FOXES, FLEAS, AND PLAGUE IN NEW MEXICO

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ABSTRACT—We identified species of fleas found in New Mexico on kit foxes (*Vulpes macrotis*), swift foxes (*V. velox*), red foxes (*V. vulpes*), and gray foxes (*Urocyon cinereoargenteus*). *Pulex irritans* and *P. simulans* were the fleas found most commonly. All species found, except 2, are known to carry plague, and we found fleas on foxes throughout New Mexico capable of carrying plague, which occurs in every county of New Mexico. Thus, every fox in New Mexico should be considered a potential carrier of plague.

RESUMEN—Identificamos especies de pulgas encontradas en Nuevo México en la zorra del desierto (*Vulpes macrotis*), la zorra de pradera (*V. velox*), la zorra roja (*V. vulpes*) y la zorra gris (*Urocyon cinereoargenteus*). *Pulex irritans* y *P. simulans* fueron las pulgas más frecuentemente halladas. Se sabe que todas las especies encontradas, excepto dos, transportan la plaga, y encontramos pulgas en zorros de todas partes de Nuevo México capaces de trasportar la plaga, la cual puede ocurrir en cualquier condado de Nuevo México. Entonces, cada zorro de Nuevo México se debe considerar un portador potencial de la plaga.

Foxes and other furbearers can have a variety of diseases and parasites (Addison et al., 1987). Some furbearer diseases, such as plague, murine typhus, tularemia, and salmonellosis, also affect humans and are associated with fleas (Siphonaptera; Cheng, 1973). To investigate the risk of plague exposure to biologists, trappers, and others handling furbearers in New Mexico, we collected and identified fleas from fox carcasses obtained by the New Mexico Department of Game and Fish from 1996 through 1998.

Four species of foxes occur in New Mexico (Findley et al., 1975). The kit fox (*Vulpes macrotis* Merriam) occurs west of the Pecos River in desert grassland and desert shrub habitats. The swift fox (*Vulpes velox* Say) occurs east of the Pecos River in shortgrass prairie habitats. The red fox (*Vulpes vulpes* Linnaeus) occurs statewide, especially in montane and cropland habitats. The gray fox (*Urocyon cinereoargenteus* Schreber) occurs statewide, primarily in woodland and rocky habitats. We note that the taxonomy of *V. velox, V. macrotis,* and *V. vulpes* is controversial. We follow Mercure et al. (1993) and describe *V. velox* and *V. macrotis* as separate species. We did not distinguish native and nonnative red foxes, and we describe all red foxes that we collected as *V. vulpes* (Kamler and Ballard, 2002).

We obtained fox specimens from roadkills, United States Department of Agriculture Wildlife Services trappers, and private landowners. Foxes were placed in plastic bags as soon as possible after death and were frozen until they could be examined in the laboratory. Each fox was examined thoroughly for fleas using a fine-toothed comb. Flea species were identified using original descriptions and a key to the Siphonaptera of Utah by Stark (1958). We deposited voucher specimens in the Division of Arthropods, Museum of Southwestern Biology, University of New Mexico, Albuquerque.

We examined 53 kit foxes, 30 swift foxes, 8 red foxes, and 14 gray foxes. We obtained fleas from 36 kit foxes, 15 swift foxes, 4 red foxes, and 9 gray foxes. We collected a total of 422 fleas from 64 foxes (Table 1). Some fox carcasses did not have fleas. Fleas leave carcasses after the death of hosts. Our lists of flea species might be incomplete for this reason. A few foxes might not have had fleas prior to death. The intensity of flea infestation (number of fleas per individual fox) was low. The median (and range) numbers of fleas of all species per fox

TABLE 1—Percentage of hosts carrying fleas, median and range of numbers of fleas per host, and county in New Mexico where fleas were collected from kit foxes (n = 36), swift foxes (n = 15), red foxes (n = 4), and gray foxes (n = 9).

