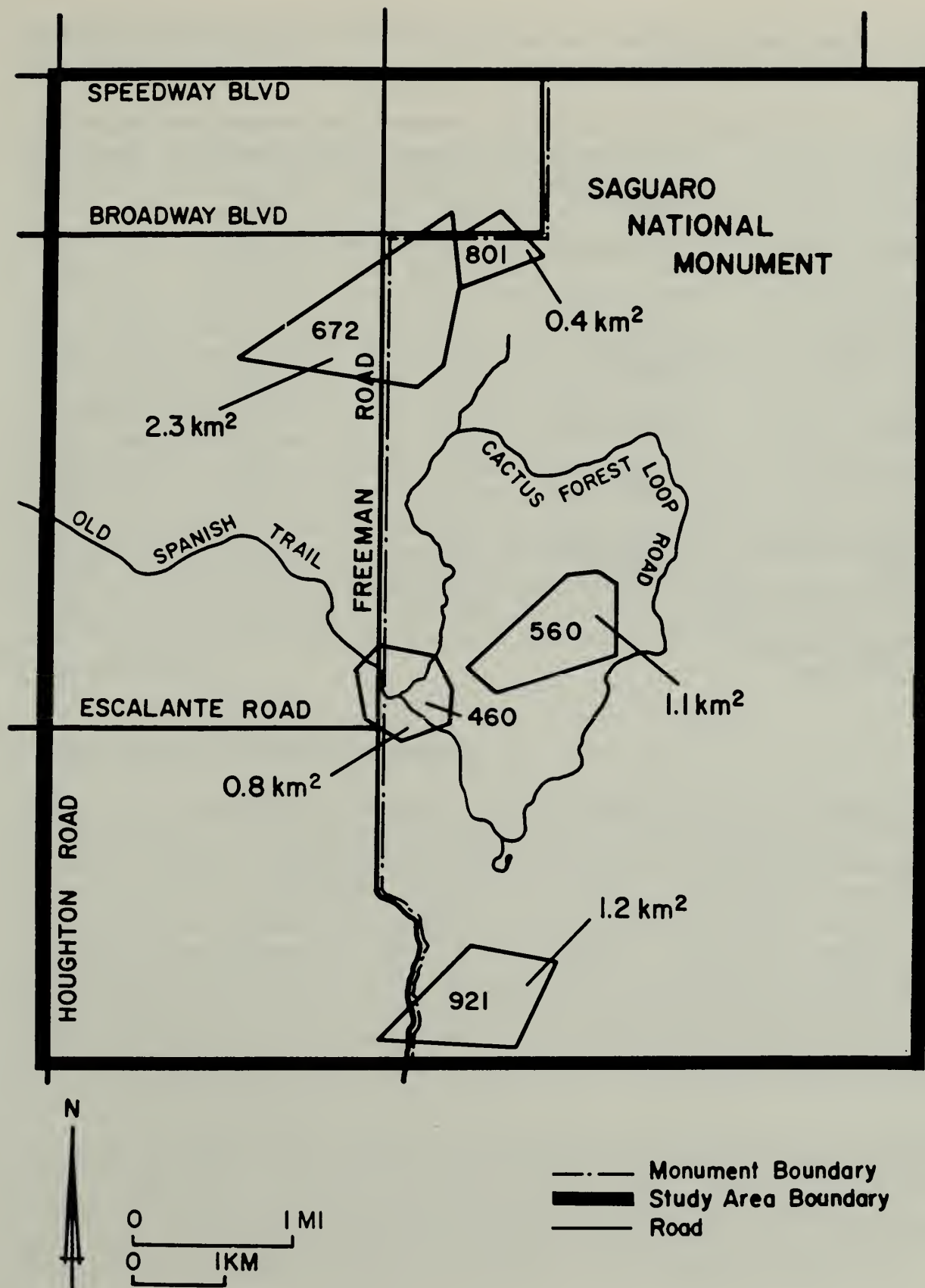


Figure 4. Minimum convex polygon (MCP) estimates of annual home-range size (km²) for 5 collared peccary herds, Saguaro National Monument, Tucson, Arizona, 1988-89.

Table 3. Comparison of minimum convex polygon (MCP) estimates of home-range size (km²) for collared peccary herds in Arizona.

Reference	Location	No. herds	\bar{X} home range (km ²)	Range (km ²)
Minnamon (1962)	Tucson Mtns.	2 ^a	3.9	—
Schweinsburg (1971)	Tucson Mtns.	4 ^a	1.0	0.5 - 1.6
Bigler (1974)	Tortolita Mtns.	11 ^a	4.7	2.7 - 8.0
Supplee (1981)	Three Bar Wildlife Area	6 ^a	4.0	2.5 - 5.2
Day (1985)	Tortolita Mtns.	6 ^a	3.1	2.1 - 4.6
Day (1985)	Three Bar Wildlife Area	25 ^a	3.2	1.0 - 7.5
Bellantoni and Krausman (this study)	Saguaro National Monument	4 ^b	1.0	0.4 - 2.3
		1 ^a	1.0	—

^a Non-urban herd.

^b Urban herd.

DESERT MULE DEER

Seasonal Use of Vegetation Associations

Use of vegetation series (i.e., creosote series, palo verde-cacti series, and mesquite series) did not differ significantly between sexes ($P > 0.05$) for any season. For females, use of vegetation associations (Table 4) differed from availability during spring ($X^2 = 20.10$, 8 df, $P = 0.0100$), early summer ($X^2 = 60.99$, 8 df, $P < 0.0001$), and late summer ($X^2 = 84.13$, 8 df, $P < 0.0001$). For males, use differed significantly from availability during all seasons ($X^2 = 345.70$, 95.28, 140.91, and 145.83, 8 df, $P < 0.0001$, for spring, early summer, late summer, and winter). Males used jojoba-mixed scrub during spring, and either avoided or did not use vegetation associations in mountainous terrain from spring through late summer (Table 4). In contrast, females did not use jojoba-dominated associations during any season. During spring, both sexes either avoided or did not use palo verde-mixed shrub located outside the monument. During early summer, males and females used vegetation associations similarly, selecting associations exhibiting a diversity of forage species. Females selected xeroriparian areas and palo verde-acacia-dominated associations and avoided areas dominated by creosote. Males selected mesquite-acacia and palo verde-creosote-dominated associations. In late summer, both sexes avoided creosote-dominated and palo verde-mixed shrub associations, and used associations containing acacia as a primary component. Females did not use palo verde-creosote from late summer until spring. During winter, males either avoided or did not use palo verde-mixed shrub and xeroriparian areas, and used palo verde-creosote and palo verde-acacia associations.

