Human–Wildlife Conflicts 1(2):152–160, Fall 2007

Demographic and spatial characteristics of feral hogs in the Chihuahuan Desert, Texas

Roger N. Adkins,[1] Department of Natural Resource Management, Sul Ross State University, Alpine, TX 79832, USA *Adkins@valornet.com*

Louis A. Harveson, Department of Natural Resource Management, Sul Ross State University, Alpine, TX 79832, USA

Abstract:
Feral hogs (*Sus scrofa*) have recently expanded their range to include portions of the arid regions of the Chihuahuan Desert, Texas. We examined feral hog density, survival rates, range size, and habitat use in the Davis Mountains, Texas, to understand hog ecology in a desert environment. We tested the hypothesis that densities of feral hogs across Texas would be positively related to precipitation. Feral hog densities in the Chihuahuan Desert were low (0.65 individuals/km^2), supporting our prediction. Annual home range sizes (100% minimum convex polygon) were also high and averaged 48.3 ± 4.4 km^2 and 34.0 ± 4.4 km^2 for males and females, respectively. Feral hogs exhibited a generalized use of habitats but preferred open-canopy, evergreen woodland. Annual survival rates for feral hogs were 0.86 (95% CI = 0.68-1.00). In the Chihuahuan Desert, feral hogs occurred in lower densities and had larger ranges than in more mesic environments. Efforts to control feral hogs in the Chihuahuan Desert should be concentrated on open-canopy, evergreen woodlands and sources of free-standing water.

Key words: Chihuahuan Desert, demography, density, feral hog, habitat use, home range, human–wildlife conflicts, survival, *Sus scrofa*, Texas

Feral hogs (*Sus scrofa*) inhabit much of the eastern United States and occur westward along the Gulf Coast to Texas (Mayer and Brisbin 1991; Engeman et al. 2007*a*, 2007*b*; Hartin et al. 2007; Kaller et al. 2007). Feral hogs use a variety of habitats varying from southern Appalachian mixed deciduous forests and old-growth pinelands (Singer et al. 1981), to Mediterranean oak woodlands of Santa Catalina Island (Baber and Coblentz 1986), to the salt and brackish marshes of coastal South Carolina (Wood and Roark 1980). In Texas, feral hogs have been recorded in 8 of the state's 10 ecological regions (Taylor 1993). They have been documented using reclaimed mining areas in the Post Oak Savannah vegetation region (Mersinger and Silvy 2007), to the Coastal Prairie of southern Texas dominated by mixed honey mesquite (*Prosopis glandulosa)* and live oak (*Quercus virginiana*; Ilse and Hellgren 1995), and the chaparral communities of western Rio Grande plains (Gabor et al. 1999).

Densities of feral hogs vary widely across North America. Mesic climates produce more resources and have higher feral hog densities than do xeric climates. This trend is noticeable in Texas where densities of feral hogs are highest in the pineywoods and coastal prairies with 9.5 individuals/km^2 (Ilse and Hellgren 1995). Annual precipitation in this area is 89–101 cm. However, density of feral hogs decreased to 4.9 individuals/km^2 in the central Rio Grande plains (Harveson et al. 2000) where annual precipitation is 70 cm, and 2.7–3.2 individuals/km^2 in the western Rio Grande plains (Gabor et al. 1999) where annual precipitation is 58 cm.

Although feral hogs have occurred in western Texas since the early 1990s (L. Harveson, unpublished data), resource managers have only recently taken interest in the ecology of hogs and their impact on natural ecosystems as their distribution and abundance appear to be increasing in the Trans-Pecos region of Texas (Texas Cooperative Extension, unpublished report). Because of the dry conditions throughout the Chihuahuan Desert, feral hogs are thought to be limited to riparian habitats (R. Skiles, Big Bend National Park, personal communication). However, no ecological studies have been conducted on feral hogs in desert environments. Therefore, we initiated a study to document the demographic (density, survival, and herd composition) and spatial characteristics (range and habitat use) of feral hogs in the Chihuahuan Desert, Texas. We tested the hypothesis that feral hog densities

[1]Current address: Wildlife Division, Texas Parks and Wildlife, P. O. Box 1874, Dumas, TX 79029, USA

will be positively related to precipitation in Texas. More specifically, we predict that densities of feral hogs in the Trans-Pecos will follow a general linear trend (i.e., that they will be lower than densities reported in other portions of the state).

