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ASSESSING MEDIUM-SIZED MAMMAL ABUNDANCE AT FORT HOOD MILITARY INSTALLATION USING LIVE-TRAPPING AND SPOTLIGHT COUNTS

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INTRODUCTION

Fort Hood Military Post is located in central Texas in Bell and Coryell counties. It lies approximately 93 km north of Austin, Texas, and 63 km southwest of Waco, Texas. The reservation encompasses approximately 87,800 ha (339 square miles; 217,000 acres) and is in the southern portion of the Cross Timbers and Prairie Vegetational Area (Gould, 1975; Severinghaus et al., 1980). This area of central Texas also is recognized as occurring in two distinct geographic regions: the Lampasas Cut Plain and the Blackland Prairie. The Lampasas Cut Plain is that portion of the Edwards Plateau drained by the tributaries of the Brazos River. It is characterized by grass-covered low hills and oak-juniper woodlands consisting of Ashe juniper (*Juniperus ashei*), blackjack oak (*Quercus marilandica*), and post oak (*Q. stellata*) with thin, stony soils and narrow valleys cut in Lower Cretaceous limestones. The Blackland Prairie extends from the Red River southward to near San Antonio. This region is underlain by Upper Cretaceous clays and soft limestones and is characterized by mixed grasslands dominated by little bluestem (*Schizachyrium scoparium*), big bluestem (*Andropogon gerardii*), yellow Indiangrass (*Sorghastrum nutans*), and sideoats grama (*Bouteloua curtipendula*) often associated with stands of sugar hackberry *(Celtis laevigata)* and honey mesquite (*Prosopis glandulosa*). Trees such as pecan *(Carya illinoinensis)*, American elm (*Ulmus americana*), and red ash (*Fraxinus pennsylvanica*) are dominant in riparian habitats along major waterways within the Blackland Prairie (Kutac and Caran, 1994).

Major plant communities on Fort Hood are coniferous woodland, deciduous woodland, mixed woodland, and savannah. The first three community types can be subdivided further on the basis of canopy cover of over or under 50%. The woodland plant communities make up ca. 57% of the vegetation of the military reservation. Savannah areas account for ca .38% and the remaining 5% is developed land. (Department of the Army, 1979).

Fort Hood lies between two climate zones, the humid subtropical region to the east and the semi-arid region to the west. Tropical maritime air masses predominate throughout the late spring, summer, and early autumn months while polar air masses frequent the area in winter (Department of the Army, 1979). Daily temperature variations in August generally range from 21°C to 37°C with readings over 38°C possible. January tem-

peratures usually vary between 1.7°C and about 16°C (Kutac and Caran, 1994). Average annual rainfall for Fort Hood is 74 cm (ETAC, 1970).

Fort Hood Military Reservation is situated in the Brazos River Basin on the boundary of two major physiographic regions: the Comanche Plateau to the west and the Gulf Coastal Plain to the south. From north to south, the major drainages are the Leon River, Owl Creek, Cowhouse Creek, North Nolan Creek, and Reese Creek. All of these, with the exception of Reese Creek and North Nolan Creek, flow into Belton Lake. Of these, Cowhouse Creek is the major drainage on the reservation (Severinghaus et al., 1980; Department of the Army, 1979).

Fort Hood houses two military divisions, the First Cavalry Division and the Second Armored Division, and also serves as the major training area for the Forty-Ninth Armored Division, a division of the Texas National Guard, as well as several reserve units. Total tracked vehicles utilized for training are in excess of 2,500 (Goran et al., 1983). Of the 878 km^2 (217,000 acres) comprising Fort Hood, 533 km^2 (131,704 acres) are used for maneuver training activities and another 251 km^2 (62,000 acres) for live-fire training. Collectively, these areas account for 784 km^2 or ca. 89% of Fort Hood's property (Department of the Army, 1979; Miller-Talley Associates and Espey Huston and Associates, Inc., 1978).

A series of Army Corp of Engineers Construction Engineering Research Laboratory (CERL) reports (Severinghaus et al., 1979, 1980, 1981; Goran et al., 1983) have assessed ecological differences between selected tracked vehicle training areas and areas representing pre-training (i.e., no training) conditions. These reports focus on the major components of the terrestrial and aquatic ecosystems in an attempt to quantify cause and effect relationships between army activities and their impact on ecosystems. Although the effects of training activities on mammals are included in the reports, the primary focus was placed on small mammal communities. Medium-sized and large mammals were documented as present or absent, but no analyses were conducted to determine possible effects on their populations from military training maneuvers (Severinghaus et al., 1979, 1981; Goran et al., 1983).

CERL reports by Severinghaus et al. (1980, 1981) included information on the effects of tactical vehicle activity on the mammals, birds, and vegetation at Fort Hood, Texas. These reports included a list of mammals (including medium-sized mammal species) whose known geographic ranges included the Fort Hood area as well as a checklist of those species observed during the study period. Severinghaus et al. (1980) included an inventory of medium-sized mammals observed while trapping for small mammals and via a 64-km nocturnal road-cruise census. Additional information on medium-sized mammals was obtained through the Fort Hood Fish and Wildlife Division in the form of a 64-km diurnal road-cruise census for white-tailed deer (*Odocoileus virginianus*) and harvest records for furbearing mammal species (e.g. raccoon, *Procyon lotor*; opossum, *Didelphis virginiana*; gray fox, *Urocyon cinereoargenteus*; coyote, *Canis latrans* and others).

Studies of the medium-sized mammals of Fort Hood include a cursory report compiled in 1978 (Miller-Talley and Associates and Espey Huston and Associates, Inc.) and a mammal survey on land condition trend plots by Baumgardner (1990). The first study was based on a literature search of mammal species whose distributional range includes Fort Hood. This report was initiated to provide information on mammals for the environmental impact statement issued by the Department of the Army (1979) for Fort Hood. Baumgardner (1990) integrated a mammal inventory into the Construction Engineering Research Lab's Land Condition Trend Analysis (LCTA) Program. Results from his study were combined with a previous study (Severinghaus and Goran, 1982) to produce a species list of all small and medium-sized mammals known to occur on the Fort Hood Military Post. Although medium-sized mammals were included in the report, the primary focus of the study was placed on trapping and documenting small mammal species.

Due to the absence of information regarding the effects of long-term military activities on medium-sized mammal species, a need exists for accurate methods which can be used for monitoring these populations. Information gained through such studies can be integrated into LCTA programs to provide army land managers with additional natural resource data for input into land use management planning. Environmental impact studies (such as the study detailed herein) provide means for obtaining data on impacts on natural environments and wild populations. For the purposes of this study, medium-sized mammals include the carnivores, opossum,

armadillos (*Dasypus novemcinctus*), lagomorphs, and large rodent species such as squirrels (*Sciurus niger*).

The objectives of this research were to: 1) determine medium-sized mammal species composition and calculate relative abundances of species present in high and low use areas within the three major selected habitat types, 2) determine any significant difference in relative abundances of medium-sized mammal species between areas of high and low military use within the three selected habitat types, as well as any differences existing due to seasonal, day of sampling, or transect effect, and 3) determine the effectiveness of field survey methods, including live-trapping and nocturnal census counts, for monitoring the medium-sized mammal populations present.

METHODS

Field work was conducted from September 1995 through January 1997. During the first four months, a preliminary survey was conducted to select appropriate study sites. Three of Fort Hood's four major plant communities were selected to serve as the major habitat types to be sampled during the survey. These include: riparian habitats consisting primarily of pecan, American elm, sycamore (*Platanus occidentalis*), live oak (*Quercus fusiformis*), and bigtooth maple (*Acer grandidentatum*); upland habitats consisting of Ashe juniper, Texas oak (*Quercus texana*), live oak, and netleaf hackberry (*Celtis reticulata*); and savannah habitats consisting of little bluestem, yellow Indiangrass, sideoats grama, buffalograss (*Buchloe dactyloides*), and common broomweed (*Xanthocephalum dracunculoides*), with scattered Ashe juniper, and honey mesquite (Correll and Johnston, 1979).

Survey sites were selected on the basis of high and low military use within each habitat type following consultation with the Fort Hood Environmental Division and Fort Hood wildlife officials (Fig. 1). Designation of high and low use reflected the amount of military activity occurring regularly in the area. High military use areas are utilized regularly by troops, armored and/or tracked support vehicles. Low use sites are utilized primarily for the training of ground troops with little armored and/or tracked vehicle disturbance. The six sites selected were surveyed to test whether high and low use areas were quantifiably different for degree of vehicle disturbance. A 16 km transect was driven in each of the six survey areas. At 1.0 km intervals, a random compass direction was selected in which a 50 m transect was walked. The observer attached one end of a 100 m measuring tape at the beginning of the transect and walked 50 m in the selected direction. Number of obvious roads or vehicle trackways crossed within the 50 m transect were recorded. A mean (total roads crossed) was calculated for each area by taking the total number of roads crossed within each area and dividing by the total number of transects sampled in each area. A student's t-test was used to detect any differences between high and low use sites for each of the three habitat types. All sites designated as low use had significantly fewer ($P<0.05$) roads relative to the high use areas for a given habitat type.

Survey sites are abbreviated to 3-letter designations: savannah (Sav), riparian (Rip), and upland (Upl) with numbers signifying high (1) or low (2) military use (Fig. 1). Savannah sites were located in training area 43 in northwestern Fort Hood (Sav 1) and training area 27 in south Fort Hood (Sav 2). Upland sites were located in training area 44 in north central Fort Hood (Upl 1) and training areas 2, 3, and 5 in east Fort Hood (Upl 2). Riparian sites were located in training area 53 in north Fort Hood (Rip 1) and in training area 8 in east Fort Hood (Rip 2).

Each site was surveyed once per season (beginning in December 1995 through January 1997). Surveys were conducted in the following order: Sav 2, Sav 1, Upl 1, Rip 2, Upl 2, Rip 1. This sequence was maintained to ensure that at least five weeks had passed from the time of one survey of an area until the next survey of that area in the following season. This allowed adequate time for captured animals to remix with the population (Begon, 1979) as well as to ensure that each survey represented a true sampling of each season (i.e., an area was not sampled at the end of one season then subsequently sampled the following week, during the next season). The only violation of this sampling series occurred during the autumn survey. Deer hunting within two of the survey areas required work in areas where no hunting was occurring. One area (Sav 1) was sampled during deer season with hunting activity ongoing.