Activity and Use of Vegetation Associations

Activity was recorded for 596 visual observations of radio-collared deer. Foraging and bedding were the 2 most frequently observed activities, accounting for 51% and 25% of all activities observed. Vegetation series used for foraging did not differ significantly between sexes ($X^2 = 1.02$, 2 df, $P = 0.5990$). For females, use of vegetation associations (Table 5) differed significantly from availability during early summer ($X^2 = 46.74$, 8 df, $P < 0.0001$) and late summer ($X^2 = 83.92$, 8 df, $P < 0.0001$). During early summer, females selected xeroriparian areas for foraging (Table 5). During late summer, females foraged in palo verde-acacia and avoided palo verde-mixed shrub. Females either avoided or did not forage in creosote-dominated areas during all seasons except spring. Palo verde-creosote was not used from late summer until spring. Females did not forage in areas dominated by jojoba during any season.

Vegetation associations used by males for foraging differed significantly from availability during all seasons ($X^2 = 75.70$, 63.14, 59.15, and 39.75, 8 df, $P < 0.0001$, for spring, early summer, late summer, and winter). Males foraged in jojoba-dominated associations during spring, and mesquite-dominated associations during early summer, as did females (Table 5). Creosote-dominated areas were avoided by males during spring and late

Table 4. Availability and use (%) of vegetation associations by season for desert mule deer in the Rincon Mountain District of Saguaro National Monument, Tucson, Arizona, 1988-89.

Vegetation association	Random availability (n=383)	Spring ^a use		Early summer ^a use		Late summer ^a use		Winter ^a use	
		F (n=64)	M (n=81)	F (n=93)	M (n=91)	F (n=75)	M (n=89)	F (n=32)	M (n=55)
<u>Creosote Series</u>									
Creosote-acacia- palo verde- ocotillo-zinnia	14.6	12.5	6.2	5.4- ^b	8.8	1.3-	4.5-	6.3	7.3
<u>Palo Verde-Cacti Series</u>									
Palo verde-mixed shrub-mixed cacti- zinnia/burroweed	29.8	15.6-	0.0	25.8	18.7	16.0-	3.4-	37.5	3.6-
Palo verde-saguaro- mixed cacti-mixed scrub	14.6	10.9	4.9-	10.8	0.0	21.3	1.1-	15.6	9.1
Jojoba-mixed scrub	1.8	0.0	22.2+	0.0	7.7	0.0	10.1	0.0	3.6
Palo verde-creosote- desert broom- brittlebush- ocotillo	4.4	1.6	12.4	1.1	15.4+	0.0	10.1	0.0	25.5+
Palo verde-saguaro- brittlebush	14.9	26.6	16.1	7.5	8.8	6.7	13.5	18.8	9.1
Palo verde-acacia- mixed cacti-mixed scrub-grass	6.3	14.1	12.4	18.3+	9.9	25.3+	23.6+	9.4	25.5+
<u>Mesquite Series</u>									
Mesquite-acacia- palo verde-mixed cacti-mixed scrub	5.7	6.3	11.1	10.8	19.8+	17.3	19.1+	6.3	16.4
Mesquite-mixed short tree and mesquite- wolfberry-mixed scrub	7.8	12.5	14.8	20.4+	11.0	12.0	14.6	6.3	0.0

^a Spring = 1 Feb-30 Apr; early summer = 1 May-Jul 15; late summer = 16 Jul-31 Oct; and winter = 1 Nov-31 Jan.

^b A + indicates use > availability and - indicates use < availability.

Table 5. Availability and use (%) of vegetation associations for foraging activity by season for desert mule deer in the Rincon Mountain District of Saguaro National Monument, Tucson, Arizona, 1988-89.

Vegetation association	Random availability (n=383)	Spring ^a use		Early summer ^a use		Late summer ^a use		Winter ^a use	
		F (n=27)	M (n=31)	F (n=43)	M (n=24)	F (n=46)	M (n=46)	F (n=15)	M (n=24)
<u>Creosote Series</u>									
Creosote-acacia- palo verde- ocotillo-zinnia	14.6	11.1	3.2- ^b	2.3-	4.2	0.0	4.4-	0.0	8.3
<u>Palo Verde-Cacti Series</u>									
Palo verde-mixed shrub-mixed cacti- zinnia/burroweed	29.8	22.2	0.0	27.9	25.0	13.0-	4.4-	26.7	0.0
Palo verde-saguaro- mixed cacti-mixed scrub	14.6	7.4	3.2-	4.7	0.0	17.4	2.2-	26.7	12.5
Jojoba-mixed scrub	1.8	0.0	25.8+	0.0	12.5	0.0	6.5	0.0	4.2
Palo verde-creosote- desert broom- brittlebush- ocotillo	4.4	3.7	6.5	2.3	8.3	0.0	8.7	0.0	8.3
Palo verde-saguaro- brittlebush	14.9	37.0	25.8	7.0	4.2	8.7	19.6	13.3	16.7
Palo verde-acacia- mixed cacti-mixed scrub-grass	6.3	7.4	6.5	16.3	8.3	37.0+	23.9	13.3	29.2
<u>Mesquite Series</u>									
Mesquite-acacia- palo verde-mixed cacti-mixed scrub	5.7	3.7	9.7	11.6	33.3+	8.7	19.6	13.3	20.8
Mesquite-mixed short tree and mesquite- wolfberry-mixed scrub	7.8	7.4	19.4	27.9+	4.2	15.2	10.9	6.7	0.0

^a Spring = 1 Feb-30 Apr; early summer = 1 May-Jul 15; late summer = 16 Jul-31 Oct; and winter = 1 Nov-31 Jan.

^b A + indicates use > availability and - indicates use < availability.

summer, and mountainous terrain was either avoided or not used during all seasons except winter. Similarly, palo verde-mixed shrub located outside the monument was either avoided or not used by males during all seasons except early summer. During winter, all vegetation associations were either used in proportion to availability or were not used.