Study area

The study areas were located 39.3 km north of Fort Davis in the Davis Mountains, Jeff Davis County, Texas. The study area consisted of 2 localities, the Davis Mountains Preserve (7,287 ha) and the Sawtooth Mountain Ranch (3,238 ha). Elevations of the study area ranged from 1,254 to 2,225 m. Lowlands and basins surrounding the Davis Mountains receive 20–30 cm of precipitation, while higher elevations receive 30–46 cm of precipitation annually. Soils on the study area are predominantly igneous, well-drained, shallow to deep, loamy, and noncalcareous (U.S. Soil Conservation Service 1977). Dominant overstory species on the study area consisted of pinyon pine (*Pinus edulis)*, red berry juniper (*Juniperus pinchotii)*, ponderosa pine (*Pinus ponderosa*), and mixed oaks (*Quercus* spp.). Shrub species common on the study area were Gregg's catclaw (*Acacia greggii)*, javelina bush (*Condalia ericoides*), cane cholla (*Opuntia imbricatar*), and soap tree yucca (*Yucca elata*). Grasses of the study area consisted of 3 major genera: *Bouteloua*, *Muhlenbergia*, and *Andropogon*.

Methods

Feral hogs were trapped periodically from November 2002 to April 2003 using approximately 1- x 1- x 2-m box traps with rooter style gates. Traps were constructed from 1.6-cm angle iron and 10.2-cm grid cattle panels. Trapping and handling procedures were approved by Sul Ross State University Animal Use and Care Committee and Texas Parks and Wildlife Department permit SPR-0592-525. Each trap was placed in an area of localized hog signs and pre-baited for several days with soured corn and carrion. Traps were checked every 24 hours. Captured feral hogs were sedated with a combination of telazol and xylazine at 4.4 mg/kg of estimated body weight delivered by a jab stick (Gabor et al. 1997). Sedated feral hogs were aged according to Matschke (1967), ear-tagged, and fitted with a mortality-sensitive radio collar (Advanced Telemetry Systems, Inc., Isanti, Minn.). Juveniles were defined as feral hogs that were born within the past year (young of the year). Efforts were made to radio-collar only 1 hog/sounder.

Destructive rooting behavior of feral hogs is evident in this picture taken in western Texas.

Western Texas landscape.

Radio-monitored feral hogs were relocated weekly during aerial telemetry flights (Mech 1983), and their locations were recorded. Annual survival rates (with 95% confidence intervals) were estimated using a staggered entry design (Kaplan and Meier 1958, Krebs 1999). Densities of feral hogs were estimated according to Ilse and Hellgren (1995) based on the number of individuals captured/total area. Average group size was determined from field observations. Sex and age (juvenile:adult) composition of the population were extrapolated from data collected from trapped and shot individuals (Adkins 2005).

Annual ranges were calculated using Calhome (Kie et al. 1994) to define 100% and 95% minimum convex polygons (MCP; Mohr 1947) and 95% and 50% adaptive kernel estimators (ADK; Worton 1989). Animals with <25 locations were excluded from analysis. Output files generated from Calhome were imported into ArcGIS®8.x (ESRI, Redlands, Calif., USA) for further analysis.

Habitat delineation was performed by remote sensing. Using ERDAS IMAGINE®8.x (Leica Geosystems GIS and Mapping Company, Atlanta, Ga.) a 1° x 1° block of satellite imagery (Landsat image 31_39_093099) was clipped to the desired area of coverage (344.46 km^2). A resolution merge was performed to sharpen resolution to <30 m (Pouncey et al. 1999). Using ERDAS, an unsupervised classification was performed on the new image to produce 8 separate habitat classes using an ISODATA algorithm at a maximum of 6 iterations with a convergence threshold of 0.95. In each habitat class, we randomly selected 5 ground points to qualify vegetation. This resulted in the merging of like classes, producing 6 separate habitat classes. Because riparian habitats did not emerge from this classification, digitized hydrology files were buffered at 30 m from the midpoint of the drainages to represent riparian habitats and added to the imagery using ArcGIS®8.x (Ormsby et al. 2001).