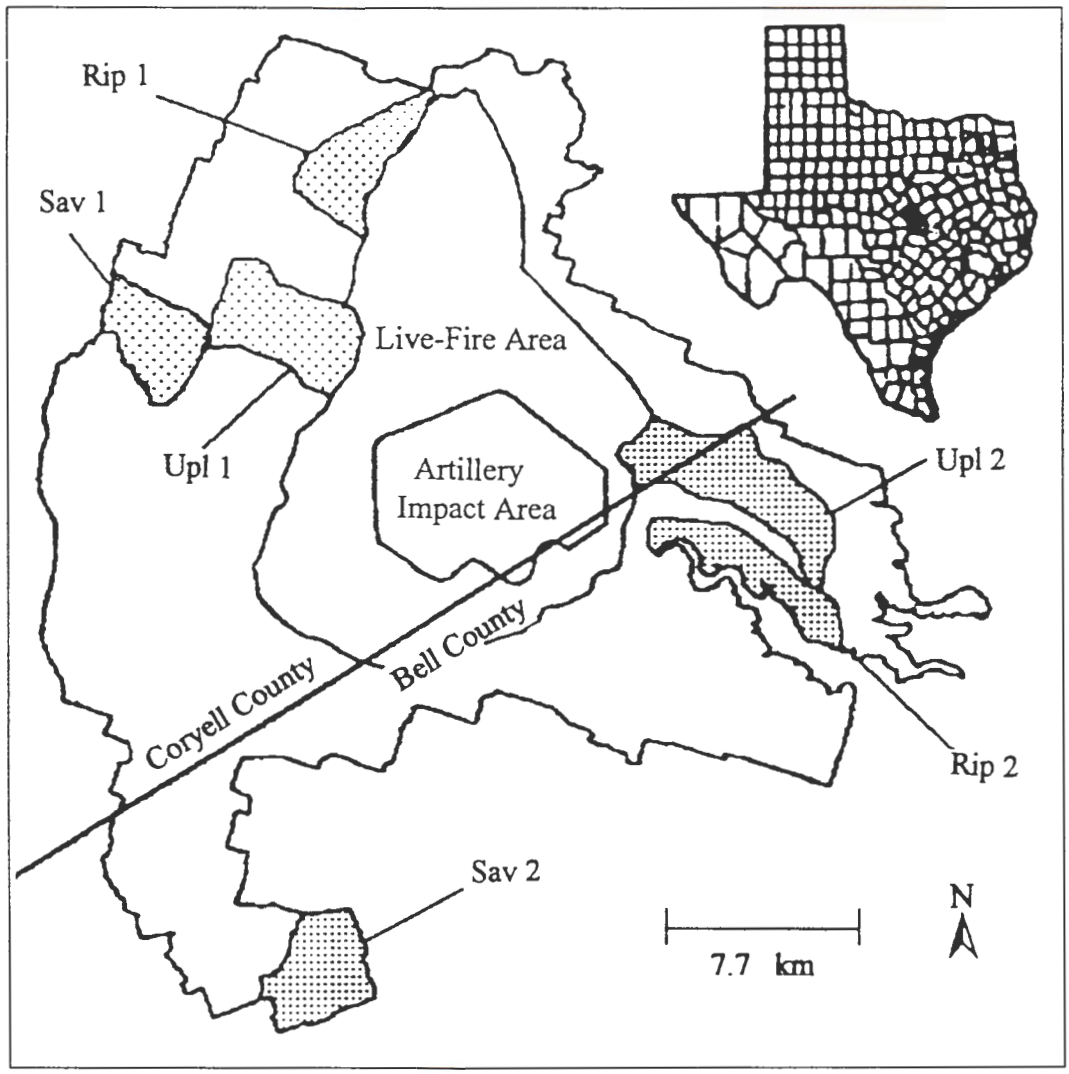

Fig. 1. Map of Fort Hood Army Post. Shaded regions depict locations of the six areas surveyed. Sav 1 = Savannah habitat with high military use, Rip 1 = Riparian habitat with high military use, Upl 1 = Upland habitat with high military use, Sav 2 = Savannah habitat with low military use, Rip 2 = Riparian habitat with low military use, and Upl 2 = Upland habitat with low military use. Texas map indicates positions of Bell and Coryell Counties in central Texas.

Surveys were conducted via line transect sampling (Burnham et al., 1980; Seber, 1982 Ratti et al., 1983). Each area survey consisted of three 5-km transects along which five sampling stations were placed at 1.0-km intervals. Each transect was sampled daily for a three-day period, giving a possible 45 trap nights per transect per sampling period. Each sampling station consisted of Tomahawk® live traps of three different sizes: 51 cm X 18 cm X 18 cm (#204), 66 cm X 23 cm X 23 cm (#205), and 81 cm X 25 cm X 30 cm (#207). Traps were placed at least 20 m from each other to minimize influence on each other. Further consideration in trap placement involved setting each trap in similar vegetation types. Because the animals being sampled were freely mobile and the microhabitat in which traps were placed was homogeneous, it is probable that different individuals would be involved each day, and the arrangement of the traps could remain fixed (Begon, 1979). Traps were baited with fish-based canned cat food, then checked the following three days. Bait was replaced on the second day, or as necessary after captures or disturbance of the traps.

Captured animals were anesthetized using ketamine hydrochloride (Ketaset at a dosage of 10 mg/kg) or a mixture of ketamine hydrochloride, xylazine (Gemini at a dosage of 5 mg/kg) and acepromazine maleate (PromAce at a dosage of 1 mg/kg) (Pond and O'Gara, 1996). Immobilized animals were removed from traps, weighed, measured, and checked for reproductive condition. Animals then were marked with # 4 monel ear tags and released at the site of capture. Voucher specimens were collected during the last quarter of the study and deposited in the Angelo State Natural History Collections. All data including species captured, weight, measurements, sex, reproductive condition, monel ear tag number (left and right ear tags), recapture or first time capture, size of trap, trap operable/inoperable (bait removed and/or trap sprung) and Universal Transverse Mercator (UTM) coordinates of station were recorded on data sheets.

Capture mean, used as an expression of relative abundance, was computed for each transect within each sample area from the number of trap nights and number of animals caught (McKeever, 1959; Clark, 1972; Knowlton, 1972). Total captures per species per transect per day were calculated for subsequent analysis. All capture data were analyzed using the statistical software JMP® (SAS Institute Inc., 1995). Repeated measures analysis of variance was used to determine if day, transect, season, trap size, habitat type, use type (high or low use) or any combination of these parameters significantly (P 0.05) affected captures (i.e., relative abundance). Because of unbalanced sample sizes caused by inoperable traps, sequential sum of squares was utilized. The following assumptions were made with regard to the above analyses: 1) traps at each station were in the same habitat type and 2) at each station an animal had an equal opportunity to select each trap size.

Area analyses involved the comparison of high and low use areas within each of the three habitat types sampled. Additionally, analyses of capture means among habitat types were conducted to determine any differences in relative abundance of medium-sized mammals. Seasonal analyses involved comparisons of capture means across the four seasons during which trapping took place. Capture means were also compared over the three days of surveys, among transects, and among the three sizes of live traps.

Data from spotlight surveys were obtained from the Natural Resources Division of Fort Hood. These data were collected from nocturnal surveys of white-tailed deer and included information on medium-sized mammals. Six 24-km transects were surveyed annually (August and September) from 1978 to 1996. All data were collected following standardized procedures as described in Farfarman and DeYoung (1986) and Ralls and Eberhardt (1997).

Presence of medium-sized mammal species detected by spotlight surveys was compared to our data determined via trapping. Additional analyses include only those data from transects where both live-trapping and spotlight surveys were conducted over the same routes. Relative abundance was calculated by dividing the number of individuals of a species observed on spotlight surveys or trapped in live traps by the number of kilometers over which surveys or live-trapping were conducted. Relative abundance is expressed as the number of individuals of a species per kilometer. A 14-km section of spotlight survey line #1 overlapped the transect on which live-trapping stations #1, 3, 5, 7, 9, 13, 15, 17, 19, 21, 23, 25, 27, and 29 of Upl 2 were located. The final 5 km of spotlight line #1 overlapped the transect on which live-trapping stations #11, 13, 15, 19, and 21 within Rip 2 were located. Spotlight survey line #2 had a 5-km segment which overlapped a section of the transect containing live-trapping stations #13, 15, 17, and 19 located in Rip 1. The initial 5-km of spotlight survey line #3 and an 8-km segment of line #5 overlapped the transects on which live-trapping stations #1, 3, 5, 7, and 9 of Sav 2 and live-trapping stations #1, 3, 5, 7, 9, 11, 13, and 15 of Sav 1 were located. Species used in these analyses were those documented on sections of spotlight routes that overlapped live-trapping transects within the six survey areas. No spotlight survey route passed through Upl 1, therefore it was excluded from any comparisons. Information gained via comparisons between spotlight surveys and live-trapping was used to assess their relative effectiveness for monitoring medium-sized mammal populations.Results

Sampling effort using live traps for medium-sized mammals totaled 2,945 trap nights. A total of 149 medium-sized mammals were captured giving a total trap success of 5.06%. Nine medium-sized mammal species were documented on the base (Fort Hood) as a re-

sult of live-trapping efforts (Fig. 2). Fifty-five opossums, 31 raccoons, 30 striped skunks (*Mephitis mephitis*), 11 ringtails (*Bassariscus astutus*), 9 eastern woodrats (*Neotoma floridana*), 6 feral cats (*Felis catus)*, 3 eastern spotted skunks (*Spilogale putorius*), 2 eastern cottontails (*Sylvilagus floridanus*), and 2 fox squirrels (*Sciurus niger*) were captured during the survey.

Total captures for each season were 35 for winter, 44 for spring, 39 for summer, and 31 captures recorded for the autumn. Sav 2 had 38 total captures documented across seasons (Fig. 3 and 4), Sav 1 had 25 captures (Fig. 5 and 6), Upl 1 had 25 captures (Fig. 7), Upl 2 had 17 captures (Fig. 8), Rip 2 had 26 captures (Fig. 9), while Rip 1 had 18 captures reported (Fig. 10). Opossums, raccoons, and striped skunks comprised 78% of total captures. Number of captures by species, area, and season is detailed in Table 1.

Capture means were calculated for each species per area per season (Table 2) as well as for each species for each season (Fig. 11). Capture means varied for each season from 0.047 for winter and autumn to 0.058 for spring. Capture means for each species ranged from 0.019 for opossums to 0.00068 for eastern cottontails and fox squirrels.

Previously-captured animals (i.e., recaptures) accounted for 10 of the 149 total captures. Opossums comprised six recaptures of which three involved the same individual. Striped skunk recaptures numbered three while only one raccoon was recaptured. Areas and corresponding number of recaptures included three for Upl 1, three for Sav 2, two for Sav 1, one for Rip 1, one for Rip 2, and none for Upl 2.

Large traps accounted for 60 of the 149 captures (ca. 40%), while medium and small traps accounted for 50 (ca. 34%) and 39 (ca. 26%) of total captures, respectively (Table 3). Of the nine species captured, small and medium traps each captured six and large traps captured eight (Table 4). The eastern spotted skunk (n=3) was captured only in small traps.