Use of vegetation series for bedding did not differ significantly between sexes ($X^2 = 0.84$, 2 df, $P = 0.6574$). For females, use of vegetation associations (Table 6) differed significantly from availability during early summer only ($X^2 = 46.33$, 8 df, $P < 0.0001$). For males, use differed from availability during all seasons ($X^2 = 45.67$, 33.83, 73.23, 8 df, $P < 0.0001$, for spring, early summer, and late summer; $X^2 = 24.50$, 8 df, $P = 0.0019$, for winter). Males and females used vegetation associations similarly for bedding (Table 6). For both sexes, all associations were either used in proportion to availability or were not used, except during early summer when females avoided bedding in palo verde-mixed shrub outside the monument, and late summer when males avoided creosote-dominated associations.

Seasonal Use of Aspect

Evaluated over broad categories, (i.e., level ground [$<10\%$ slope] versus aspects with $\geq 10\%$ slope), use of aspect did not differ significantly between sexes ($P > 0.05$) during any season. For females, aspect use (Table 7) differed significantly from availability during spring ($X^2 = 19.00$, 4 df, $P = 0.0008$), early summer ($X^2 = 23.40$, 4 df, $P = 0.0001$), and late summer ($X^2 = 53.31$, 4 df, $P < 0.0001$). For males, use of aspect differed significantly from availability during spring ($X^2 = 21.66$, 4 df, $P = 0.0002$), late summer ($X^2 = 35.33$, 4 df, $P < 0.0001$), and winter ($X^2 = 9.86$, 4 df, $P = 0.0429$). Sexes used aspects similarly. During late summer, north slopes were used and level ground was avoided (Table 7). Males also avoided south slopes during late summer and spring. During winter, females did not use east slopes and males avoided west slopes. All other aspects were used in proportion to availability.

Activity and Use of Aspect

Aspects used for foraging did not differ significantly between sexes ($X^2 = 0.80$, 1 df, $P = 0.3700$). For females, use of aspect differed significantly from availability during late summer only ($X^2 = 12.07$, 4 df, $P = 0.0168$). For males, use differed from availability during spring ($X^2 = 14.54$, 4 df, $P = 0.0058$) and late summer ($X^2 = 18.77$, 4 df, $P = 0.0009$). Females did not forage on east slopes during winter and south slopes during all seasons except late summer (Table 8). Males did not forage on east slopes during early or late summer, and on west slopes during winter. Both sexes used all other aspects in proportion to availability.

Table 6. Availability and use (%) of vegetation associations for bedding activity by season for desert mule deer in the Rincon Mountain District of Saguaro National Monument, Tucson, Arizona, 1988-89.

Vegetation association	Random availability (n=383)	Spring ^a use		Early summer ^a use		Late summer ^a use		Winter ^a use	
		F (n=18)	M (n=23)	F (n=20)	M (n=32)	F (n=14)	M (n=34)	F (n=10)	M (n=13)
<u>Creosote Series</u>									
Creosote-acacia- palo verde- ocotillo-zinnia	14.6	16.7	8.7	5.0	6.3	7.1	2.9 ^b	10.0	7.7
<u>Palo Verde-Cacti Series</u>									
Palo verde-mixed shrub-mixed cacti- zinnia/burroweed	29.8	33.3	0.0	10.0	21.9	21.4	0.0	30.0	0.0
Palo verde-saguaro- mixed cacti-mixed scrub	14.6	16.7	13.0	10.0	0.0	28.6	0.0	20.0	23.1
Jojoba-mixed scrub	1.8	0.0	26.1	0.0	3.1	0.0	14.7	0.0	0.0
Palo verde-creosote- desert broom- brittlebush- ocotillo	4.4	0.0	17.4	0.0	15.6	0.0	8.8	0.0	15.4
Palo verde-saguaro- brittlebush	14.9	11.1	8.7	0.0	9.4	7.1	11.8	20.0	7.7
Palo verde-acacia- mixed cacti-mixed scrub-grass	6.3	11.1	13.0	30.0	15.6	21.4	26.5	10.0	38.5
<u>Mesquite Series</u>									
Mesquite-acacia- palo verde-mixed cacti-mixed scrub	5.7	5.6	4.4	15.0	15.6	14.3	20.6	0.0	7.7
Mesquite-mixed short tree and mesquite- wolfberry-mixed scrub	7.8	5.6	8.7	30.0	12.5	0.0	14.7	10.0	0.0

^a Spring = 1 Feb-30 Apr; early summer = 1 May-Jul 15; late summer = 16 Jul-31 Oct; and winter = 1 Nov-31 Jan.

^b A + indicates use > availability and - indicates use < availability.

Table 7. Availability and use (%) of aspect, slope class, slope position, and distance to housing by season for desert mule deer in the Rincon Mountain District of Saguaro National Monument, Tucson, Arizona, 1988-89.

Habitat component	Random availability (n=385)	Spring ^a use		Early summer ^a use		Late summer ^a use		Winter ^a use	
		F (n=63)	M (n=82)	F (n=96)	M (n=93)	F (n=78)	M (n=90)	F (n=34)	M (n=57)
<u>Aspect</u>									
North	8.3	9.5	12.2	7.3	7.5	25.6+ ^b	20.0+	8.8	10.5
East	0.5	7.9	6.1	5.2	2.2	5.1	3.3	0.0	5.3
South	6.8	3.2	1.2-	3.1	2.2	6.4	1.1-	2.9	1.8
West	8.3	3.2	7.3	14.6	9.7	14.1	15.6	5.9	1.8-
Level (<10% slope)	76.1	76.2	73.2	69.8	78.5	48.7-	60.0-	82.4	80.7
<u>Slope class</u>									
<10%	76.1	76.2	73.2	70.8	78.5	50.0-	60.0-	82.4	82.5
10-40%	21.3	22.2	26.8	29.2	20.4	47.4+	38.9+	14.7	17.5
>40%	2.6	1.6	0.0	0.0	1.1	2.6	1.1	2.9	0.0
<u>Slope position</u>									
flats/benches	75.6	73.0	72.0	69.8	78.3	43.6-	60.0-	79.4	79.0
mid-slope	18.2	22.2	24.4	19.8	16.3	39.7+	33.3+	14.7	19.3
top of slope	4.4	0.0	2.4	10.4	1.1	11.5	6.7	5.9	1.8
ridgeline	1.8	4.8	1.2	0.0	4.4	5.1	0.0	0.0	0.0
<u>Distance to housing</u>									
<100 m	2.9	9.5	0.0	20.8+	11.8+	5.1	4.4	11.8	1.8
>100 m	97.1	90.5	100.0+	79.2-	88.2-	94.9	95.6	88.2	98.3

^a Spring = 1 Feb-30 Apr; early summer = 1 May-Jul 15; late summer = 16 Jul-31 Oct; and winter = 1 Nov-31 Jan.