Habitat selection was assessed at 2 scales: second- and third-order selection (Thomas and Taylor 1990). Available habitat was extracted using ArcGIS®8.x by digitizing the 100% MCP of all locations and individual locations (second and third orders, respectively) and converting each shapefile to raster. We then used zonal statistics to determine availability of habitat classes within the annual range polygon of each individual feral hog and within the composite range of all feral hogs. Second-order habitat use was determined by extracting a raster value (habitat class) for every telemetry location for all radioed feral hogs (e.g., point to study area). For third-order habitat use, we extracted raster values according to each individual location within its given 100% MCP home range (e.g., point to range). We determined feral hog use versus availability of habitats using Bailey's 95% confidence intervals (Bailey 1980; Cherry 1996, 1998). Habitat use was interpreted as follows: habitats were selected if feral hogs used them in greater proportion than available; habitats were avoided if their availability was greater than that used by feral hogs; and habitats were neither selected nor avoided if feral hogs used habitats in proportion to availability.

Roger "Bo" Adkins prepares to sedate a captured feral hog before radio-tagging it.

Results

Sixty-eight feral hogs were captured during >1,000 trap nights (< 0.07 captures/trap-night). Of the 68 feral hogs captured, 18 were radio-tagged (10 males and 8 females), 41 were euthanized for dietary analysis (Adkins and Harveson 2006), and 9 were released. The sex ratio (male:female) of captured individuals was 1:1.2, and 53% were adult. Based on field observations, group size ranged from 2 to 12 individual feral hogs and averaged 6 (SE = 1.4). Three of 18 radio-tagged feral hogs died as a result of hunting and control efforts during our study; 1 feral hog was omitted from analysis because of radio failure. Annual survival for feral hogs was 0.86 (95% CI = 0.68-1.00). Feral hog density was estimated at 0.65 feral hogs/km^2.

Feral hogs were radio-located 420 times from March 2003 to January 2004. Thirteen feral hogs (7 males and 6 females) had an adequate number of locations (≥25) for range analysis (Table 1). Average range size for males was generally larger than that of female feral hogs. Using 100% MCP, range overlap within sexes occurred at higher levels than range overlap between females and males. Male ranges were more exclusive than those of females (Figure 1).

Seven habitat types were delineated using remote sensing: open-canopy evergreen woodland, closed-canopy evergreen woodland, evergreen savannah grassland, open-mixed grassland, mixed-evergreen deciduous savannah, grassland, and riparian (Table 2). Based on our habitat delineation, open-canopy evergreen woodland was the most abundant habitat (110.9 km^2) and riparian was the least abundant habitat (10.4 km^2).

Feral hogs were located in all habitat classes that were delineated. Second-order analysis (i.e., population) indicated that feral hogs avoided evergreen savannah grassland, open-mixed grassland, mixed-evergreen deciduous savannah, and grasslands. They preferred open-canopy evergreen woodland and used closed-canopy evergreen woodland and riparian habitats in proportion to availability (Table 3). Similar trends in habitat use were identified using third-order analysis (i.e., individual use). Open mixed grassland was avoided by 10 feral hogs and used by 3 feral hogs in proportion to availability. Mixed-evergreen, deciduous savannah was avoided by 8 hogs and was used proportionately by another 5 hogs. Grasslands were avoided by 11 of 13 radio-tagged feral hogs. Feral hogs either avoided (n = 7) or used riparian habitats proportionately (n = 6). Both closed-canopy, evergreen woodlands, and evergreen savannah grasslands were used in proportion to availability by most feral hogs (n = 9). Ten of the 13 radio-tagged hogs also used open canopy, evergreen woodland in proportion to availability. Few of the radio-tagged feral hogs showed preference for the following habitats: closed canopy, ever-green woodland (n = 3), evergreen savannah grasslands (n = 2), and grasslands (n = 1).

Table 1. Mean (±SE) annual ranges (km^2) for adult feral hogs in the Chihuahuan Desert, Texas, 2003–2004.