Flea species	%	Median (range)	County[a]
Kit fox:			
Cediopsylla inaequalis (Baker)	2.8	1.0	13
Euhoplopsyllus glacialis affinis (Baker)	2.8	1.0	2
Foxella ignota apachina (C. Fox)	2.8	2.0	10
Orchopeas agilis (Rothschild)	2.8	1.0	2
Orchopeas caedens (Jordan)	8.3	1.0 (1–1)	2, 5, 10
Oropsylla (*Diamanus*) *montana* (Baker)	2.8	1.0	10
Pleochaetis exilis (Jordan)	5.6	1.0 (1–1)	4, 15
Pulex irritans (Linnaeus)[b]	58.3	2.0 (1–8)	2, 4, 9, 10, 16
Pulex simulans (Baker)[b]	27.8	1.0 (1–2)	2, 13
Pulex sp.[c]	75.0	2.0 (1–12)	2, 4, 5, 8, 9, 10, 13, 16
Stenistomera alpina (Baker)	2.8	6.0	10
Swift fox:			
Euhoplopsyllus glacialis affinis (Baker)	13.3	1.5 (1–2)	7
Orchopeas agilis (Rothschild)	6.7	1.0	7
Orchopeas caedens (Jordan)	6.7	3.0	7
Pulex irritans (Linnaeus)[b]	73.3	3.0 (1–11)	7, 12, 17
Pulex simulans (Baker)[b]	20.0	3.0 (1–4)	7
Pulex sp.[c]	86.7	7.0 (1–23)	6, 7, 12, 17
Red fox:			
Cediopsylla inaequalis inaequalis (Baker)	25.0	2.0	10
Euhoplopsyllus glacialis affinis (Baker)	25.0	1.0	12
Pulex simulans (Baker)[b]	25.0	4.0	12
Pulex sp.[c]	50.0	3.0 (2–3)	12
Gray fox:			
Cediopsylla inaequalis (Baker)	22.2	2.0 (1–3)	13
Euhoplopsyllus glacialis affinis (Baker)	22.2	2.0 (2–2)	11, 13
Pulex irritans (Linnaeus)[b]	11.1	1.0	1
Pulex simulans (Baker)[b]	33.3	1.0 (1–2)	7, 14
Pulex sp.[c]	77.8	3.0 (2–9)	3, 7, 11, 13, 14

[a] Counties: 1, Catron; 2, Chaves; 3, Colfax; 4, DeBaca; 5, Eddy; 6, Harding; 7, Lea; 8, Lincoln; 9, Luna; 10, McKinley; 11, Otero; 12, Roosevelt; 13, San Juan; 14, Santa Fe; 15, Socorro; 16, Torrance; 17, Union.
[b] Numbers given are only for males of the species.
[c] Numbers given are only for females of the species complex.

were: kit fox 2 (1 to 21); swift fox 7 (1 to 37); red fox 2 (1 to 7); and gray fox 4 (1 to 10). Two species, *Pulex irritans* (Linnaeus) and *P. simulans* (Baker), were the most common fleas collected. There were no new records of occurrence of fleas for New Mexico. Species richness of fleas found upon the 4 fox species corresponded by rank exactly with the number of flea-infested fox carcasses of each fox species (Table 1).

All of the flea species that we found on foxes are known to carry plague (Fagerlund et al., 2001), with the exceptions of *Orchopeas caedens* (Jordan) and *O. agilis* (Rothschild). *Orchopeas agilis* was formerly considered a subspecies of *O. sexdentatus* (Baker) (Hubbard, 1947), which has been found to be naturally infected with plague (K. Gage, Centers for Disease Control, Fort Collins, Colorado, pers. comm.). We found fleas capable of carrying plague on foxes from counties throughout New Mexico, including 17 of 33 counties in the state (Table 1). Plague might occur in every county of New Mexico (P. Reynolds, New Mexico Department of Health, Santa Fe, New Mexico, pers. comm.).

People handling foxes in New Mexico should consider every fox as a potential carrier of plague. When handling foxes likely to have live fleas, we recommend dusting the foxes immediately with flea powder containing pyrethrins. Handlers should wear long sleeves, long pants, and double or heavy gloves, and handle foxes on a brightly-colored plastic sheet so that fleas are more easily seen.

We thank R. A. Fagerlund (Environmental Services, University of New Mexico, Albuquerque) for assistance with species identification and taxonomy, R. E. Lewis (Department of Entomology, Iowa State University, Ames) for information on fox fleas, and D. Campagna and D. Sinah for technical assistance in the laboratory. This project was funded in part by the New Mexico Department of Game and Fish and Pennsylvania State University.

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Submitted 12 June 2002. Accepted 16 December 2002.
Associate Editor was Steven Goldsmith.