^b A + indicates use > availability and - indicates use < availability.

Table 8. Availability and use (%) of aspect, slope class, slope position, and distance to housing for foraging activity by season for desert mule deer in the Rincon Mountain District of Saguaro National Monument, Tucson, Arizona, 1988-89.

Habitat component	Random availability (n=385)	Spring ^a use		Early summer ^a use		Late summer ^a use		Winter ^a use	
		F (n=26)	M (n=31)	F (n=42)	M (n=24)	F (n=44)	M (n=44)	F (n=15)	M (n=23)
<u>Aspect</u>									
North	8.3	15.4	19.4	4.8	4.2	9.1	25.0	13.3	13.0
East	0.5	11.5	12.9	2.4	0.0	6.8	0.0	0.0	4.4
South	6.8	0.0	3.2	0.0	4.2	4.6	2.3	0.0	4.4
West	8.3	3.9	9.7	16.7	20.8	20.5	15.9	6.7	0.0
Level (<10% slope)	76.1	69.2	54.8	76.2	70.8	59.1	56.8	80.0	78.3
<u>Slope class</u>									
<10%	76.1	69.2	54.8	76.2	70.8	61.4	56.8-	80.0	78.3
10-40%	21.3	30.8	45.2+ ^b	23.8	29.2	38.6	43.2+	13.3	21.7
>40%	2.6	0.0	0.0	0.0	0.0	0.0	0.0	6.7	0.0
<u>Slope position</u>									
flats/benches	75.6	65.4	54.8	76.2	75.0	54.6-	56.8	73.3	78.3
mid-slope	18.2	30.8	38.7	11.9	20.8	34.1	38.6+	20.0	21.7
top of slope	4.4	0.0	3.2	11.9	0.0	6.8	4.6	6.7	0.0
ridgeline	1.8	3.9	3.2	0.0	4.2	4.6	0.0	0.0	0.0
<u>Distance to housing</u>									
<100 m	2.9	15.4	0.0	21.4+	16.7	6.8	2.3	6.7	0.0
>100 m	97.1	84.6	100.0+	78.6-	83.3	93.2	97.7	93.3	100.0+

^a Spring = 1 Feb-30 Apr; early summer = 1 May-Jul 15; late summer = 16 Jul-31 Oct; and winter = 1 Nov-31 Jan.

^b A + indicates use > availability and - indicates use < availability.

Aspects used for bedding also did not differ significantly between sexes ($X^2 = 0.08$, 1 df, $P = 0.7815$). For both sexes, use differed significantly from availability during late summer only ($X^2 = 39.27$, 4 df, $P < 0.0001$, females; $X^2 = 23.49$, 4 df, $P = 0.0001$, males). During late summer, females bedded on northern aspects and avoided bedding on level ground, as did males (Table 9). Males bedded on south slopes during late summer only, whereas, females bedded on south slopes during all seasons except early summer. In winter, males bedded exclusively on level ground. All other aspects were either used in proportion to availability or were not used.

Seasonal Use of Slope and Slope Position

Overall use of slope (i.e., $<10\%$ slope versus $\geq 10\%$ slope) did not differ significantly between sexes ($P > 0.05$) during any season. Use differed significantly from availability during early summer ($X^2 = 6.54$, 2 df, $P = 0.0380$) and late summer ($X^2 = 30.31$, 2 df, $P < 0.0001$) for females, and during late summer ($X^2 = 16.86$, 2 df, $P = 0.0002$) for males. Slope use was similar for sexes. During late summer, both sexes used moderately steep slopes (10-40%) and avoided terrain with $<10\%$ slope (Table 7). All other slopes were either used in proportion to availability or were not used.

Use of slope position (i.e., flats/wash/bench [$<10\%$ slope] versus mid-slope and higher positions) differed significantly between sexes during late summer only ($X^2 = 3.88$, 1 df, $P = 0.0489$). For females, use differed significantly from availability during spring ($X^2 = 7.90$, 3 df, $P = 0.0481$), early summer ($X^2 = 11.73$, 3 df, $P = 0.0084$), and late summer ($X^2 = 52.24$, 3 df, $P < 0.0001$). For males, use differed from availability during late summer only ($X^2 = 18.13$, 3 df, $P = 0.0004$). Sexes used slope positions similarly. During late summer, both sexes selected mid-slopes and avoided flats, washes, and benches (Table 7). Throughout the year, all other slope positions were either used in proportion to availability or were not used.

Activity and Use of Slope and Slope Position

Use of slope for foraging did not differ significantly between sexes ($X^2 = 1.06$, 1 df, $P = 0.3026$). For females, use differed significantly from availability during late summer only ($X^2 = 9.20$, 2 df, $P = 0.0101$). For males, slope use differed from availability during spring ($X^2 = 10.04$, 2 df, $P = 0.0066$) and late summer ($X^2 = 14.05$, 2 df, $P = 0.0009$). Males foraged on moderate (10-40%) slopes during spring and late summer, and avoided foraging on terrain with $<10\%$ slope during late summer (Table 8). Except for females in winter, both sexes did not forage on steep slopes. All other slopes were used in proportion to availability.

Use of slope for bedding did not differ significantly between sexes ($X^2 = 0.08$, 1 df, $P = 0.7815$). For both sexes, use differed significantly from availability during late summer

Table 9. Availability and use (%) of aspect, slope class, slope position, and distance to housing for bedding activity by season for desert mule deer in the Rincon Mountain District of Saguaro National Monument, Tucson, Arizona, 1988-89.