Overall capture mean varied significantly among areas (n=211; df=5; F=3.75; P<0.01). Sav 2 had the highest capture mean (=0.092) while the lowest capture mean was reported from Upl 2 (=0.033). No significant difference in capture mean was detected among trap sizes (n=633; df=2; F=1.17; P=0.738) or among days (n=211; df=2; F=0.304; P=0.738), transects (n=211; df=2; F=2.41; P=0.095) or seasons (n=211; df=2; F=0.433; P=0.730).

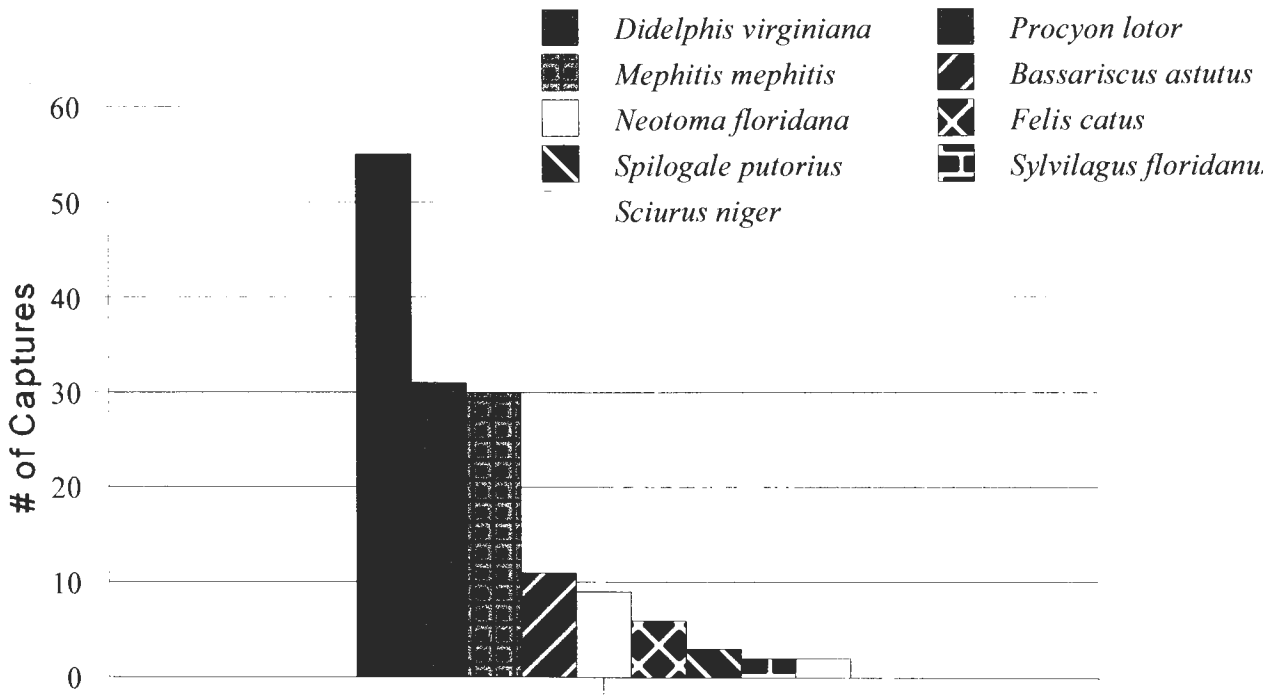

Fig. 2. Total number of medium-size mammals captured at Fort Hood, Texas, 1995-97.

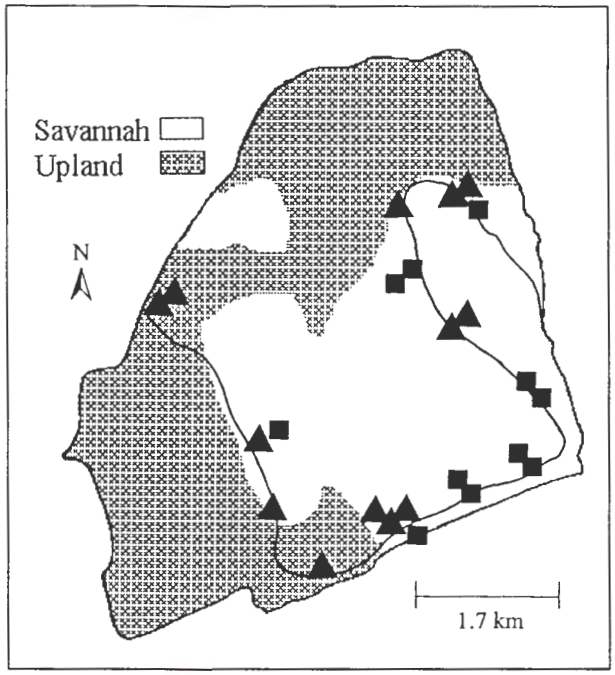

Fig. 3. Map of survey site Sav 2 (savannah habitat with low military use) showing locations of raccoon captures (triangles) and ringtail captures (squares). Dark line through area depicts the survey route.

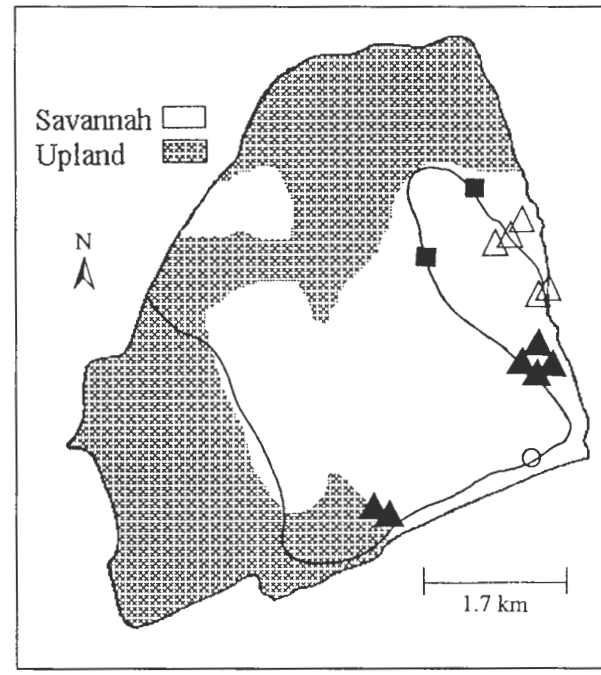

Fig. 4. Map of survey site Sav 2 (savannah habitat with low military use) showing capture locations for opossums (closed triangles), striped skinks (closed squares), fox squirrel (open circle), and feral cat (open triangels). Dark line through area depicts the survey route.

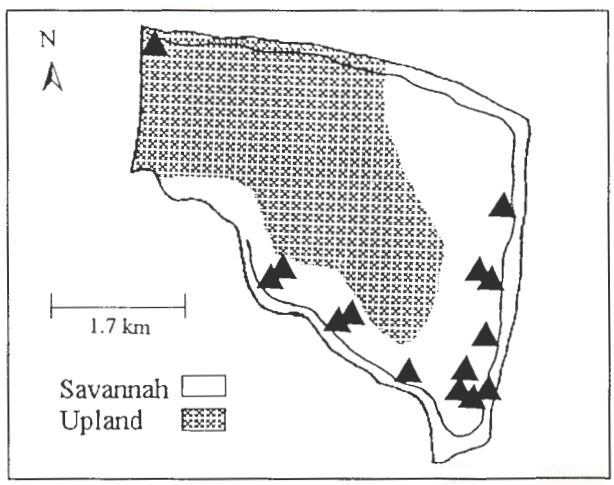

Fig. 5. Map of survey site Sav 1 (savannah habitat with high military use) showing capture locations for opossums (triangles). Dark line through area depicts the survey route.

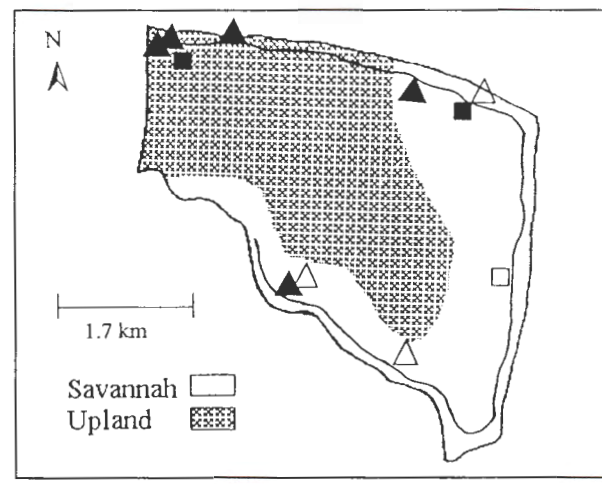

Fig. 6. Map of survey site Sav 1 (savannah habitat with high military use) showing locations of raccoon captures (closed triangles), striped skunk captures (closed squares), feral cat capture (open square), and wastern woodrat captures (open triangles). Dark line through area depicts the survey route.

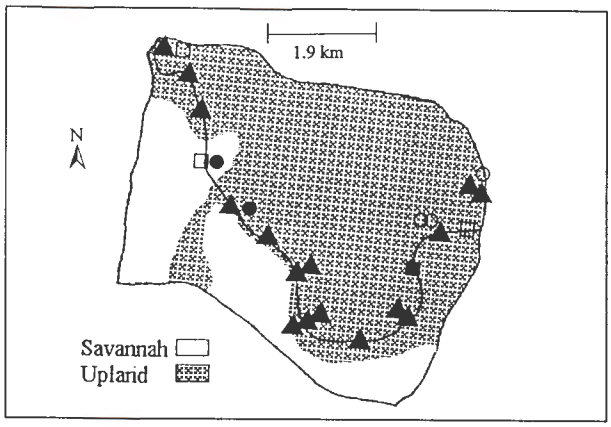

Fig. 7. Map of survey site Up 1 (upland habitat with high military use) showing capture locations for striped skunk (closed triangles), fox squirrel (closed square, eastern woodrat (open squares), eastern spotted skunk (closed circles), and opossum (open circles). Dark line through area depicts the survey route.

The number of captures of opossums, raccoons, and striped skunks were sufficient to statistically analyze capture means for these species. Capture means for raccoons varied significantly with area (n=211; df=5; F=5.22; P<0.001). Capture mean was highest in Sav 2 (=0.029) and lowest in Upl 1 (< 0.0001). Capture means for raccoons also varied significantly with trap size (n=633; df=2; F=7.38; P<0.001), with large traps capturing 21 raccoons while small traps caught no raccoons. Capture means for raccoons did not vary significantly with season (n=211; df=3; F=0.707; P=0.550), day (n=211; df=2; F=1.44; P=0.242), or transect (n=211; df=2; F=0.349; P=0.706).