USE OF CENTURY PLANTS (*AGAVE PALMERI*) BY COATIS (*NASUA NARICA*)

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Abstract—We report observations and quantification of white nosed coatis (*Nasua narica*) using century plants (*Agave palmeri*) as a novel food source in Arizona. After observing a female coati eating in century plants, we inspected all flowering century plants in areas of coati activity for presence of scratch marks. Use of agaves by coatis was relatively common. Coatis climbed plants with large diameter at breast height relative to unscratched plants, but did not preferentially use agaves based on height or number of flower aggregations. Agaves in areas of high coati activity were more likely to possess scratch marks. Flowering agaves contain nectar, pollen, and arthropod species, all of which likely provide nutrition. The opportunistic foraging and willingness of coatis to experiment with unique food sources might partially explain the expansive distribution of the species under a wide variety of ecological conditions.

Resumen—Describimos y cuantificamos el uso del agave (*Agave palmeri*) por los pisotes (*Nasua narica*) como nuevas fuentes alimenticias en Arizona. Después de observar a una hembra alimentándose de un agave, buscamos los rasguños de pisote en todas las agaves en flor ubicadas en áreas utilizadas por pisotes. El uso de las agaves por los pisotes fue relativamente común. Los pisotes treparon las agaves con el tallo más grueso en comparación a las plantas no rascadas, pero no distinguieron entre las plantas según la altura ni el número de agregaciones florales. Las agaves ubicadas en las áreas más utilizadas por los pisotes mostraron más probabilidad de tener rasguños. Las flores del agave contienen néctar, polen y especies de artrópodos: alimentos potenciales para los pisotes. Puede ser que el forrajeo oportunista y la tendencia a experimentar con nuevas fuentes alimenticias parcialmente expliquen la habilidad del pisote de habitar un rango geográfico amplio y con diversas condiciones ecológicas.

White nosed coatis (*Nasua narica*) are social carnivores common to Neotropical forests (Gompper, 1995), but reach the northernmost point of their range in xeric mountains of southeastern Arizona and southwestern New Mexico (Kaufmann et al., 1976). In tropical forests, coatis forage in canopy and subcanopy vegetation consuming large numbers of invertebrates and fruit (Gompper, 1995). In the northern part of their range, coati food habits are less well described; large fruits are uncommon and invertebrates, such as insects, are plentiful only during warm months. Temperate coati home ranges are markedly larger than tropical ranges (Lanning, 1976; Ratnayeke et al. 1994; Gompper, 1995). This discrepancy might be due to decreased productivity of northern forests (Lanning, 1976; Valenzuela and Ceballos, 2000). In the southwestern United States, anecdotal sightings report coatis shifting from fruits and invertebrates to a more granivorous diet composed of seeds of oak (*Quercus*), juniper (*Juniperus*), and manzanita (*Arctostaphylos*) (Wallmo and Gallizioli, 1954; Gilbert, 1973; Kaufmann et al., 1976).

On 18 July 1997, at approximately 0700 hours, we observed an adult female coati climbing and foraging in a century plant (*Agave palmeri*) in Chiricahua National Monument, Arizona (31°60.5'N, 109°19.0'W). She fed for several minutes, descended, and repeated her behavior on 2 neighboring plants. Upon examination of the stalk, we noted that coatis leave distinctive claw marks (multiple parallel scratches approximately 5 cm wide and ≥1 cm apart) when ascending century plants. Ringtails (*Bassariscus astutus*) and Chiricahua fox squirrels (*Sciurus nayaritensis chiricahae*), the only other clawed arboreal mammals in Chiricahua, would leave substantially smaller scratches. During summers of 1998 and 1999, our research team observed 4 females and 1 male on century plants, suggesting that this foraging behavior might be relatively common. Herein, we report results of our survey of use of century plants by coatis.

Since 1996, coatis have been captured using live traps (102 cm × 31 cm × 31cm; Tomahawk Live Traps, Tomahawk, Wisconsin) baited with wet cat food. Traps were set in Bonita and Rhyolite canyons of Chiricahua National Monument. Once trapped, animals were transferred to handling cones, weighed (±100 g), sexed, and fitted with radio collars (Wildlife Materials, Inc., Carbondale, Illinois). Individual identification was enhanced by banding tails with unique colored tape patterns (Gilbert, 1973). Radiotelemetry was used to locate 16 adult coatis (10 females, 6 males) every hour (0600 to 1900) from 19 July through 21 August 1997. Locations were triangulated within 2.5-ha grid squares on study area maps.