Sex		ADK[a]		MCP[b]	
ID	n	95%	50%	100%	95%
Females	6	43.35 ± 5.92	10.29 ± .86	34.04 ± 4.41	28.27 ± 3.30
Males	7	58.69 ± 6.41	10.18 ± 1.38	48.34 ± 7.54	35.01 ± 4.53

[a]ADK= adaptive kernel estimator
[b]MCP= minimum convex polygon

Table 2. Availability of habitats (km^2) delineated in the study area in the Chihuahuan Desert, Texas, 2003–2004.

Habitat	Dominant overstory	Dominant understory	Total area (km^2)	Percentage of total area
Open canopy evergreen woodland	*Pinus edulis, Juniperus pinchotii, Quercus* spp.	*Mulhenbergia* spp., *Bouteloua* spp.	15.7	4.6
Closed canopy evergreen woodland	*Pinus edulis, Juniperus pinchotii, Quercus* spp., *Pinus ponderosa*	*Mulhenbergia* spp., *Andropogon* spp.	110.9	32.2
Evergreen savannah grassland	*Juniperus pinchotii, Pinus edulis, Acacia greggii*	*Bouteloua* spp., *Mulhenbergia* spp.	109.5	31. 8
Open mixed grassland	*Juniperus pinchotii, Pinus edulis*	*Bouteloua* spp., *Mulhenbergia* spp.	24.7	7.1
Mixed evergreen deciduous savannah	*Juniperus pinchotii, Pinus edulis, Quercus* spp., *Opuntia spinosior*	*Bouteloua* spp., *Mulhenbergia* spp.	53.0	15.4
Grassland	*Opuntia spinosior, Opuntia* spp., *Yucca elata*	*Bouteloua* spp., *Andropogon* spp.	20.3	5.9

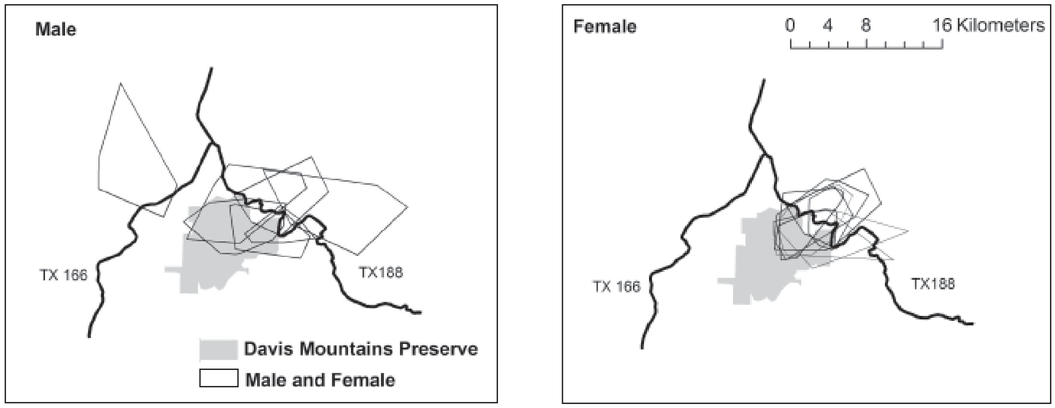

Figure 1. Annual ranges (100% MCP) of male and female feral hogs in the Chihuahuan Desert, Texas, 2003–2004.

Discussion

In western Texas, where precipitation was 17.5 cm, densities of feral hogs were low (0.65 individuals/km^2). This finding supported our prediction that densities of feral hogs across Texas increase with increased precipitation (Figure 2). Although more data are needed to support the precipitation–feral hog density model, it may prove useful for resource managers in predicting feral hog abundance throughout their range.

Although feral hogs occurred at relatively low densities in the Chihuahuan Desert, there is still concern over their potential damage to natural resources. Feral hog damage may be direct or indirect and includes: loss of soil cover, reduction in soil stability, influence on vegetation succession, predation of terrestrial fauna, interspecific competition for resources, and habitat disturbance (Engeman et al. 2007*a*, 2007*b*; Kaller et al. 2007; Rollins et al. 2007). In their review, Pimentel et al. (2000) conservatively estimated that feral hogs cause >$800 million in damage annually in the United States. In Texas, estimates of hog damage to landowners averaged over $7,000 in 2004 (Rollins et al. 2007). Damage in desert habitat may not reach the levels experienced in other parts of the country where feral hog densities are higher. However, in Texas the limited amount of free water may concentrate feral hogs around perennial water sources (tinajas, springs, seeps, and riparian habitats). Riparian habitats and other water sources are thought to contain some of the highest levels of biodiversity in the region (Ohmart and Anderson 1986, Mersinger and Silvy 2007). The adaptability and mobility of feral hogs has allowed populations to establish themselves in the Chihuahuan Desert and utilize limited resources in areas that are ecologically

Table 3. Occurrence of feral hogs in different habitat types compared with habitat availability and second order selection in the Chihuahuan Desert, Texas, 2003–2004.