Capture means for striped skunks varied among areas (n=211; df=5; F=7.61; P<0.001) with highest capture mean recorded in Upl 1 (=0.032) and lowest recorded in Rip 2 (=0.002). No significant differences were detected in capture mean among trap sizes (n=633; df=2; F=0.7055; P=0.4943), seasons (n=211; df=3; F=2.3779; P=0.0741), or days trapped (n=211; df=2; F=0.2271; P=0.7972). There may have been a difference among transects sampled (n=211; df=2; F=2.7239; P=0.0703). Capture means for opossums varied significantly among areas (n=211; df=5; F=6.0664; P<0.001). Highest capture mean for opossums was in Rip 2 (=0.048) with lowest capture mean from Upl 2 (=0.0019).

Both riparian and savannah habitats revealed significantly different capture means (P<0.05) for high and low military use for some species (Table 5). Comparisons of upland habitats revealed no (P<0.05) differences in capture means between the two military use types. Additional analyses involved between habitat comparisons of capture means. Capture means were generated for each habitat (both high and low use sites) and were used to determine if medium-sized mammal species relative abundance varied significantly with habitat type (Table 6). Because no ringtails were captured in riparian and upland habitats, these animals were excluded from analyses involving upland versus riparian habitats.

Spotlight surveys indicated the presence of nine medium-sized mammal species (Table 7). Relative abundances obtained through comparisons of spotlight survey routes and corresponding transects in areas sampled using live traps showed higher relative abundances generated through the use of spotlight surveys in 18 of 30 comparisons involving 12 medium-sized mammal species (Table 8). Analyses include only those transects where both live-trapping and spotlight surveys were conducted over the same routes.

Spotlight data were analyzed to determine if any trends existed in raccoon abundance over the 18 years during which the spotlight surveys had been conducted. Raccoons were used for these analyses because they were documented in greater numbers on spotlight surveys than other medium-sized mammal species. Further analysis included a graphical depiction of average number of raccoons documented using data from all six surveys lines.

Spotlight line #1 includes spotlight surveys conducted from 1979-1996 (Fig. 12). No surveys were conducted in 1980, 1986, or 1992-1995. On this line, raccoons were documented in greatest numbers in 1984 (n = 15). The following year the survey was conducted, no raccoons were documented. The average number of raccoons seen per year was 4.67. Raccoons sighted ranged from 0 (1983, 1985, and 1996) to 15 (1984).

Spotlight line #2 includes surveys from 1978-1996 (Fig. 13). The peak year for raccoon abundance was 1982 (n = 14). A definite decline in raccoons is evident from 1982 (n = 14) to 1984 (n = 1). The average number of raccoons seen per year was 5.25. Raccoons sighted per survey ranged from 1 (1984, 1988, 1992, and 1996) to

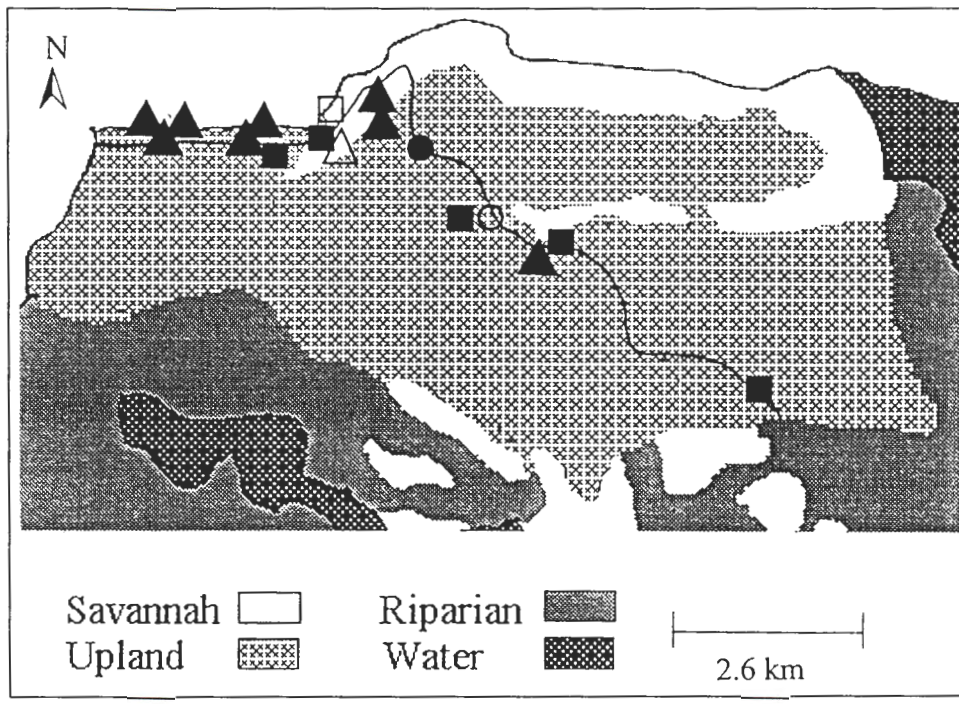

Fig. 8. Map of survey site Up1 2 (upland habitat with low military use) showing capture locations for striped skunk (closed triangles), raccoon (closed squares), opossum (open box), eastern woodrat (open triangle), eastern cottontail (closed circle), and eastern spotted skunk (open circle). Dark line through area depicts the survey route.

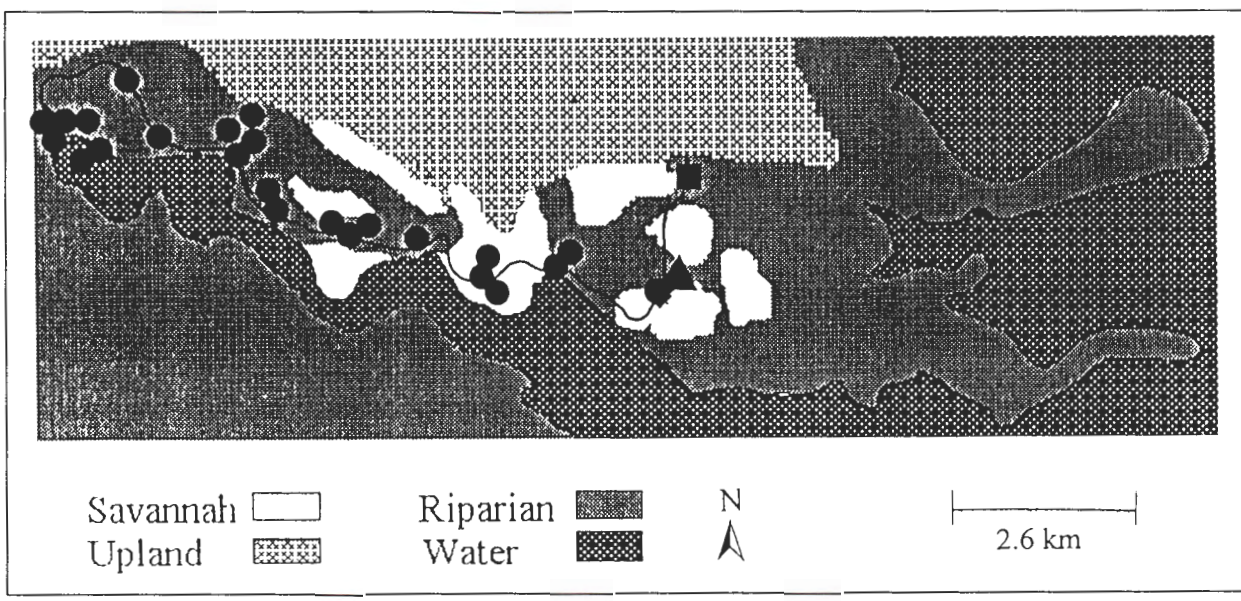

Fig. 9. Map of survey site Rip 2 (riparian habitat with low military use) showing captures locations for opossum (closed circles), striped skunk (closed triangle), and raccoon (closed square). Dark line through area depicts the survey route.

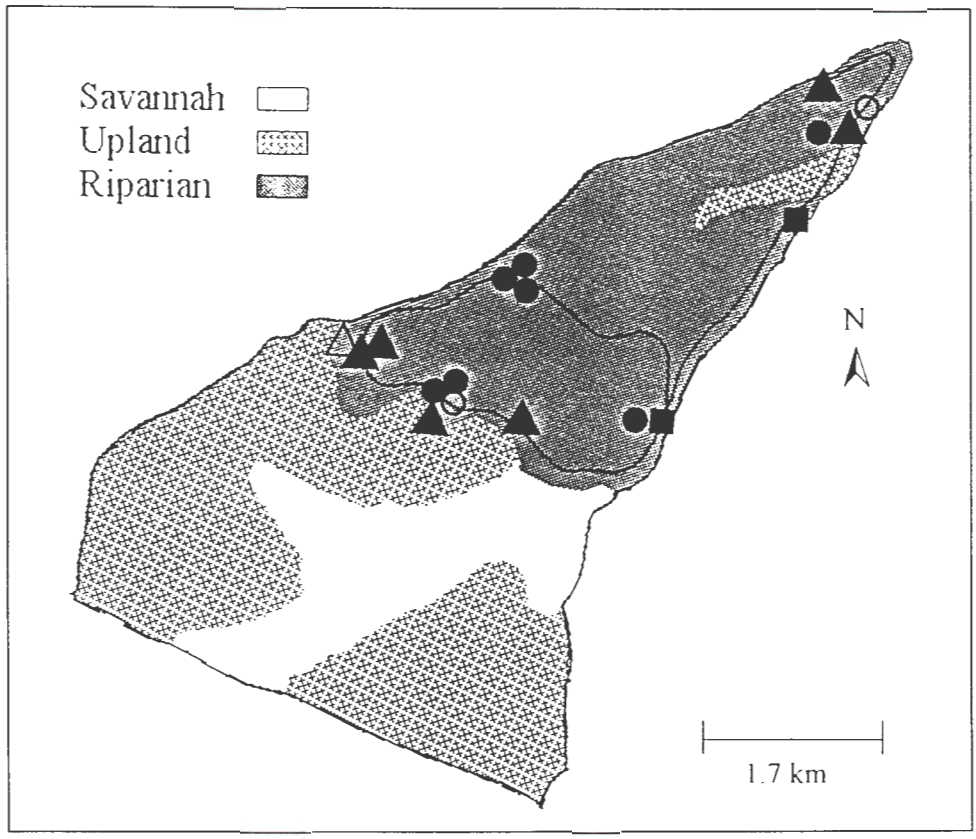

Fig. 10. Map of survey site Rip 1 (riparian habitat with high military use) showing capture locations for raccoon (closed triangles), striped skunk (closed squares), eastern cottontail (open triangle), opossum (closed circles), and eastern woodrat (open circles). Dark line through area depicts the survey route.