To quantify frequency of century plant use, we examined all flowering century plants (n = 111) located in canyons monitored for coati activity. Century plant stalks were inspected for presence of coati scratch marks. Plant height (measured by clinometer) and number of branches in the inflorescence (number of flower aggregations) were recorded for all plants. Diameter at breast height (DBH) was measured for 82 plants. Plant locations were plotted on a topographical map of the study area, which was divided into 2.5-ha grid squares.

To determine whether coatis preferentially used plants with particular morphology, Student's *t*-tests were used to compare mean DBH, stalk height, and number of branches on scratched versus unscratched plants. Coati locations within the grid square containing a plant and in the 8 contiguous grid squares were tallied for all plants. Chi-square goodness-of-fit tests were used to examine congruence between coati distribution and grid squares with scratched and unscratched century plants. Mann-Whitney *U*-tests were used to compare number of radiotelemetry locations near scratched and unscratched agaves. Scratched agaves should be more likely found in areas with more coati activity.

Use of agaves by coatis was relatively common, with scratch marks detected on 24.3% of 111 century plants. Coatis climbed plants with large DBH (5.83 ± 0.34 cm) relative to unscratched plants (4.64 ± 0.25 cm; $t = 2.76$, $df = 80$, $P < 0.01$), but did not differentially use agaves based on height (scratched: 6.05 ± 0.35 m, unscratched: 6.24 ± 0.20 m; $t = 0.46$, $df = 109$, $P > 0.06$) or number of flower aggregations (scratched: 15.52 ± 0.87, unscratched: 14.86 ± 0.59; $t = 0.57$, $df = 109$, $P > 0.50$). More frequent use of agaves with large DBH suggests plant selection might be influenced by ability of the stalk to support a body mass over 6 kg (Gilbert, 1973; Gompper, 1995).

Agaves in areas of high coati activity were more likely to possess scratch marks. Scratched agaves were found in areas frequently visited by coatis (within the same grid square as agave: $\chi^2 = 54.70$, $df = 1$, $P < 0.01$; within 1 grid square surrounding agave: $\chi^2 = 185.57$, $df = 1$, $P < 0.01$). Mean number of coati visits to the same grid square as agaves did not differ between scratched and unscratched plants ($W = 1000.00$, $df = 70$ and 25, $P > 0.50$); however, mean number of coati visits within 1 surrounding grid square was greater for scratched plants ($W = 1163.00$, $df = 70$ and 25, $P = 0.05$).

A. palmeri produces large amounts of nectar (Schaffer and Schaffer, 1977), which is used by other species as a food source (Slauson, 2000). These agaves also house several species of arthropods (Waring and Smith, 1987) that, along with pollen, might make up a portion of coati diet. Flowering agaves likely provide a reliable, though short-lived (mean flowering duration for a related agave species is 29 days according to Arizaga et al., 2000), food source for coatis. Opportunistic foraging by coatis (Kaufmann, 1962) and home range plasticity, combined with willingness to experiment with novel food sources (such as century plants), might partially explain the expansive distribution of the species and its ability to survive under a wide range of ecological conditions.

This paper is dedicated to the memory of Anna L. Eilers; she continues to inspire us. The authors would like to thank the Southwest Parks and Monuments Association, National Geographic Society, The Explorers Club, Murdock Charitable Trust, and Willamette University for funding various aspects of the project. The field efforts of L. Compton, P. Jaderholm, S. Komak, A. Kolosseus, D. Cervenak, Z. Koprowski, N. Koprowski, A. Edelman, P. Gump, S. Piluso, I. Silvernail, J. Girard, J. Jorgensen, and P. Eilers are greatly appreciated. Additional accolades to the National Park Service, particularly A. Whalon, A. Cox, and the staff at Chiricahua National Monument for providing housing, field assistance, and access to the study population. Field research vehicles were provided by Withnell Dodge. The manuscript was improved by comments from P. M. Waser. All methods of capture, marking, and handling were approved by Willamette University's Institutional Review Board and were conducted under permits from the National Park Service and Arizona Game and Fish.

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Submitted 28 October 2001. Accepted 15 November 2002.
Associate Editor was Loren K. Ammerman.