Habitat [a]	Proportion of total area	Proportion of total observations	95% confidence intervals	Selection [b]
CCEW	0.05	0.06	0.03–0.09	=
OCEW	0.32	0.62	0.56–0.67	+
ESG	0.32	0.26	0.21–0.31	-
OMG	0.07	0.01	0.00–0.03	-
MEDS	0.15	0.02	0.01–0.04	-
G	0.06	0.01	0.00–0.02	-
R	0.03	0.02	0.01–0.04	=

[a] CCEW = closed canopy, evergreen woodland, OCEW = open canopy, evergreen woodland, ESG = evergreen savannah grassland, OMG = open mixed grassland, MEDS = mixed evergreen, deciduous savannahs, G = grassland, R = riparian.
[b] Habitat selection based on Bailey's confidence intervals where =, +, and − represent use in proportion to availability, preference, and avoidance, respectively.

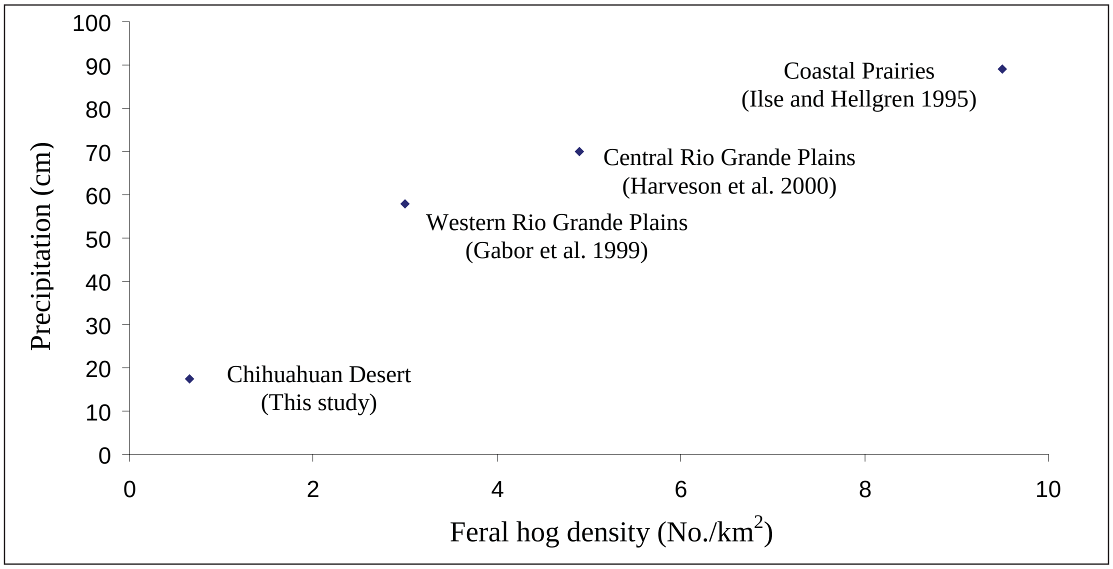

Figure 2. Relationship between precipitation and feral hog densities across the ecoregions of Texas.

sensitive (e.g., rare riparian habitats).

Feral hogs in the Chihuahuan Desert also had uncharacteristically large range sizes compared to what is described in other published literature: 95% MCP 3.36 km^2 (Ilse and Hellgren 1995); 95% ADK 5.95 km^2 (Gabor et al. 1999). Like density, range size may be a function of precipitation; lower average rainfall may result in greater need for feral hogs to travel to obtain sustaining resources in the Chihuahuan Desert. Male home ranges were larger than those of females following a common trend found in several home range studies of feral hogs (Kurz and Marchinton 1972, Baber and Coblentz 1986).