14 (1982). No surveys were conducted in 1980, 1981, 1985, 1986, or 1993-1995.

Spotlight line #3 includes surveys from 1979-1996 (Fig. 14). The number of raccoons seen per year appears to be cyclic with a decrease noted from 1988 (n = 4) to 1989 (n = 0) followed by a sharp increase from 1991 (n = 0) to 1996 (n = 6). Average number of raccoons documented per survey was 2.23. Number of raccoons seen per survey ranged from 0 (1989 and 1991) to 6 (1996). No surveys were conducted in 1980 or 1992-1995.

Surveys from spotlight line #4 were conducted from 1987-1996 (Fig. 15). This survey is represented by two distinct peaks in raccoon abundance in 1990 (n = 7) and 1993 (n = 6) both followed by years with no raccoons sighted. Raccoons documented ranged from 0 (1989, 1992, and 1996) to 7 (1990). Average raccoons seen per survey was 2.14. No surveys of line #4 were conducted in 1991, 1994, or 1995.

Surveys of spotlight lines #5 (Fig. 16) and #6 (Fig. 17) were conducted from 1990-1996. A sharp decline in raccoons documented is evident from 1991 to 1993 on line #5 as well as from 1993 to 1996 on line #6. Average number of raccoons documented were 2.0 for line #5 and 3.75 for spotlight line #6.

Data from the six surveys were combined and graphed to depict average number of raccoons seen per 24-km transect per year (Fig. 18). Raccoon abundance appears higher in 1978 (= 8 raccoons documented per year), 1982 (= 9.8 raccoons documented per year) and 1984 (= 6.8 raccoons documented per year) with lower numbers recorded in 1985 (= 0.6 raccoons documented per year) and 1996 (= 1.7 raccoons documented per year). No consistency in raccoon trends is apparent

Table 1. Number of captures per medium-sized mammal species for each season trapping was conducted at Fort Hood Military Post, Texas, 1995-97.

Area	Winter	Spring	Summer	Autumn
Sav 2	1 *Procyon lotor* 1 *Mephitis mephitis* 5 *Bassariscus astutus*	3 *Procyon lotor* 1 *Mephitis mephitis* 6 *Didelphis virginiana* 2 *Felis catus* 1 *Bassariscus astutus*	6 *Procyon lotor* 3 *Felis catus* 1 *Sciurus niger*	3 *Procyon lotor* 5 *Bassariscus astutus*
Sav 1	1 *Procyon lotor* 1 *Neotoma floridana* 2 *Didelphis virginiana*	2 *Procyon lotor* 1 *Mephitis mephitis* 4 *Didelphis virginiana* 1 *Felis catus*	1 *Procyon lotor* 4 *Didelphis virginiana*	1 *Procyon lotor* 1 *Mephitis mephitis* 2 *Neotoma floridana* 4 *Didelphis virginiana*
Upl 1	9 *Mephitis mephitis* 1 *Didelphis virginiana*	2 *Neotoma floridana* 1 *Spilogale putorius* 1 *Mephitis mephitis* 1 *Didelphis virginiana*	4 *Mephitis mephitis* 1 *Didelphis virginiana*	1 *Procyon lotor* 1 *Neotoma floridana* 1 *Spilogale putorius* 1 *Mephitis mephitis* 1 *Sciurus niger*
Upl 2	1 *Procyon lotor* 1 *Sylvilagus floridanus*	1 *Procyon lotor* 3 *Mephitis mephitis* 1 *Didelphis virginiana*	2 *Procyon lotor* 1 *Spilogale putorius* 2 *Mephitis mephitis*	1 *Procyon lotor* 1 *Neotoma floridana* 3 *Mephitis mephitis*
Rip 2	10 *Didelphis virginiana*	6 *Didelphis virginiana*	7 *Didelphis virginiana* 1 *Mephitis mephitis*	1 *Didelphis virginiana* 1 *Procyon lotor*
Rip 1	1 *Procyon lotor* 1 *Mephitis mephitis*	4 *Procyon lotor* 3 *Didelphis virginiana*	1 *Mephitis mephitis* 4 *Didelphis virginiana*	1 *Procyon lotor* 2 *Neotoma floridana* 1 *Sylvilagus floridanus*
Total	35 med-sized mammals	44 med-sized mammals	39 med-sized mammals	31 med-sized mammals

among the years the surveys were conducted. Inability to describe any trends in raccoon numbers could be caused by food availability from year to year, degree of vegetative cover, differential death and/or birth rates, and/or human error in sampling.

DISCUSSION

Mark-recapture studies have proved useful in determining densities of medium-sized mammal species for a given area (Greenwood et al., 1985; Kennedy et al., 1985; Kennedy et al., 1986). Although such techniques have proved successful in estimating densities, certain assumptions must be met for validity (Seber, 1982). Because of the low number of individuals captured (n=149), as well as the lack of success in recapturing previously marked individuals (n=10), mark-recapture data in this study could not be used to determine densities of medium-sized mammal species present. This low sample size in each sampling area violates the assumption of mark-recapture density estimation models (of closed populations) which states, "the proportion of marked individuals in the second sample is a reasonable estimate of the unknown population proportion" (Seber, 1982). Likewise, no area sampled met the minimum number of different individuals observed (n=25) in order for a valid estimation of density to be calculated (Otis et al., 1978; White et al., 1982; Smith and Brisbin, 1984). Furthermore, mark-recapture studies usually involve trapping of a location for 8 to 12 consecutive nights to achieve ad-

Table 2. Capture means for each species among areas for each season the survey was conducted. Capture means were calculated by dividing number of captures by the number of operable traps.

Area	Winter	Spring	Summer	Autumn
Sav 2	0.0095 *Procyon lotor* 0.0095 *Mephitis mephitis* 0.0480 *Bassariscus astutus*	0.0250 *Procyon lotor* 0.0083 *Mephitis mephitis* 0.0500 *Didelphis virginiana* 0.0170 *Felis catus* 0.0083 *Bassariscus astutus*	0.0570 *Procyon lotor* 0.0290 *Felis catus* 0.0095 *Sciurus niger*	0.0250 *Procyon lotor* 0.0410 *Bassariscus astutus*
Sav 1	0.0080 *Procyon lotor* 0.0080 *Neotoma floridana* 0.0160 *Didelphis virginiana*	0.0160 *Procyon lotor* 0.0078 *Mephitis mephitis* 0.0310 *Didelphis virginiana* 0.0078 *Felis catus*	0.0084 *Procyon lotor* 0.0340 *Didelphis virginiana*	0.0360 *Didelphis virginiana* 0.0091 *Procyon lotor* 0.0180 *Neotoma floridana* 0.0091 *Mephitis mephitis*
Upl 1	0.0680 *Mephitis mephitis* 0.0076 *Didelphis virginiana*	0.0150 *Neotoma floridana* 0.0077 *Spilogale putorius* 0.0077 *Mephitis mephitis* 0.0077 *Didelphis virginiana*	0.0310 *Mephitis mephitis* 0.0078 *Didelphis virginiana*	0.0097 *Procyon lotor* 0.0097 *Neotoma floridana* 0.0097 *Spilogale putorius* 0.0097 *Mephitis mephitis* 0.0097 *Sciurus niger*
Upl 2	0.0077 *Procyon lotor* 0.0077 *Sylvilagus floridanus*	0.0079 *Procyon lotor* 0.0240 *Mephitis mephitis* 0.0079 *Didelphis virginiana*	0.0160 *Procyon lotor* 0.0079 *Spilogale putorius* 0.0160 *Mephitis mephitis*	0.0076 *Procyon lotor* 0.0076 *Neotoma floridana* 0.0230 *Mephitis mephitis*
Rip 2	0.0780 *Didelphis virginiana*	0.0460 *Didelphis virginiana*	0.0490 *Didelphis virginiana* 0.0070 *Mephitis mephitis*	0.0079 *Didelphis virginiana* 0.0079 *Procyon lotor*
Rip 1	0.0078 *Procyon lotor* 0.0078 *Mephitis mephitis*	0.0320 *Procyon lotor* 0.0240 *Didelphis virginiana*	0.0078 *Mephitis mephitis* 0.0310 *Didelphis virginiana*	0.0110 *Procyon lotor* 0.0220 *Neotoma floridana* 0.0110 *Sylvilagus floridanus*

equate recaptures (White et al., 1982; Smith and Brisbin, 1984). Because of time constraints of the study and the need for sampling multiple areas, each area was trapped only three nights which probably affected the number of recaptures.

Estimation of abundance of vertebrate populations has proven problematic due to the general trend of low capture probabilities that vary among individuals (Otis et al., 1978) and low densities of populations (Chao, 1989; Hammond, 1990; Hallett et al., 1991; Rosenberg et al., 1995). Weather conditions, habitat, trap type, and population structure also have been related to capture success of various mammals (Geis, 1955; Sealander and James, 1958; Mystkowska and Sidorowicz, 1961; Gentry et al., 1966; Perry et al., 1977).

Relative abundance is a useful alternative to density studies as a tool for comparing mammal populations. Numerous studies have used relative abundance in analysis of methods for censusing medium-sized mammal species (McKeever, 1959; Wood, 1959; Davis, 1977). Capture means, used as a function of relative abundance, were analyzed in this study.