PRONGHORN USE OF AREAS WITH VARYING SOUND PRESSURE LEVELS

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ABSTRACT—The Sonoran pronghorn (*Antilocapra americana sonoriensis*), a subspecies in danger of extinction, inhabits an area of the Barry M. Goldwater Range (BMGR) in southwestern Arizona. Since 1941, BMGR has been a training site for military pilots. We evaluated whether this subspecies of pronghorn used areas, as defined by noise levels produced by military aircraft, in proportion to their availability. Radiocollar-equipped pronghorn were monitored during September 1994 to August 1998, and their locations were recorded on a map of sound levels. In general, pronghorn used areas with lower levels of noise (<45 decibels [dB]) more than expected and areas with higher levels (≥55 dB) less than expected. More intensive monitoring, habitat influences, and additional measurements of noise in the area, could produce a clearer picture of the factors that determine areas of use within the BMGR by Sonoran pronghorn.

RESUMEN—El berrendo Sonorense (*Antilocapra americana sonoriensis*), una subespecie en peligro de extinción, habita una porción del área Barry M. Goldwater Range (BMGR) en el suroeste de Arizona. Desde 1941, BMGR ha sido un sitio de entrenamiento para pilotos militares. Evaluamos si ésta subespecie de berrendo usa las áreas dentro de BMGR (áreas definidas por el nivel de ruido de aviones militares) en proporción a su disponibilidad. Berrendos equipados con collares con radios fueron monitoreados durante septiembre 1994 y agosto 1998, y sus localizaciones fueron registradas en un mapa de niveles de sonido. Por lo general, los berrendos usaron las áreas con menores niveles de ruido (<45 decibeles [dB]) más de lo esperado, y áreas con mayores niveles (≥55 dB) menos de lo esperado. Un monitoreo más intenso, la influencia del hábitat y registros adicionales de ruido en el área, podrían dar una figura más clara de los factores que determinan el uso de las áreas dentro de BMGR por el berrendo Sonorense.

Wildlife, even in remote settings, are susceptible to human disturbance (Dunnett, 1977). Noise (i.e., sound pressure levels) associated with military aircraft activity and its effects on wildlife is an area of concern for wildlife biologists (Greater Owyhee legal defense versus United States Department of Defense [case number CIV 92 0189 S BLW, United States District Court, District of Idaho, 1999]). Effects of noise from military activity on coyotes (*Canis latrans*) (Gese et al., 1989), mule deer (*Odocoileus hemionus*) (Stephenson et al., 1996; Weisenberger et al., 1996), waterfowl (Conomy et al., 1998), caribou (*Rangifer tarandus*) (Calef et al., 1973), and bighorn sheep (*Ovis canadensis*) (Weisenberger et al., 1996; Krausman, et al., 1998*b*) have been evaluated (Krausman et al., 1998*a*). These studies examined the responses of wildlife to general noise created by military activity, but few (Weisenberger et al., 1996; Krausman et al., 1998*b*) examined the influence of specific sound pressure levels on wildlife. The response of pronghorn (*Antilocapra americana*) to noise created by military activity has not been documented. Sonoran pronghorn (*A. a. sonoriensis*), under the tenets of the Endangered Species Preservation Act of 1966, have been declared endangered since 1967 (United States Fish and Wildlife Service, 1998). In the United States, Sonoran pronghorns inhabit areas in southwestern Arizona: portions of Organ Pipe Cactus National Monument, Cabeza Prieta National Wildlife Refuge, and Barry M. Goldwater Range (BMGR). The BMGR makes up the largest portion of this area (1,090,000 ha). Since the creation of BMGR in 1941, military aircraft routinely have overflown this population of Sonoran pronghorns. In a legal action (i.e., Greater Owyhee legal defense versus United States Department of Defense), wildlife managers claim noise from military activity is detrimental to populations of wildlife. If sound pressure levels have a negative influence on ungulates, we hypothesize they would avoid areas with higher sound pressure levels more than areas with lower sound pressure levels. Our objective was to evaluate whether Sonoran pronghorns use areas in the BMGR with different sound pressure levels in proportion to the availability of those areas.

We used a contour map of the average ambient sound pressure levels on the BMGR created by Wyle Laboratories (WL) (Sypek and Long, Wyle Research Report-WR 97-9, June 1997). The maps provide a relative measure of sound pressure levels due to military aircraft and weapons training operations. The level of military activity was similar from 1994 through 1998, therefore the maps represent ambient sound levels during this study. We placed all locations of 31 radiocollared Sonoran pronghorn (15% of the population) on the BMGR from September 1994 through August 1998 onto the contour map of ambient sound pressure levels. The Arizona Game and Fish Department collected these locations once a week via fixed-wing aircraft and assumed they represented the endangered population. Locations were separated into cool (ca. 28 to 44°C) (September through May) and hot (>44°C) (June through August) periods. All radiocollared animal locations were pooled within each period (hot and cool) from 1994 through 1998.