Most studies have supported the notion that feral hogs are habitat generalists and use habitats based on availability (Ilse and Hellgern 1995, Gabor et al. 2001). In our study we evaluated feral hog use of habitats at 2 spatial scales that produce contradictory results. As a population (second order analysis), feral hogs preferred 1, avoided 4, and used 2 habitats in proportion to availability. Selection of open-canopy, evergreen woodland by feral hogs may be attributed to the structural components, such as light infiltration, vertical cover, vegetation present, and thermoregulation. Feral hogs were shown to be primarily grazers and rooters (Adkins and Harveson 2006), and the open-canopy, evergreen woodland likely provided adequate forage while maintaining adequate screening cover. On an individual basis (third order analysis), feral hogs exhibited more of a generalist behavior. They showed little preference for any specific habitats and either used habitats proportionally or avoided most delineated habitats. The results from this level of analysis are more consistent with methods used by and subsequent results of previous researchers. For example, Gabor et al. (2001) reported feral hogs used vegetation types in proportion to availability in southern Texas, and Ilse and Hellgren (1995) described feral hogs using most habitats in proportion to availability and only selecting for mesquite, bunch-grass habitat. Feral hogs in the Chihuahuan Desert may be more selective during drier times and use riparian areas more, as suggested by Ilse and Hellgren (1995).

Few studies have provided empirical data on the structure of feral hog populations. Gabor et al. (1999) reported a sex ratio (male:female) of 1.0:0.59 in southern Texas, and Ilse and Hellgren (1995) reported a sex ratio of 1.0:1.29. In our study, the sex ratio of feral hogs approached equality (1:1.2). Sex ratios were based on trapped feral hogs (harvested and radio-tagged samples) and may be skewed from sex-biased trapping (e.g., males excluding females from bait). However, based on visual observations, it appears the reported sex ratio adequately represented the population of feral hogs in the Chihuahuan Desert.

Many people consider feral hogs to be pests (Rollins et al. 2007). Feral hogs may be capable of having 2 litters/year (Ilse and Hellgren 1995, Taylor et al. 1998). Their reproductive output is likely highest when density independent factors (e.g., weather) are favorable. During our study, precipitation levels were 3% above average (10-year mean), providing favorable conditions for feral hog reproduction. Our reported age ratios (juvenile:adult) were approximately equal (1:1.1), indicating a slow growing population. Ilse and Hellgren (1995) reported an age ratio of 1:3 in the Coastal Prairies of Texas, whereas Gabor et al. (1999) reported an age ratio of 1:0.3 in the Rio Grande Plains of Texas. In our study, average group size (6 ± 1.4) was similar to that reported by Ilse and Hellgren (1995; 5.3 ± 0.04). Trap-biases may also influence age ratios because of social dominance of adults over juveniles. Additionally, the small number of juveniles in our trapped sample may be a result of high mortality of young feral hogs. Harveson et al. (2000) noted that mountain lions (*Puma concolor*) were more likely to kill and consume juvenile, rather than adult, feral hogs.

Few studies have documented survival rates or cause-specific mortality rates for feral hogs. We found annual survival rates were higher (86%) for feral hogs in the Chihuahuan Desert than the 56% survival rate in southern Texas (Gabor et al. 1999), where hunting pressure was higher. Areas with significantly higher hunting and trapping pressures may result in lower survival rates. The high survival rates at our study site indicate that more pressure would need to be applied through hunting and trapping to affect local populations (survival and densities).

Because of the unique ecology of feral hogs, their management in the Chihuahuan Desert will prove to be difficult. First, low densities make control techniques less effective and more costly. Second, high mobility and large home ranges of feral hogs make it very difficult and time consuming to encounter them. Third, their generalist behavior also makes it difficult to locate the animals. Collectively, these demographic and spatial attributes will make the control of feral hogs challenging in the Chihuahuan Desert.

To maximize control efforts, resource managers in the Chihuahuan Desert would be best served by placing rooter gate style traps in open canopy, evergreen woodlands that are in close proximity to water or riparian areas during the dry season. Concentrating on these areas should increase trap success and reduce man-hours and trap nights required to capture feral hogs. Additionally, the large ranges of feral hogs suggest that resource managers of large areas of land will need to work in unison to manage feral hogs (Hartin et al. 2007). Feral hogs will continue to be a concern for resource managers in the Chihuahuan Desert of western Texas until a proactive approach to feral hog management and control is adopted.