Analysis of overall capture means across all areas surveyed revealed surprising trends, differing significantly with area sampled. These results imply habitat association of species involved. Specifically, raccoons and ringtails had higher relative abundances in savannah habitats. Striped skunks showed higher relative abundances in upland habitats and opossums showed higher relative abundances in riparian habitats. Fifty-eight percent of raccoon captures (n=32) were recorded in savannah habitats while all ringtails (n=10) were captured in savannah. For striped skunks, 77% (n=30) were captured in upland habitats while 56% (n=55) of opossums were captured in riparian habitats. Three eastern woodrats

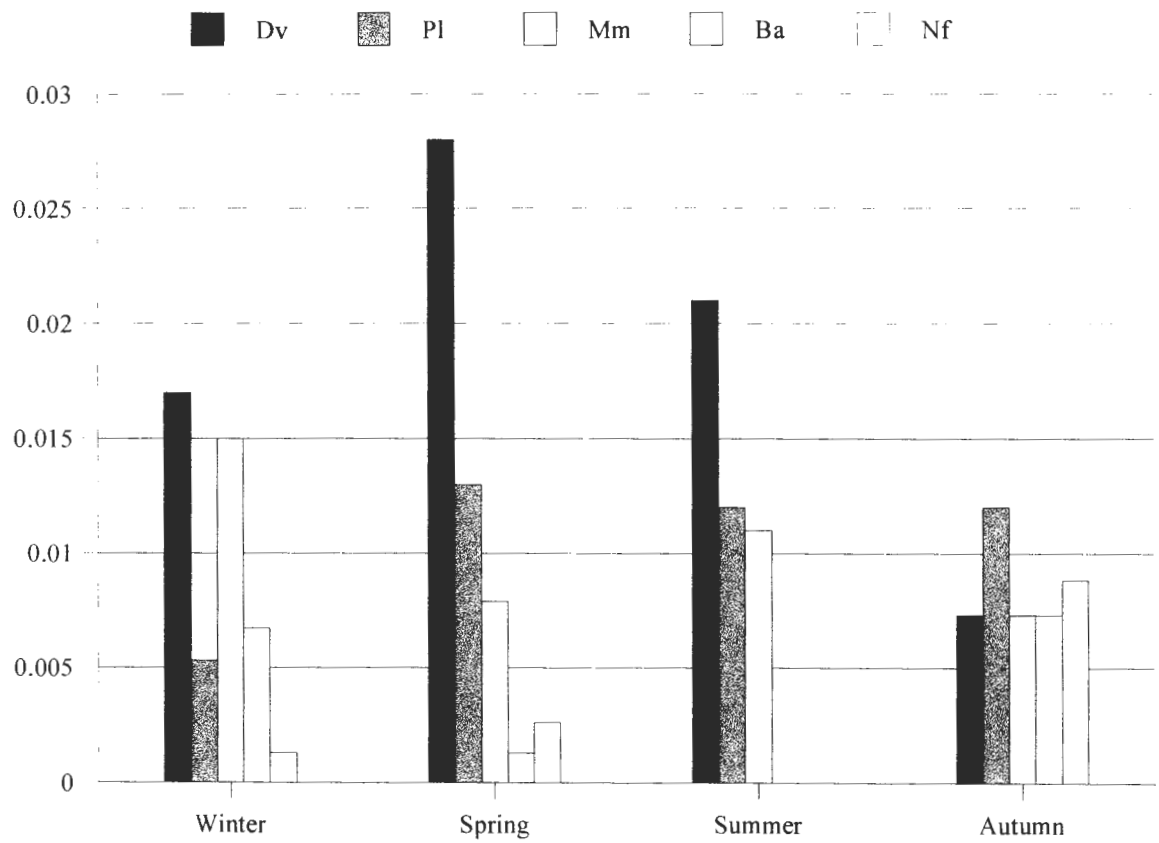

Fig. 11. Capture means for the five most frequently captured medium-sized mammal species calculated for each season the survey was conducted. Species abbreviations are: Dv = *Didelphis virginiana*, Pl = *Procyon lotor*, Mm = *Mephitis mephitis*, Ba = *Bassariscus astutus*, and Nf = *Neotoma floridana*.

were captured in Sav 1 (Fig. 5) as well as three captured in Upl 1 (Fig. 7), two were captured in Rip 1 (Fig. 10), while one eastern woodrat was captured in Upl 2 (Fig. 8). Five feral cats were captured in Sav 2 (Fig. 4) and one was recorded in Sav 1 (Fig. 6). All captures (n=3) of eastern spotted skunks were recorded in upland habitats with two captures recorded in Upl 1 (Fig. 7) and one capture in Upl 2 (Fig. 8).

Military use appeared to have a direct effect on certain medium-sized mammal populations present, but no effect was detected in others. Most species seem to prefer low use rather than high use sites. The only exceptions were eastern spotted skunks and eastern woodrats, both with higher relative abundances in high use areas than in low use areas.

In savannah habitats (Sav 1 and Sav 2), raccoons and ringtails were the only medium-sized mammals (of those analyzed) that showed significant differences between the two use types. In both cases, relative abundance was significantly higher in the low use areas. All ringtail captures occurred in Sav 2 habitat. Military use appeared to affect relative abundances of opossums in riparian habitats as evident by more captures in low use areas, and appeared to have no significant effects on striped skunk populations present.

This heterogenous response of mammals to military activity is consistent with a study by Gese et al. (1989). They found that coyotes at the Pinyon Canyon Maneuver Site, Colorado, responded to military maneuvers by contracting, abandoning, or not changing their

Table 3. Number of medium-sized mammals captured in each trap size for the four seasons the survey was conducted.

Season	Small	Medium	Large
Winter	5 *Mephitis mephitis* 4 *Didelphis virginiana* 1 *Sylvilagus floridanus* 1 *Bassariscus astutus*	4 *Mephitis mephitis* 3 *Didelphis virginiana* 1 *Bassariscus astutus*	6 *Didelphis virginiana* 4 *Procyon lotor* 3 *Bassariscus astutus* 2 *Mephitis mephitis* 1 *Neotoma floridana*
Spring	5 *Didelphis virginiana* 1 *Neotoma floridana* 1 *Spilogale putorius*	5 *Mephitis mephitis* 4 *Didelphis virginiana* 3 *Procyon lotor* 3 *Felis catus* 1 *Neotoma floridana*	12 *Didelphis virginiana* 7 *Procyon lotor* 1 *Memphitis mephitis* 1 *Bassariscus astutus*
Summer	6 *Didelphis virginiana* 3 *Mephitis mephitis* 1 *Spilogale putorius*	7 *Didelphis virginiana* 4 *Procyon lotor* 2 *Mephitis mephitis* 1 *Felis catus*	5 *Procyon lotor* 3 *Mephitis mephitis* 3 *Didelphis virginiana* 2 *Felis catus* 1 *Sciurus niger*
Autumn	3 *Neotoma floridana* 3 *Mephitis mephitis* 3 *Bassariscus astutus* 1 *Didelphis virginiana* 1 *Spilogale putorius*	4 *Procyon lotor* 3 *Neotoma floridana* 2 *Didelphis virginiana* 2 *Mephitis mephitis* 1 *Bassariscus astutus*	5 *Procyon lotor* 2 *Didelphis virginiana* 1 *Sciurus niger* 1 *Sylvilagus floridanus*

Table 4. Species captured in each size of live trap. Species abbreviations are: Dv=Didelphis virginiana, *Pl*=Procyon lotor, *Mm*=Mephitis mephitis, *Ba*=Bassariscus astutus, *Nf*=Neotoma floridana, *Fc*=Felis catus, *Sp*=Spilogale putorius, *Sf*=Sylvilagus floridanus, *and Sn*=Sciurus niger.

Trap Size	Dv	Pl	Mm	Ba	Nf	Fc	Sp	Sf	Sn
Small	X		X	X	X		X	X	
Medium	X	X	X	X	X	X			
Large	X	X	X	X	X	X		X	X

home range, shifting centers of activity away from military activity, and increasing their diurnal rate of movement during maneuvers. Furthermore, a coyote's response appeared to be related to the topography, amount of available cover, and the duration of human activity within the coyote's home range.

A study by W. D. Severinghaus et al. (1981) conducted at Fort Hood reported significantly higher biomass of *Perognathus flavus* in high military use areas. They found no significant differences in biomass of *Peromyscus attwateri* and *P. pectoralis* between high and low use sites; however, biomass of both species was higher in the high use area. Results of similar studies conducted at 10 additional military installations showed that military training had a negative effect on the biomass of small mammal populations present at each site (Goran et al., 1983). Biomass of small mammals stud-

*Table 5. F-values for capture means from analysis of variance comparing high and low use sites within savannah and riparian habitats. Three transects were nested in each site and data were analyzed for differences among trap sizes (small, medium, and large) for level of use. Collections were repeated for three days in each of the four seasons. F-values are given for ANOVA analyses (ns = not significant, * = P < 0.05, ** = P < 0.01).*

Species	Day	Transect	Season	Trap Size	Use Type
Savannah Habitats					
Procyon lotor	1.56 ns	0.46 ns	0.77 ns	4.57*	5.28*
Didelphis virginiana	0.92 ns	2.98 ns	1.81 ns	0.16 ns	2.92 ns
Mephitis mephitis	0.70 ns	0.70 ns	0.67 ns	0.48 ns	0.16 ns
Bassariscus astutus	0.47 ns	1.84 ns	2.77 ns	0.04 ns	10.90**
Total Capture Mean	0.32 ns	4.50*	0.52 ns	1.57 ns	5.06*
Riparian Habitats					
Procyon lotor	0.19 ns	1.20 ns	2.50 ns	1.86 ns	5.54*
Didelphis virginiana	1.19 ns	2.19 ns	2.12 ns	0.22 ns	6.02*
Mephitis mephitis	0.85 ns	0.00 ns	1.13 ns	0.86 ns	0.35 ns
Total Capture Mean	1.62 ns	3.67 ns	0.887 ns	0.39 ns	0.82 ns

ied at these sites was significantly higher in areas where no or little military training had occurred.

McKeever (1959), VanDruff and Rowse (1986), Leberg and Kennedy (1988), and Kennedy et al. (1991) reported differences in habitat association for numerous mammal species. Opossums generally utilized a wide variety of habitats, ranging from areas of relative aridity to much more mesic environments, but are typically found in the wetter areas, particularly near streams and swamps (McManus, 1974). Kissell and Kennedy (1992) reported highest abundance of opossums in riparian habitats with lowest abundances in areas dominated by savannah habitats. Results of live-trapping efforts in this study support the trend of higher opossum abundance in riparian areas. Their abundance, however, was not significantly higher in riparian areas than in savannah habitats. Opossum abundance in upland habitats was significantly lower than in both riparian and savannah habitats.

Studies involving raccoons have shown higher abundance in riparian habitats (Lotze and Anderson, 1979; Kaufman, 1982), than in upland and savannah sites (Lotze and Anderson, 1979; Kaufman, 1982; Leberg and Kennedy, 1988). However, in this study, the highest relative abundance of raccoons was reported in savannah habitats. No significant differences in capture means were detected between riparian and upland habitats. The apparent preference of raccoons for savannah habitats might be misleading. Both savannah habitats sampled contained widespread oak-juniper stands of varying canopy cover. These stands are large enough to provide adequate cover for this species. Although traps were placed to sample savannah habitats, they often times were in close proximity to fairly dense upland habitat. The majority of Sav 1 and Sav 2 are, however, savannah habitats. Furthermore, as seen in Fig. 3 and 4, the majority of live-trapping stations within these areas were located within savannah habitats.

Striped skunks generally inhabit areas consisting of a mixture of woodlands, brushy corners, and open fields broken by wooded ravines and rocky outcrops (Wade-Smith and Verts, 1982). Striped skunk abundance at Fort Hood showed a similar trend; relative abundance of striped skunks was significantly higher in upland habitats than in riparian or savannah habitats. McKeever (1959) reported significantly higher striped skunk abundance in areas dominated by savannah habitat when compared to primarily wooded areas such as upland or riparian sites. Similarly, Verts (1967) found striped skunks more abundant in intensively cultivated areas of Illinois rather than in areas where woodlands, brushlands, and cultivated areas were intermixed.