Habitat component	Random availability (n=385)	Spring ^a use		Early summer ^a use		Late summer ^a use		Winter ^a use	
		F (n=18)	M (n=23)	F (n=20)	M (n=32)	F (n=15)	M (n=34)	F (n=10)	M (n=13)
<u>Aspect</u>									
North	8.3	11.1	13.0	0.0	9.4	46.7+ ^b	20.6	10.0	0.0
East	0.5	0.0	4.4	5.0	0.0	6.7	5.9	0.0	0.0
South	6.8	5.6	0.0	0.0	0.0	6.7	2.9	10.0	0.0
West	8.3	0.0	8.7	15.0	3.1	6.7	26.5	10.0	0.0
Level (<10% slope)	76.1	83.3	73.9	80.0	87.5	33.3-	44.1-	70.0	100.0+
<u>Slope class</u>									
<10%	76.1	83.3	73.9	80.0	87.5	33.3-	44.1-	70.0	100.0+
10-40%	21.3	16.7	26.1	20.0	12.5	66.7+	52.9+	30.0	0.0
>40%	2.6	0.0	0.0	0.0	0.0	0.0	2.9	0.0	0.0
<u>Slope position</u>									
flats/benches	75.6	77.8	69.6	80.0	87.5	26.7-	44.1-	60.0	92.3
mid-slope	18.2	16.7	26.1	15.0	9.4	40.0	47.1+	30.0	0.0
top of slope	4.4	0.0	4.4	5.0	0.0	20.0	8.8	10.0	7.7
ridgeline	1.8	5.6	0.0	0.0	3.1	13.3	0.0	0.0	0.0
<u>Distance to housing</u>									
<100 m	2.9	22.2	0.0	5.0	15.6	0.0	0.0	0.0	0.0
>100 m	97.1	77.8	100.0+	95.0	84.4	100.0+	100.0+	100.0+	100.0+

^a Spring = 1 Feb-30 Apr; early summer = 1 May-Jul 15; late summer = 16 Jul-31 Oct; and winter = 1 Nov-31 Jan.

^b A + indicates use > availability and - indicates use < availability.

only ($X^2 = 20.61$, 2 df, $P < 0.0001$, females; $X^2 = 21.94$, 2 df, $P < 0.0001$, males). Males and females used slopes similarly for bedding. During late summer, both sexes used moderately steep slopes and avoided bedding on terrain with $<10\%$ slope (Table 9). Females used all other slopes in proportion to availability, except for steep slopes that were not used during any season. Males bedded on steep slopes during late summer only, using this slope in proportion to its availability. In winter, males bedded exclusively on terrain with $<10\%$ slope. All other slopes were used in proportion to availability.

Use of slope position for foraging did not differ significantly between sexes ($X^2 = 0.05$, 1 df, $P = 0.8163$) or from availability for either sex during any season ($P > 0.05$). Females did not forage on slope tops during spring or on ridgelines during early summer and winter (Table 8). Flats, washes, and benches were avoided during late summer. In contrast, males did not forage on slope tops during early summer and winter, or on ridgelines during late summer and winter. During late summer, males selected mid-slopes when foraging. Both sexes used all other slope positions in proportion to availability.

Slope positions used for bedding did not differ significantly between sexes ($X^2 = 0.41$, 1 df, $P = 0.5205$). For both sexes, use of slope position differed significantly from availability during late summer only ($X^2 = 12.45$, 3 df, $P = 0.006$, females; $X^2 = 22.82$, 3 df, $P < 0.0001$, males). Females did not use slope tops during spring, and ridgelines during early summer and winter (Table 9). During late summer, males selected mid-slopes, and avoided bedding on flats, washes, and benches, as did females. Males used ridgelines during early summer only, and did not use slope tops during early summer, or mid-slopes in winter. Both sexes used all other slope positions in proportion to availability.

Distance to Housing

Distance of deer to housing (i.e., within 100 m versus beyond 100 m of housing) differed significantly between sexes during early summer only ($X^2 = 4.43$, 1 df, $P = 0.0353$). For females, use differed from availability during all seasons except late summer ($X^2 = 8.26$, 1 df, $P = 0.0041$; $X^2 = 99.44$, 1 df, $P < 0.0001$; $X^2 = 9.27$, 1 df, $P = 0.0023$; spring, early summer, and winter), whereas, for males, use differed from availability during early summer only ($X^2 = 22.04$, 1 df, $P < 0.0001$). With the exception of males in spring, both sexes used areas within 100 m of residential housing in proportion to its availability during all seasons except early summer (Table 7). In early summer, both sexes selected habitat within 100 m of housing, with females located almost 100 m closer ($\bar{X} = 161$ m) to housing than males ($\bar{X} = 250$ m). Males did not forage within 100 m of housing during spring and winter, and used this area in proportion to its availability during early and late summer (Table 8). In contrast, females selected areas within 100 m of housing when foraging in early summer, and used this area in proportion to its availability during all other seasons. Areas within 100 m of housing were used as bedsites in proportion to

availability by females during spring and early summer, and by males during early summer. Deer were not observed bedded within 100 m of housing during any other season.

COLLARED PECCARY

Annual Use of Vegetation Associations

Vegetation use differed significantly between herd classes ($X^2 = 9.85$, 2 df, $P = 0.0073$) and from availability for urban ($X^2 = 271.14$, 8 df, $P < 0.0001$) and non-urban herds ($X^2 = 195.43$, 8 df, $P < 0.0001$). Both classes used mesquite-dominated vegetation associations (Table 10). Non-urban peccaries also used palo verde-acacia-dominated areas in greater proportion than available. Urban herds either avoided or did not use palo verde-mixed shrub, areas dominated by jojoba, and vegetation associations in rocky terrain. Similarly, non-urban animals did not use associations dominated by creosote and those found in mountainous terrain or beyond monument boundaries.

Activity and Use of Vegetation Associations

Activity was recorded for 277 visual observations of radio-collared herds. Foraging and bedding, the 2 most frequently observed activities, accounted for 30%, and 44%, respectively, of all activities observed. Vegetation series used for foraging differed significantly between urban and non-urban herds ($X^2 = 9.33$, 2 df, $P = 0.0094$). Use of vegetation associations also differed from availability for both classes ($X^2 = 32.02$, 8 df, $P < 0.0001$, urban; $X^2 = 76.63$, 8 df, $P < 0.0001$, non-urban). When foraging, peccaries either avoided or did not use palo verde-mixed shrub, palo verde-saguaro-mixed cacti, and jojoba-mixed scrub associations (Table 10). Non-urban peccaries also did not use creosote-dominated areas. Except for palo verde-acacia-dominated areas that were used by non-urban animals, all other vegetation associations were used in proportion to availability. Although vegetation series used for bedding did not differ significantly between classes ($X^2 = 3.48$, 2 df, $P = 0.1758$), use of vegetation associations differed from availability for each class ($X^2 = 254.56$, 8 df, $P < 0.0001$, urban; $X^2 = 118.00$, 8 df, $P < 0.0001$, non-urban). Both classes selected mesquite-dominated associations when bedding (Table 10). Urban herds did not bed in areas dominated by jojoba and avoided bedding in vegetation associations located outside the monument (palo verde-mixed shrub-mixed cacti-zinnia/burroweed) or in rocky terrain (palo verde-saguaro-mixed cacti-mixed scrub). Non-urban peccaries either did not use or used all other vegetation associations in proportion to availability.