Acknowledgments

We thank The Nature Conservancy of Texas for access to the Davis Mountain Preserve and for logistical support. We also thank M. Leonard for access to her properties and for her monetary contribution. Many thanks to the students and staff of St. Stephen's school and Sul Ross State University for their assistance with this project. R. J. Kinucan, B. J. Warnock, E. C. Hellgren, L. M. Ilse, and T. M. Gabor reviewed and improved earlier drafts of this manuscript.

Literature cited

Adkins, R. N. 2005. Food habits, demography, and spatial characteristics of a feral hog (*Sus scrofa*) population in the Davis Mountains, Jeff Davis County, Texas. Thesis, Sul Ross State University, Alpine, Texas, USA.

Adkins, R. N., and L. A. Harveson. 2006. Summer diet of feral hogs in the Davis Mountains, Texas. Southwestern Naturalist 51:578–580.

Baber, D. W., and B. E. Coblentz. 1986. Density, home range, habitat use, and reproduction in feral pigs on Santa Catalina Island. Journal of Mammalogy 67:512–525.

Bailey, B. J. 1980. Large sample simultaneous confidence intervals for the multinomial probabilities based on transformations of the cell frequencies. Technometrics 22:583–589.

Cherry, S. 1996. A comparison of confidence interval methods for habitat use-availability studies. Journal of Wildlife Management 60:653–658.

Cherry, S. 1998. Statistical tests in publications of The Wildlife Society. Wildlife Society Bulletin 26:947–953.

Engeman, R. M, B. U. Constantin, S. A. Shwiff, H. T. Smith, J. Woolard, J. Allen, and J. Dunlap. 2007*a*. Adaptive and economic management methods for feral hog control in Florida. Human–Wildlife Conflicts 1:178–185.

Engeman, R. M., J. Woolard, H. T. Smith, J. Bourassa, B. U. Constantin, and D. Griffin. 2007*b*. An extraordinary patch of feral swine damage in Florida before and after initiating hog removal. Human–Wildlife Conflicts 1:271–275.

Gabor, T. M., E. C. Hellgren, and N. J. Silvy. 1997. Immobilization of collared peccaries (*Tayassu tajacu*) and feral hogs (*Sus scrofa*) with Telazol® and xylazine. Journal of Wildlife Disease 33:161–164.

Gabor, T. M., E. C. Hellgren, and N. J. Silvy. 2001. Multi-scale habitat partitioning in sympatric suiforms. Journal of Wildlife Management 65:99–110.

Gabor, T. M., E. C. Hellgren, R. A. Van Den Bussche, and N. J. Silvy. 1999. Demography, sociospatial behavior and genetics of feral pigs (*Sus scrofa)* in a semi-arid environment. Journal of Zoology, London, 247:311–322.

Hartin, R. E., M. R. Ryan, and T. A. Campbell. 2007. Distribution and disease prevalence of feral hogs in Missouri. Human–Wildlife Conflicts 1:186–191.

Harveson, L. A., M. E. Tewes, N. J. Silvy, J. D. Hillje, and J. Rutledge. 2000. Prey use by mountain lions in southern Texas. Southwestern Naturalist 45:472–476.

Ilse, L. M., and E. C. Hellgren. 1995. Resource partitioning in sympatric populations of collared peccaries and feral hogs in southern Texas. Journal of Mammalogy 76:784–789.

Kaller, M. D., J. D. Hudson III, E. C. Archberger, and W. E. Kelso. 2007. Feral hog research in western Louisiana: expanding populations and unforeseen consequences. Human–Wildlife Conflicts 1:168–177.

Kaplan, E. L., and P. Meier. 1958. Nonparametric estimation from incomplete observations. Journal of American Statisticians Association 53:457–481.

Kie, J. G., J. A. Baldwin, and C. J. Evans. 1994. Calhome: home range analysis program, electronic user's guide. U.S. Forest Service. Fresno, California, USA.

Krebs, C. J. 1999. Ecological methodology. Benjamin-Cummings, Menlo Park, California, USA.