Table 6. F-*values for capture means from analysis of variance comparing riparian, savannah, and upland sites. Three transects were nested in each site and data were analyzed for differences among trap sizes (small, medium, and large) for level of use. Collections were repeated for three days in each of the four seasons.* F-*values are given for ANOVA analyses (ns = not significant,* * = P < *0.05,* ** = P < *0.01, and* *** = P < *0.001).*

Species	Day	Transect	Season	Trap Size	Area
Upland vs. Riparian Habitats					
Procyon lotor	0.67 ns	0.60 ns	0.66 ns	3.17*	0.41 ns
Didelphis virginiana	0.41 ns	1.00 ns	1.65 ns	0.62 ns	13.3***
Mephitis mephitis	0.94 ns	1.83 ns	0.92 ns	0.66 ns	14.1***
Total Capture Mean	1.35 ns	2.95 ns	0.35 ns	0.20 ns	0.17 ns
Riparian vs. Savannah Habitats					
Procyon lotor	1.56 ns	0.24 ns	0.76 ns	6.32**	6.19*
Didelphis virginiana	0.54 ns	2.62 ns	1.38 ns	0.30 ns	1.48 ns
Mephitis mephitis	0.79 ns	0.34 ns	0.21 ns	0.71 ns	0.28 ns
Bassariscus astutus	0.37 ns	1.42 ns	2.11 ns	0.04 ns	8.04**
Total Capture Mean	0.14 ns	4.27 ns	0.63 ns	1.79 ns	5.34*
Upland vs. Savannah Habitats					
Procyon lotor	1.53 ns	0.47 ns	0.83 ns	5.57**	8.44**
Didelphis virginiana	0.86 ns	3.07 ns	2.03 ns	0.68 ns	8.55**
Mephitis mephitis	0.58 ns	0.97 ns	0.65 ns	0.69 ns	11.7***
Bassariscus astutus	0.37 ns	1.46 ns	2.12 ns	0.04 ns	8.08**
Total Capture Mean	0.08 ns	1.13 ns	0.19 ns	0.79 ns	7.83**

Table 7. Medium-sized mammal species detected using live traps and spotlight surveys. Trp = live-trapping efforts, sptl = spotlight surveys. Species abbreviations are: Dv = Didelphis virginiana, *Pl* = Procyon lotor, *Mm* = Mephitis mephitis, *Ba* = Bassariscus astutus, *Sp* = Spilogale putorius, *Nf* = Neotoma floridana, *Sn* = Sciurus niger, *Sf* = Sylvilagus floridanus, *Fc* = Felis catus, *Uc* = Urocyon cinereoargenteus, *Cl* = Canis latrans, *Lr* = Lynx rufus, *Ov* = Odocoileus virginianus, *and Pc* = Puma concolor.

	Dv	Pl	Mm	Ba	Sp	Nf	Sn	Sf	Fc	Uc	Cl	Lr	Ov	Pc
Trp	X	X	X	X	X	X	X	X	X					
Sptl	X	X	X	X						X	X	X	X	X

Ringtails exploit a variety of habitats. They occur in broken, semi-arid regions characterized by mixed oak woodlands and also are known to inhabit montane conifer forests, chaparral, desert, and dry tropical habitats, provided there are rocky outcroppings, canyons, or talus slopes present (Poglayen-Neuwall and Toweill, 1988). In this study, all ringtail captures occurred in Sav 2, which is surprising because of the preferred habitats of these animals. Sav 2 is characterized by sparse juniper stands along with widespread rocky outcroppings. Ringtails were documented using scent-stations in other areas where live-trapping was conducted (Carroll, 1997). It is

Table 8. A comparison of relative abundances of medium-sized mammal species obtained from live-trapping and spotlight surveys. Analyses involve comparisons of live-trapping transects and spotlight surveys which were conducted over the same routes. Relative abundances were calculated by dividing the number of individuals of a species observed on spotlight surveys or trapped in live traps by the number of kilometers over which surveys or live-trapping were conducted. Relative abundances are expressed as the number of individuals of a species per kilometer. Species abbreviations are: Dv = Didelphis virginiana, *Pl* = Procyon lotor, *Mm* = Mephitis mephitis, *Ba* = Bassariscus astutus, *Sp* = Spilogale putorius, *Nf* = Neotoma floridana, *Sn* = Sciurus niger, *Sf* = Sylvilagus floridanus, *Uc* = Urocyon cinereoargenteus, *Cl* = Canis latrans, *and Lr* = Lynx rufus.

	Dv	Pl	Mm	Ba	Sp	Nf	Sn	Sf	Cl	Lr	Uc
Upl 2	0.03	0.14	0.22	----	---	0.03	---	0.03	---	---	---
Line 1	0.13	1.05	0.43	0.28	---	---	---	---	0.10	0.03	0.31
Rip 2	1.00	---	---	---	---	---	---	---	---	---	---
Line 1	0.08	0.21	0.13	0.08	---	---	---	---	---	---	0.05
Rip 1	0.17	0.42	0.03	---	---	0.17	---	0.03	---	---	---
Line 2	0.08	0.18	0.08	---	---	---	---	---	---	---	0.03
Sav 2	---	0.42	---	0.08	---	---	---	---	---	---	---
Line 3	0.08	0.15	0.10	0.08	---	---	---	---	---	---	0.18
Sav 1	0.10	0.10	0.10	---	---	0.05	---	---	---	---	---
Line 5	---	0.27	---	---	---	---	---	---	---	0.07	0.07

unclear why no ringtails were captured in presumably more suitable habitat.

Eastern woodrats were collected in all three major habitat types. All feral cats were collected in savannah habitats, while essentially all eastern spotted skunk captures were recorded in upland habitats.

Seasonal variations have been shown to influence trap success in many studies (Davis, 1977; Greenwood et al., 1985; Moore and Kennedy, 1985). Davis (1977) found capture mean in the fall was significantly lower than in the spring and summer, but the same as in winter. Mean capture rates in winter for this study were similar to mean capture rates in spring and summer. Moore and Kennedy (1985) indicated that, during the spring and summer months, when food was readily available, trap success for raccoons was low. When food is still available during the autumn, raccoons were gaining weight and apparently feeding more in preparation for winter, and winter rates are usually high because of lack of food. In this study, no differences in overall capture rates were detected among seasons. Because of mild winters in this region of Texas, food availability may not vary greatly by season, which could explain why capture success did not vary seasonally during this survey.

No significant difference in overall capture mean was detected between medium and large traps for all species analyzed with the exception of raccoons. Raccoon capture means varied significantly among trap sizes in all but one comparison (Upl 1 vs. Upl 2). Twenty of 31 raccoon captures (64.5%) were recorded in large traps with no raccoon captures in small traps. Mean capture rates for raccoons and opossums varied significantly between large and small traps but not between medium and small traps. No species were captured in only large traps. Because no significant difference was detected between overall capture means of large and medium traps, the latter would be preferable for medium-sized mammal surveys because they are less expensive and easier to carry into the field. The lower capture rates of small traps were probably due to the physical dimensions of the traps and animals. Although small traps recorded the lowest number of captures, they were the only size of trap which captured eastern spotted skunks.

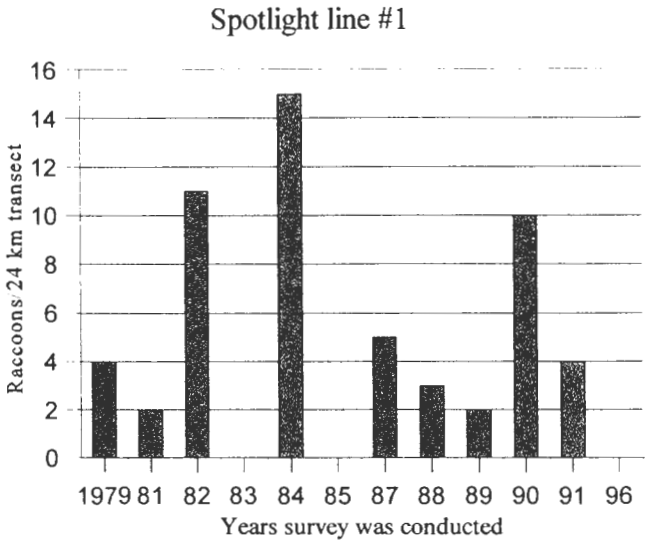

Fig. 12. Number of raccoons documented for each year spotlight surveys were conducted on line #1. No surveys were conducted in 1980, 1986, 1992, 1993, 1994, and 1995.

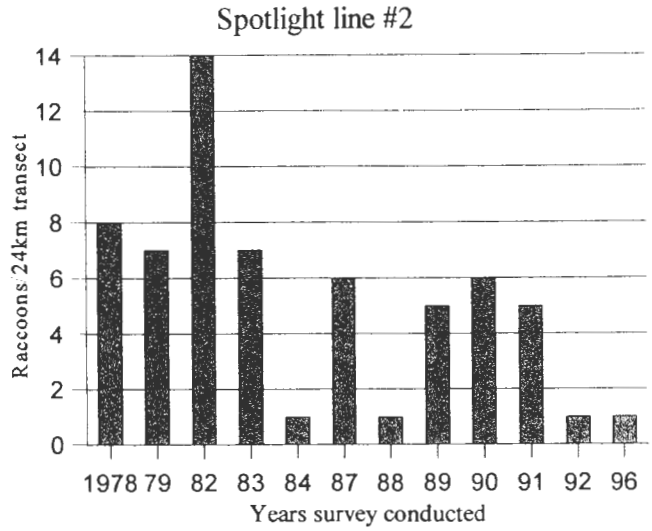

Fig. 13. Number of raccoons documented for each year spotlight surveys were conducted on line #2. No surveys were conducted in 1980, 1981, 1985, 1986, 1993, 1994, and 1995.

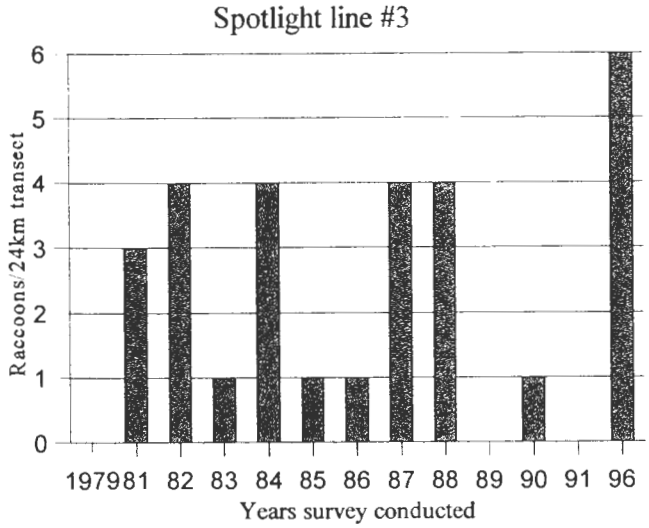

Fig. 14. Number of raccoons documented for each year spotlight surveys were conducted on line #3. No surveys were conducted in 1980, 1992, 1993, 1994, and 1995.

