Longnose leopard lizard (*Gambelia wislizenii*) home range and habitat use on Cannonball Mesa, Colorado

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November 2006

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ABSTRACT

The longnose leopard lizard is one of the largest lizards found in the major desert systems of North America. It inhabits xeric shrublands from eastern Oregon to western Colorado and from southern Idaho to northern Mexico. Studies of longnose leopard lizard movement and microhabitat use have found lizards utilize several ha of sparsely-covered shrubs with minimal grass cover. However, there is limited information on longnose leopard lizard movement and habitat use in western Colorado, where populations may be declining. To study longnose leopard lizard habitat use and movement in the eastern part of its range, we radio-collared seven lizards on Cannonball Mesa in Canyons of the Ancients National Monument, Montezuma County, Colorado. We found longnose leopard lizards' mean home range size was 20 ha, and lizards utilized habitats with medium cover of one-seeded juniper and Mormon tea, but with little grass cover. Because longnose leopard lizards occupy relatively large parcels of xeric shrublands with minimal grass cover, populations may be more and more isolated as shrublands are cleared and invaded by exotic grasses. It is possible that longnose leopard lizards act as indicators of healthy, undisturbed shrublands in the arid Southwest.

Cover photographs:
1. Longnose leopard lizard habitat on Cannonball Mesa. Photograph by Judith Franklin.
2. Longnose leopard lizard with radiotelemeter eating sagebrush lizard (*Sceloporus graciosus*). Photograph by Paul Morey.

INTRODUCTION

The longnose leopard lizard (*Gambelia wislizenii*) is a large-bodied lizard that occurs in the Chihuahuan, Great Basin, Mojave, and Sonoran deserts (Stebbins 1985). It ranges from southern Idaho and southeastern Oregon, south to Baja California and northern Mexico, and east to western Colorado, southeastern New Mexico, and west Texas (McGuire 1996, Orange et al. 1999). The lizard is typically found at low densities and is believed to be declining in range and abundance, but gaps in distribution may be a product of the paucity of survey effort (Hammerson 1999).

Habitat for longnose leopard lizards is described as flat shrublands with much bare ground. They inhabit greasewood (*Sarcobatus vermiculatus*), sagebrush (*Artemisia* spp.), saltbush (*Atriplex* spp.), and rabbitbush (*Chrysothamnus* spp.) shrublands (McCoy 1967), seeming to prefer areas where there is little or no grass cover (Hammerson 1999). Longnose leopard lizards may spend time basking on rocks and climbing into low branches of trees and shrubs, but most observations are of lizards on the ground (McCoy 1967).

Longnose leopard lizards are ferocious predators, sometimes ingesting prey nearly as large as they are (Gracie and Murphy 1986). Their diet is varied, including beetles, flies, grasshoppers, wasps, spiders, a host of lizard species, and small mammals (McCoy 1967, Tanner and Krogh 1974, Pietruszka et al. 1980, Mitchell 1984). In the southern parts of the range, longnose leopard lizards ingest larger prey (predominantly other lizards) leading some to suggest that the species plays different ecological roles in northern versus southern desert grassland systems (Pianka 1970, Parker and Pianka 1976). Because it acts as a competitor of similar-sized lizards in the north and as a predator of similar-sized lizards in the south, the longnose leopard lizard can play a vital role in community assemblage and diversity of vertebrates in desert grassland/shrubland systems.

In Colorado, the longnose leopard lizard is restricted to the west-central and southwest edge of the state (Hammerson 1999). Surveys to locate longnose leopard lizards in Colorado have produced several dozen records from the west-central part of the state (McCoy 1967), but efforts to locate them in previously occupied areas of Montezuma County have been unsuccessful (Hammerson 1999). Considered to be rare in the Canyons of the Ancients Monument and McElmo Rare Snake and Lizard Area of southwest Colorado (Zortman 1968 in Bury 1977), surveys have uncovered only a handful of individuals (Bury 1977, Lambert 2004).