We evaluated whether pronghorns used areas with different sound pressure levels (i.e., <45 decibels [dB], 45–50 dB, 51–55 dB, 56–60 dB, >60 dB) equal to the availability of those areas, for each season, using a Pearson's Chi-square goodness-of-fit test (Neu et al., 1974; White and Garrott, 1990). We calculated Bonferroni confidence intervals, taking into account familywise variability between sound pressure areas (Byers et al., 1984).

There were 1,587 and 526 locations of pronghorns in the cool period and hot period, respectively. Pronghorns did not use the areas with different sound pressure levels in proportion to their availability (cool period: χ^2 = 67.73, df = 4, P < 0.0001; hot period: χ^2 = 183.85, df = 4, P < 0.0001). In the cool period, pronghorn used areas with <45 dB more than would be expected by chance (i.e., selected), the 45–50 dB and 51–55 dB noise levels in proportion to their availability, and areas with sound pressure levels >55 dB less than would be expected by chance (i.e., avoided) (Table 1). In the hot period, pronghorns selected areas with <45 dB and 51–55 dB and avoided areas with 45–50, 56–60, and >60dB (Table 1). Across both periods, pronghorn selected areas with the lowest sound pressure levels and avoided areas with the highest sound pressure levels (Table 1).

The results are important because wildlife biologists assert that noise from military activity is detrimental to wildlife populations. There is a paucity of data to substantiate or deny such a claim. This study begins to address this issue by suggesting that Sonoran pronghorns do not use the areas with varying sound pressure levels on the BMGR in proportion to their availability. Generally, pronghorns used the lowest noise level area more than the higher noise level areas.

However, sound pressure levels are only 1 variable that might influence the distributions of animals. Pronghorns might choose areas with higher sound pressure levels because of, or in association with, some other variable associated with those areas. Areas with the highest sound pressure levels are also the areas with the highest levels of military activity (e.g.,

TABLE 1—Radiocollared pronghorn use of areas with different sound pressure levels on Barry M. Goldwater Range, Arizona, September through May 1994–1998 (cool period) and June through August 1995–1998 (hot period).

		Cool period		Hot period	
Sound pressure levels	Expected proportion of use	Actual proportion of use	Bonferroni confidence interval	Actual proportion of use	Bonferroni confidence interval
<45dB	0.2654	0.3466	0.3159–0.3773[a]	0.4981	0.4421–0.5441[a]
45–50dB	0.5053	0.4802	0.4479–0.5124	0.3042	0.2562–0.3557[a]
51–55dB	0.0944	0.0825	0.0648–0.1003	0.1388	0.1000–0.1775[a]
56–60dB	0.0219	0.0113	0.0045–0.0182[a]	0.0038	0.0031–0.0107[a]
>60dB	0.1130	0.0794	0.0620–0.0968[a]	0.0551	0.0296–0.0807[a]

[a] Different at 0.05 level of significance.

bombing and strafing) (United States Fish and Wildlife Service, 1997). These areas could have inadequate vegetation and cover for pronghorns, or the disturbance could be a detriment to use.

Quantifying noise levels on BMGR, collecting more pronghorn locations, and evaluating vegetation and cover in areas with different noise levels might provide a clearer picture of how and why pronghorns are using areas with various noise levels. We could not examine other elements (e.g., habitat, weather, elevation, water availability) that influence pronghorn distribution because of military restrictions on the use of BMGR.

Despite potential limitations of this preliminary study, it is a first attempt to align Sonoran pronghorn behavior with a model of noise from military activity, and it is relevant to the management of Sonoran pronghorn. Because the Sonoran pronghorn is endangered and the population has failed to increase to a sustainable number in >30 years, any information gathered on this animal is important. These results have implications for scheduled use of areas by the military, placement of water catchments in relation to military sites, and future management.

We thank Wyle Laboratories for supplying the contour map with the sound pressure levels, the United States Fish and Wildlife Service for supplying the location data on the radiocollared pronghorn, and R. Steidl for providing assistance during analysis and manuscript preparation. Earlier drafts were reviewed by J. Yoakum and 2 anonymous referees. This study was funded by Versar, Inc., and Harris Environmental Group, Inc.

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Submitted 26 May 2000. Accepted 21 October 2002.
Associate Editor was Loren K. Ammerman.