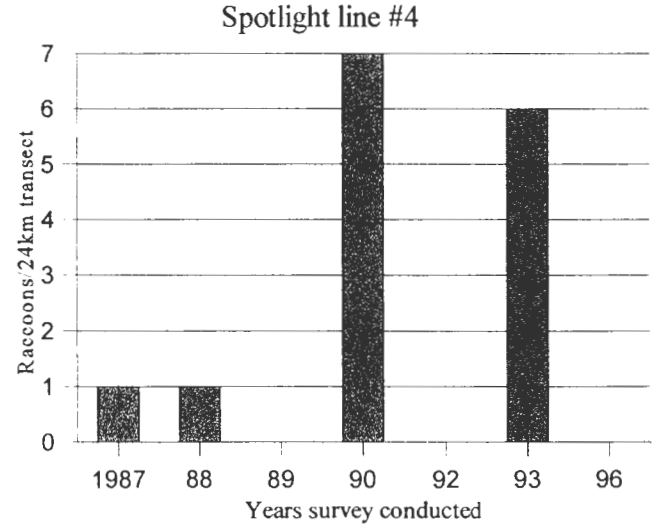

Fig. 15. Number of raccoons documented for each year spotlight surveys were conducted on line #4. No surveys were conducted in 1991, 1994, and 1995.

Of 30 medium-sized mammal species whose range is known to include Fort Hood (Davis and Schmidly, 1994), nine were detected using live traps as well as nine detected via spotlight surveys. No coyotes, gray foxes, bobcats (*Lynx rufus*), or mountain lions (*Puma concolor*) were captured using live traps, but these species were recorded on spotlight surveys. Although spotlight surveys proved more effective in detecting larger medium-sized mammal species, they are limited when used for detecting diurnal species or for smaller species during seasons when vegetation is obstructive. Spotlight surveys have primarily been used in gathering data for white-tailed deer studies (Progulske and Duerre, 1964; McCullough, 1982; Farfarman and DeYoung, 1986), but

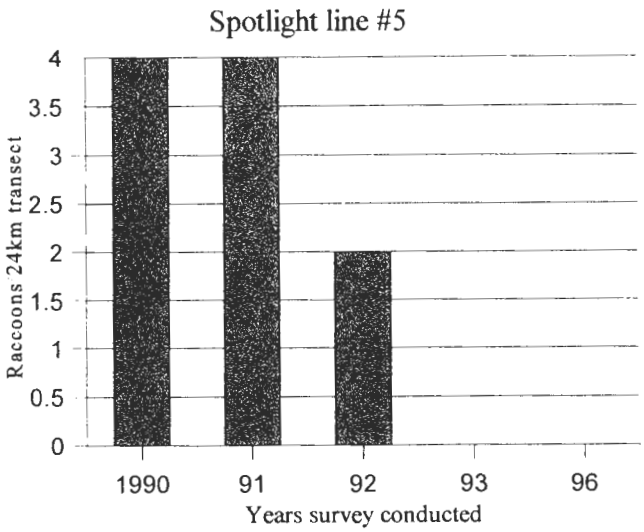

Fig. 16. Number of raccoons documented for each year spotlight surveys were conducted on line #5. No surveys were conducted in 1994 and 1995.

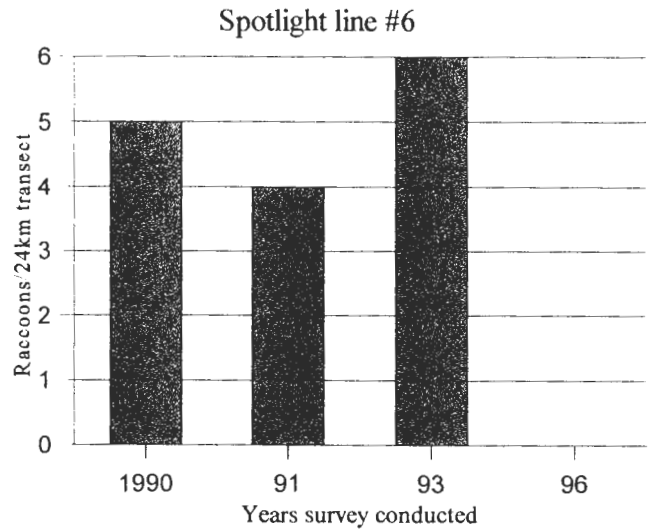

Fig. 17. Number of raccoons documented for each year spotlight surveys were conducted on line #6. No surveys were conducted in 1992, 1994, and 1995.

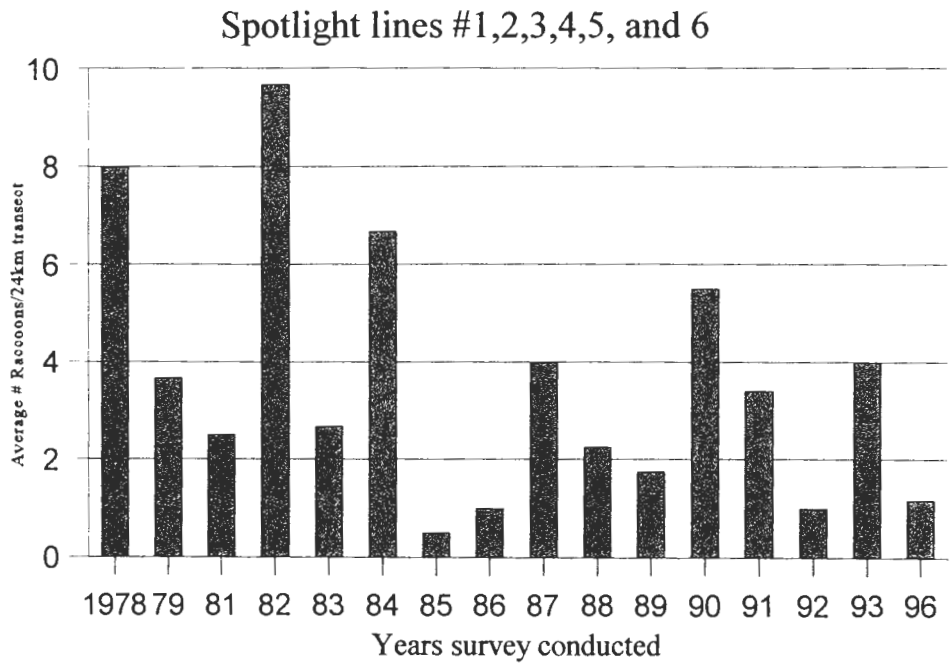

Fig. 18. Average number of raccoons documented for each year spotlight surveys were conducted on line #1, 2 ,3, 4, 5, and 6. No surveys were conducted in 1980, 1994, and 1995.

have also proven useful for some smaller mammal species such as brown hares (*Lepus capensis*) (Barnes and Tapper, 1985). In areas where spotlight survey routes overlapped with trapping transects, spotlight surveys suggested higher relative abundances (of four species detected by both methods: opossums, raccoons, striped skunks, and ringtails) in nine of the comparisons (Table 8). Live-trapping data also showed higher relative abun-

dances in nine of the comparisons between the two methods.

No red foxes (*Vulpes vulpes*) were documented using live-trapping or spotlight counts. However, a road-kill specimen was collected on Fort Hood. Furthermore, scent-station surveys at Fort Hood verified the presence of red fox in areas where live-trapping was conducted (Carroll, 1997). Both gray fox and coyotes were seen on spotlight survey routes. Although red fox are present on Fort Hood, they appear to be less abundant than other canids such as the coyote and gray fox.

No black-tailed jackrabbits (*Lepus californicus*) were captured during the survey or documented on the spotlight surveys. They were, however, detected using scent-stations (Carroll, 1997) and were seen in areas where both spotlight surveys and live-trapping were conducted. One possible reason no jackrabbits or other leporids were seen on spotlight surveys is that tall grass or other obstructive vegetation could have impeded the observer's abilities to see them. Because cat food was used as bait, it is not surprising that no jackrabbits were captured in live traps. Although cottontails were captured using live traps, only three were captured over an 18-month period. Early morning road-cruise game censuses on Fort Hood have resulted in observations of 0.25 cottontails/km in 1977, 0.66/km in 1976, and 0.76/km in 1975. Night time road-cruise censuses in 1977 indicated 0.02/km. Numbers of black-tailed jackrabbits seen by Fort Hood Fish and Wildlife Section biologists during game censuses were 0.42/km in 1975, 0.40/km in 1976, and 0.28/km in 1977. During the 1977 night census study, 0.11 jackrabbits/km were observed (Miller-Talley and Associates and Espey Huston and Associates, Inc, 1978).

CONCLUSIONS

Savannah and upland habitats support the greatest diversity of medium-sized mammal species at Fort Hood. Seven species of medium-sized mammals were documented in each of these habitats whereas five medium-sized mammal species were captured in riparian areas. Military training appeared to have a negative affect on species diversity in that low use sites supported a greater number of medium-sized mammal species (nine) than did the high military use areas (seven species). Heavy military training in an area also had a negative effect on relative abundance of species present. High use sites had significantly lower relative abundances of medium-sized mammals for all species except striped skunks, which appeared to be unaffected by military training.

In order for Fort Hood's mammalian fauna to remain intact, it is important to continue to monitor land management, not only in areas with high military disturbance but also in the low use sites. High use sites are of particular concern because of the trend towards reduced species diversity, as well as overall species abundance documented in these areas. Low military use areas should continue to remain as free of tracked vehicle disturbance as possible to safeguard against further habitat reduction. Further monitoring of Fort Hood's mammalian fauna could give a clearer picture of the total impact of military training on species present and could also aid in studies of non-mammalian vertebrates.

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It was through the efforts of Horn Professor J Knox Jones, as director of Academic Publications, that Texas Tech University initiated several publications series including the Occasional Papers of the Museum. This and future editions in the series are a memorial to his dedication to excellence in academic publications. Professor Jones enjoyed editing scientific publications and served the scientific community as an editor for the Journal of Mammalogy, Evolution, The Texas Journal of Science, Occasional Papers of the Museum, and Special Publications of the Museum. It is with special fondness that we remember Dr. J Knox Jones.

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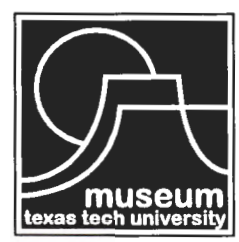

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