Table 10. Availability and use (%) of vegetation associations by year and activity for collared peccary in the Rincon Mountain District of Saguaro National Monument, Tucson, Arizona, 1988-89.

Vegetation association	Random availability (n=383)	Annual use ^a		Foraging use		Bedding use	
		Urban ^b (n=211)	Non-urban (n=64)	Urban (n=50)	Non-urban (n=33)	Urban (n=115)	Non-urban (n=22)
<u>Creosote Series</u>							
Creosote-acacia- palo verde- ocotillo-zinnia	14.6	13.7	0.0	24.0	0.0	10.4	0.0
<u>Palo Verde-Cacti Series</u>							
Palo verde-mixed shrub-mixed cacti- zinnia/burroweed	29.8	5.2- ^c	0.0	8.0-	0.0	1.7-	0.0
Palo verde-saguaro- mixed cacti-mixed scrub	14.6	1.9-	0.0	2.0-	0.0	1.7-	0.0
Jojoba-mixed scrub	1.8	0.0	1.6	0.0	0.0	0.0	4.6
Palo verde-creosote- desert broom- brittlebush- ocotillo	4.4	8.1	6.3	4.0	9.1	4.4	4.6
Palo verde-saguaro- brittlebush	14.9	13.7	12.5	24.0	21.2	7.0	0.0
Palo verde-acacia- mixed cacti-mixed scrub-grass	6.3	12.3	26.6+	8.0	33.3+	14.8	13.6
<u>Mesquite Series</u>							
Mesquite-acacia- palo verde-mixed cacti-mixed scrub	5.7	13.7+	7.8	10.0	12.1	20.0+	4.6
Mesquite-mixed short tree and mesquite- wolfberry-mixed scrub	7.8	31.3+	45.3+	20.0	24.2	40.0+	72.7+

^a Years combined (based on seasonal year, 1 Feb-31 Jan).

^b Herd classes.

^c A + indicates use > availability and - indicates use < availability.

Annual Use of Aspect

Although aspect use did not differ significantly between classes ($X^2 = 0.99$, 1 df, $P = 0.3199$), use differed from availability for urban ($X^2 = 38.41$, 4 df, $P < 0.0001$) and non-urban ($X^2 = 11.88$, 4 df, $P = 0.0183$) herds. Urban herds selected level ground and avoided south and west aspects, whereas, non-urban animals used all aspects in proportion to availability (Table 11).

Activity and Use of Aspect

Use of aspect did not differ significantly between classes for either foraging ($X^2 = 1.48$, 1 df, $P = 0.2240$) or bedding ($X^2 = 0.55$, 1 df, $P = 0.4575$) activity. Aspects used for foraging differed significantly from availability for urban herds only ($X^2 = 9.66$, 4 df, $P = 0.0466$). Except for urban animals that did not forage on south aspects, both classes used all aspects in proportion to availability (Table 11).

Use of aspect for bedding also differed significantly from availability for urban herds only ($X^2 = 12.41$, 4 df, $P = 0.0146$). Urban herds avoided bedding on south and west aspects, whereas, non-urban peccaries did not use east and west aspects (Table 11). Both classes used all other aspects in proportion to availability.

Annual Use of Slope and Slope Position

Use of slope did not differ significantly between classes ($X^2 = 0.99$, 1 df, $P = 0.3199$) but differed from availability for urban herds only ($X^2 = 11.83$, 2 df, $P = 0.0027$). Urban herds selected terrain with $<10\%$ slope and avoided moderate slopes ($10-40\%$) (Table 11). Steep slopes were used in proportion to availability. In contrast, non-urban peccaries did not use steep slopes and used all other slopes in proportion to availability.

Use of slope position also did not differ significantly between classes ($X^2 = 3.05$, 1 df, $P = 0.0808$) and differed from availability for urban peccaries only ($X^2 = 13.01$, 3 df, $P = 0.0046$). Use of slope position was closely associated with slope use. Urban herds selected flats, washes, and benches, avoided mid-slopes, and used slope tops and ridgelines in proportion to availability (Table 11). Non-urban peccaries used all slope positions in proportion to availability.

Activity and Use of Slope and Slope Position

Use of slope did not differ significantly between classes for foraging ($X^2 = 1.48$, 1 df, $P = 0.2240$) or bedding ($X^2 = 0.55$, 1 df, $P = 0.4575$) activity. Slopes used for either activity did not differ significantly from availability for urban ($X^2 = 3.11$, 2 df, $P = 0.2112$,

Table 11. Availability and use (%) of aspect, slope class, slope position, and distance to housing by year and activity for collared peccary in the Rincon Mountain District of Saguaro National Monument, Tucson, Arizona, 1988-89.

Habitat component	Random availability (n=385)	Annual use ^a		Foraging use		Bedding use	
		Urban ^b (n=212)	Non-urban (n=64)	Urban (n=50)	Non-urban (n=33)	Urban (n=115)	Non-urban (n=22)
<u>Aspect</u>							
North	8.3	8.5	7.8	4.0	9.1	12.2	4.6
East	0.5	2.4	6.3	6.0	9.1	1.7	0.0
South	6.8	0.9- ^c	3.1	0.0	3.0	1.7-	4.6
West	8.3	2.4-	3.1	4.0	6.1	2.6-	0.0
Level (<10% slope)	76.1	85.9+	79.7	86.0	2.7	81.7	90.9
<u>Slope class</u>							
<10%	76.1	85.9+	79.7	86.0	72.7	81.7	90.9
10-40%	21.3	13.2-	20.3	14.0	27.3	16.5	9.1
>40%	2.6	0.9	0.0	0.0	0.0	1.7	0.0
<u>Slope position</u>							
flats/benches	75.6	85.4+	75.0	86.0	66.7	80.0	90.9
mid-slope	18.2	9.4-	18.8	12.0	24.2	10.4	9.1
top of slope	4.4	4.3	1.6	2.0	3.0	7.8	0.0
ridgeline	1.8	0.9	4.7	0.0	6.1	1.7	0.0
<u>Distance to housing</u>							
<100 m	2.9	25.9+	—	42.0+	—	8.7	—
>100 m	97.1	74.1-	— ^d	58.0-	—	91.3	—

^a Years combined.

^b Herd classes.

^c A + indicates use > availability and - indicates use < availability.