Kurz, J. C., and R. L. Marchinton. 1972. Radiotelemetry studies of feral fogs in South Carolina. Journal of Wildlife Management 36:1240–1248.

Matschke, G. H. 1967. Aging European wild hogs by dentition. Journal of Wildlife Management 31:109–113.

Mayer, J. J., and I. L. Brisbin. 1991. Wild pigs in the United States: their life history, morphology and current status. University of Georgia Press. Athens, Georgia, USA.

Mech, L. D. 1983. Handbook of animal radio-tracking. University of Minnesota Press, Minneapolis, Minnesota, USA.

Mersinger, R. C., and N. J. Silvy. 2007. Range size, habitat use, and dial activity of feral hogs on reclaimed surface-mined lands in east Texas. Human–Wildlife Conflicts 1:161–177.

Mohr, C. O. 1947. Table of equivalent populations of North American small mammals. American Midland Naturalist 37:223–249.

Ohmart, R. D., and B. W. Anderson. 1986. Riparian habitat. Pages 169–196 *in* A. Y. Cooperrider, R. J. Boyd, and H. R. Stuart, editors. Inventory and monitoring of wildlife habitats. U.S. Department of Interior, Bureau of Land Management. Denver, Colorado, USA.

Ormsby, T., E. Napoleon, R. Burke, C. Groessl, and L. Feaster. 2001. Getting to know ArcGIS® desktop. ESRI, Redlands, California, USA.

Pimentel, D., L. Lach, R. Zuniga, and D. Morrison. 2000. Environmental and economic costs of nonindigenous species in the United States. Bioscience 50:53–65.

Pouncey, R., K. Swanson, and K. Hart. 1999. ERDAS field guide. Fifth edition. ERDAS®, Inc. Atlanta, Georgia, USA.

Rollins, D., B. J. Higginbotham, K. A. Cearley, and R. N. Wilkins. 2007. Appreciating feral hogs: extension education for diverse stakeholders in Texas. Human–Wildlife Conflicts 1:192–198.

Singer, F. J., D. K. Otto, A. R. Tipton, and C. P. Hable. 1981. Home ranges, movements, and habitat use of the European wild boar in Tennessee. Journal of Wildlife Management 45:343–353.

Taylor, R. 1993. History and distribution of feral hogs in Texas. Conference proceedings of feral swine: compendium for resource managers. Texas Cooperative Extension, College Station, Texas, USA.

Taylor, R. B., E. C. Hellgren , T. M. Gabor, and L. M. Ilse. 1998. Reproduction of feral pigs in southern Texas. Journal of Mammalogy 79:1325–1331.

Thomas, D. L., and E. J. Taylor. 1990. Study designs and tests for comparing resource use and availability. Journal of Wildlife Management 54:322–330.

U.S. Soil Conservation Service. 1977. Soil survey of Jeff Davis County, Texas. U.S. Government

Printing Office, Washington, D.C., USA.

Wood, G. W., and D. N. Roark. 1980. Food habits of feral hogs in coastal South Carolina. Journal of Wildlife Management 44:506–511.

Worton, B. J. 1989. Kernel methods for estimating the utilization distribution in home-range studies. Ecology 70:164–168.

Roger ("Bo") N. Adkins (photo) received his B.S. degree in biology from Greensboro College in North Carolina and his M.S. degree in range and wildlife management from Sul Ross State University. Currently, he works for Texas Parks and Wildlife Department in Dumas, Texas, as a regulatory wildlife biologist. His primary responsibilities include pronghorn surveys and assisting landowners in their management of wildlife resources in the Panhandle of Texas.

Louis A. Harveson is an associate professor of wildlife management and chair of the Department of Natural Resource Management at Sul Ross State University. He received a B.S. degree in wildlife management from Texas Tech University, an M.S. degree in range and wildlife management from Texas A&M University—Kingsville, and a Ph.D. degree in wildlife science from the joint Ph.D. program at Texas A&M University—Kingsville and Texas A&M University. His research program has focused on the ecology and management of large mammals and upland game birds. He is a certified wildlife biologist, the academic advisor of the student chapter of The Wildlife Society at Sul Ross State University, serves as board-member-at-large for the Texas chapter of The Wildlife Society, and is president of the Southwest section of The Wildlife Society.