^d Not located within 825 m of housing.

foraging; $X^2 = 2.18$, 2 df, $P = 0.3362$; bedding) and non-urban peccaries ($X^2 = 1.61$, 2 df, $P = 0.4471$, foraging; $X^2 = 3.33$, 2 df, $P = 0.1892$, bedding). Classes used slopes similarly when foraging and bedding. Non-urban animals did not use steep slopes for either activity, whereas, urban herds did not use steep slopes when foraging (Table 11). All other slope positions were used in proportion to availability.

Use of slope position also did not differ significantly between classes for either activity ($X^2 = 3.31$, 1 df, $P = 0.0688$, foraging; $X^2 = 0.83$, 1 df, $P = 0.3615$, bedding) or from availability for either class (urban: $X^2 = 3.16$, 3 df, $P = 0.3676$, foraging; $X^2 = 7.34$, 3 df, $P = 0.0618$, bedding; non-urban: $X^2 = 2.03$, 3 df, $P = 0.5662$, foraging; $X^2 = 3.53$, 3 df, $P = 0.3169$, bedding). Urban and non-urban herds used slope positions similarly for both activities. For foraging, all slope positions were used in proportion to availability, except for ridgelines that were not used by urban herds (Table 11). Similarly, when bedding, both classes either did not use, or used all slope positions in proportion to availability.

Distance to Housing

Only urban peccary herds were observed within 825 m of housing. Distance from housing varied depending on animal activity and the location of a herd's territory. Distance of peccaries to housing differed from availability for both foraging ($X^2 = 408.16$, 1 df, $P < 0.0001$) and bedding ($X^2 = 16.77$, 1 df, $P < 0.0001$) activities. Urban herds selected areas within 100 m of housing particularly when foraging (Table 11). On average, urban herds were located within 250 m of housing when foraging ($\bar{X} = 240$ m) and within 400 m of housing when bedded ($\bar{X} = 387$ m).

DISCUSSION

DESERT MULE DEER

Movements

Because females returned to the desert floor after their fawns were weaned or lost, water availability was likely not the primary reason for the shift to higher elevations. Possible explanations for this shift in habitat use may be predator avoidance or sexual selection (Wilson 1975; King and Smith 1980), or the result of increased nutritional demands brought on by pregnancy (Short 1981; Bowyer 1991).

The larger home-range size associated with desert mule deer males during this same period corresponded to the start of the summer rains. Males that had moved out of the monument in search of water during the early summer returned to the monument at this time as water sources became more abundant (Fig. 3).

The difference in annual precipitation between years is evidenced by the more pronounced movements of deer out of the monument in 1989. During the drought, deer tended to move earlier and remain longer in habitats outside the monument as compared to movements in 1988 when rainfall patterns were considered normal. In most cases deer tended to return to the same residential areas where they had prior knowledge of dependable water sources.

Of 10 radio-collared deer, 8 were observed out of the monument at some time during the study. A ninth animal, although not observed out of the monument, was seen on several occasions within several hundred meters of the boundary suggesting that she may have used areas outside the monument. We do not know if a tenth animal, which lost its collar midway through the study, used habitats outside the monument.

Although collared peccaries can subsist for long periods without water (Minnamon 1962), desert mule deer appear to be behaviorally dependent on the presence of free-standing water (Wood et al. 1970; Hervert and Krausman 1986; Rautenstrauch and Krausman 1989). The size of seasonal home ranges exhibited by desert mule deer at SAGU are small compared to home-range sizes reported for desert mule deer populations in western Arizona (Krausman 1985a; Rautenstrauch and Krausman 1989). Rautenstrauch and Krausman (1989) reported that desert mule deer migrated to free-standing water during the driest period of summer. Hervert and Krausman (1986) demonstrated that when denied access to water, desert mule deer females searched for water outside their known home range. Similar movements in response to water loss have been reported by Clark (1953), Hanson and McCulloch (1955), Johnson (1962), Wood et al. (1970), and Rogers et al. (1978). The same general movement patterns were evident among desert mule deer at SAGU.

Movements of desert mule deer are closely associated with the distribution of free-standing water during the driest seasons of the year. During years of normal precipitation, these dry periods occur most notably in early summer and, to a lesser extent, winter, during the breeding season. Deer responded to losses of ephemeral water sources within their home range by leaving the monument in search of available water outside the monument. In the majority of instances, the presence of water sources demonstrated a deliberate effort by homeowners to attract wildlife onto their property.

Habitat Use

Of all habitat variables examined, only distance from housing during early summer and use of slope position during late summer showed a significant difference in use between sexes. The general lack of spatial segregation and difference in habitat use between the sexes of desert mule deer at SAGU may have been the result of an abundance of high quality forage and greater vegetation diversity found within the study area as compared to other southwestern habitats.

At SAGU, desert mule deer tended to restrict their use to a relatively small area of habitat on the desert floor. Encroaching urban development, which bounds the habitat on three sides, was avoided by both sexes during all but the driest periods of the year. Rocky, mountainous terrain, largely avoided by males, bounds the study area on the remaining side.

With the exception of the breeding season, sexual segregation has been observed year-round for desert mule deer (Ordway and Krausman 1986; Scarbrough and Krausman 1988). Bowyer (1984) reported that sexual segregation among southern mule deer (*Odocoileus hemionus fuliginatus*) occurred throughout the driest portion of the year, and was most pronounced during and immediately following parturition. At SAGU sexual segregation of desert mule deer was apparent only during the fawning season.

In arid environments, density-independent factors (e.g., plant density, rainfall) may significantly influence the distribution and productivity of desert mule deer (Leopold and Krausman 1991). In a study of habitat use by desert mule deer in southcentral Arizona (Ordway and Krausman 1986), females preferred vegetation associations possessing higher quality forage. The increased nutritional demands placed on pregnant and lactating females suggests that the same may have been true for female desert mule deer at SAGU. Timing of parturition may be the result of energy requirements during the last third of gestation rather than during lactation (Bowyer 1991). The shift in habitat use to mid-slope positions and northern aspects during late summer may have been a response by both sexes to the vegetation growth occurring on these slopes after the summer rains.

In the Southwest, xeroriparian areas provide thermal cover, forage, and travel corridors for desert mule deer. Xeroriparian areas are most important for desert mule deer at

SAGU during the hot, dry period of early summer. Use of xeroriparian areas and related vegetation associations during this season may reflect the greater thermal cover and higher vegetation diversity afforded in these more mesic environments. These areas were particularly important to deer when foraging.

Similar results have been reported by Krausman et al. (1985c) for desert mule deer in Big Bend National Park, Texas. Unlike other desert mule deer habitats in Arizona (Krausman 1985a; Rautenstrauch and Krausman 1989), interwash regions at SAGU have abundant forage. Such abundance permits deer to rely less heavily on xeroriparian areas during times of reduced thermoregulatory stress. As a result, deer at SAGU may be less dependent on xeroriparian areas than in other southwestern habitats.

The presence of abundant forage in an area may not always signify high deer use if other habitat requirements are lacking (Leopold and Krausman 1991). The seasonal attraction exhibited by both sexes during early summer for habitat outside the monument appears to be related to water availability. In similar studies, mule deer tended to avoid areas less than 400 m from residential developments (deVos et al. 1984) or were more nocturnal and had different habitat use patterns when using intensively developed areas (Vogel 1989). Because deer were obtaining water on residential property, which was surrounded by patches of undisturbed habitat, animals in this study were located nearer to housing than in other similar studies (deVos et al. 1984; Vogel 1989).

COLLARED PECCARY

Movements and Habitat Use

Data on collared peccary movements and habitat use in urban environments are limited. Although information on peccary movements (Minnamon 1962; Schweinsberg 1971; Bigler 1974; Day 1977, 1985) and habitat use (Knipe 1957; Eddy 1961; Minnamon 1962; Schweinsberg 1971; Bigler 1974) in the Sonoran Desert have been reported, comparable data for collared peccary in urban environments are nonexistent.

Differences in habitat use between urban and non-urban peccaries illustrate the highly adaptable nature of these animals. The frequency with which urban herds supplemented their diet with human-provided foods indicates how readily these animals have habituated to urban environments. Urban herds all exhibited similar behavior patterns. During the day, these animals bedded primarily in washes within the monument. Although urban peccaries were known to forage on natural food sources, they were inclined to travel to residential areas during evening hours, frequenting locations where they knew they would be fed.

Day (1985) reported average live weights of adult peccaries on the Three Bar Wildlife Area ranging from 18-27 kg. The effect that supplemental food sources provided by humans has on the nutritional status or reproductive fitness of the collared peccary is

unknown. However, the increased body weight observed for peccaries in this study is most likely the result of supplemental feeding.

Supplee (1981) noted that when a collared peccary herd was reduced to ≤ 4 animals, it decreased the size of its home range. At SAGU, the extremely small home range exhibited by a herd comprised of 2 animals appears to be a function of both herd size and resource availability. This herd, perhaps more than any other in the study, has developed an apparent dependence on human-provided foods. Because of the reliability and frequency with which several homeowners provided supplemental food sources, coupled with the proximity of this herd's home-range core to housing, this pair did not have to travel far to obtain human-provided foods.

Observations by Day (1977) and Supplee (1981) indicate that dispersal and formation of new herds are frequently initiated by adult females belonging to a sub-herd. This small herd unit also typically consists of adult males and juveniles that form the nucleus of the new herd. In our study, the extraordinary distance travelled by an adult female from an urban herd may have been the result of density pressures or competition for mates (Bissonette 1976), or stimulated by the availability of suitable habitat (Supplee 1981). Because housing density increases dramatically 3.2 km west of the monument, resulting in an associated decrease in available wildlife habitat, this animal may have been forced to search much farther than expected before finding suitable habitat to establish a territory.

MANAGEMENT IMPLICATIONS

Development of water sources is a common management practice of wildlife agencies throughout the Southwest. By providing deer with ad libitum access to free-standing water during the driest times of the year, homeowners are, in effect, actively managing the SAGU deer population. By providing deer with a resource that otherwise would be limiting during the early summer and, to a lesser extent, winter months, homeowners are allowing deer to inhabit areas that otherwise could not support the high numbers of deer presently found on the desert floor during these seasons.

Hervert and Krausman (1986) demonstrated that the elimination of free-standing water within the home-range core of desert mule deer females caused these animals to seek available water in less desirable habitats. By removing water sources from outside the monument, or increasing the housing density to such a degree that the increased level of human disturbance precludes the use of private lands, thus denying deer access to water, similar movements are likely to occur among deer that use SAGU. Forcing animals to inhabit suboptimal habitats may increase their susceptibility to predation, lower their nutritional status, or decrease their reproductive fitness.

Preserving the remaining available wildlife habitat outside the boundaries of SAGU would be advantageous to desert fauna and would also aid in maintaining the integrity of monument resources. Habitat islands, when designated in strategic locations, offer a greater chance of successfully conserving and enhancing the wildlife resources of protected areas (Harris 1984). As development continues to occur along monument boundaries, a more pronounced interface between wildlife refuge and urban environment will result. This process will eventually lead to a reduction in the effective size of SAGU.

Results of our study demonstrate the needs of large mammals, particularly desert mule deer, for obtaining critical resources on lands outside the monument. Demonstrated use by desert mule deer and collared peccaries on private lands adjacent to SAGU indicates that the current pattern of habitat islands interspersed with low density housing (<1 house/2-4 ha) (A. E. Goldsmith, Univ. Arizona, pers. com., 1990) serves as an effective and highly desirable buffer zone between the monument and the more heavily developed urban areas 3.2 km west of the monument. Although several radio-collared animals were observed close (<300 m) to these heavily developed areas, neither deer nor peccaries were observed in these habitats.

The deliberate efforts made to attract wildlife onto their properties indicate the high value that homeowners living adjacent to SAGU place on wildlife-viewing recreation. Over the years, some residents have expended hundreds of dollars for food (S. Rux, pers. com., 1989) and elaborate watering devices and other habitat improvements on their property. Increased housing densities accompanied with an associated increase in human intrusions will result in deterioration of this form of recreation for homeowners. It will

also result in an increase in wildlife depredation problems. An active, coordinated effort should be made by city and county planners, park managers, and developers to take actions that will enhance the congruence of the political and biological boundaries of the monument to minimize potential losses to the wildlife resources of SAGU.

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The cover photograph was taken October 4, 1935, in Saguaro National Monument by the first National Park Service photographer, George Alexander Grant (1891-1964).



As the nation's principal conservation agency, the U.S. Department of the Interior has responsibility for most of our nationally owned public lands and natural and cultural resources. This includes fostering wise use of our land and water resources, protecting fish, wildlife and plants, preserving the environmental and cultural values of national parks and historic places, and providing for enjoyment of life through outdoor recreation. The Department assesses our energy and mineral resources and works to ensure that their development is in the best interests of all our people. The Department also has a major responsibility for American Indian reservation communities and for people who live in island territories under U.S. administration.