Figure 1. Male longnose leopard lizard with radio-collar

Because of the longnose leopard lizard's rarity in Colorado, the lack of habitat use information for this species, and the role this species plays in structuring desert vertebrate diversity we initiated a radiotelemetry study in western Montezuma County, Colorado.

Figure 2. Female longnose leopard lizard with radio-collar. Photograph by Judith Franklin.

METHODS

Study Area

Cannonball Mesa (Mesa) is located within the Canyons of the Ancients National Monument (Monument), which is managed by the Bureau of Land Management. Declared a monument in 2000, the 66,370 ha (164,000 ac) area houses a great herpetofaunal diversity. The conservation of this diversity motivated the BLM to establish the McElmo Rare Snake and Lizard Area in Bridge Canyon of the Monument in 1976. Upland mesas within the Monument are dominated by pinyon pine (*Pinus edulis*) with intermixed sagebrush, saltbush, skunkbush (*Rhus trilobata*), and some juniper (*Sabina osteosperma*). Lowland drainages are a complex of greasewood, saltbush, skunkbush, rabbitbrush, with more mesic areas supporting cottonwood (*Populus angustifolia*), willow (*Salix* spp.), and tamarisk (*Tamarix ramosissima*).

Radio-telemetry and Home Range Estimation

Prior reptile surveys at the Monument identified mesa tops as the primary habitat for the longnose leopard lizard (Lambert 2004). In late June of 2006, a crew of up to nine biologists walked the western half of the Mesa to locate, capture, and radiocollar individuals. Most searches occurred between 0800 hr and 1200 hr to match recorded activity patterns (Parker and Pianka 1976). When captured, lizards were measured (snout-to-vent length, tail length), weighed, sexed, and fitted with 1.1-g hip-attachment radiotelemeters (Knapp and Owens 2005, Holohil Limited, Inc., Carp, Ontario, Canada). Individuals with greater than 9 cm snout-to-vent length and showing orange lateral coloration were considered adult females, while individuals not showing orange coloration and greater than 8 cm snout-to-vent were considered adult males (Figures 1 and 2, Mitchell 1984, Parker and Pianka 1976). Radio-

Figure 3. Researcher conducting radio-telemetry in longnose leopard lizard habitat. Lizard is underground in front of researcher. Photograph by Rob Schorr.

collared individuals were located 2-5 times a week (mean = 3.8 locations/7 days) from June 19 to August 1, 2006 (Figure 3).

Individual home ranges and an aggregated (all individuals included) home range were estimated using minimum convex polygons (MCP) and a kernel estimator (White and Garrott 1990, Seaman and Powell 1996). Spatial representation of home ranges were made in a Geographic Information System (ArcView 3.2, ESRI, Redlands, CA) using the Home Range Extension for ArcView (Carr and Rodgers 1998).

Habitat Use

At each lizard capture and telemetry location habitat characteristics were sampled. Lizard locations were placed into one of three gross categories of landscape habitat: mesa top, rocky slope, or valley bottom. Within a 3-m radius (28 m^2) plot centered at a lizard location species-specific cover was estimated into percentage categories (0%, 1-20%, 21-40%, 41-60%, 61-80%, 81-100%). At the center and 1.5 m in each cardinal direction 1-m^2 cover plots were used to estimate ground cover of grass, forb, cactus, litter, rock, loose soil, and crypotgamic crust. Percent cover was allowed to sum to greater than 100% if vegetation overlapped within the plot. In the NW, NE, SW, and SE quadrants of lizard locations distance to nearest tree (>5 cm dbh), exposed large rock (rock with > 50% of volume above ground and >0.5 m long in any dimension), shrub, and water were estimated. The number of burrows within the 3-m radius plot was counted. Ambient temperature, soil surface temperature, and sub-surface temperature (3 cm below soil surface) were recorded. Finally, sun exposure of each lizard location was assessed using three categories: full sun, partial sun, or full shade.

Aggregated MCP and aggregated 90% kernel home range (KHR) were mapped in ArcView. The aggregated 90% KHR was considered the “core” habitat used by the lizards because kernel home range methods provide information about the intensity of use in an area (Seaman and Powell 1996). All KHR estimates were made using fixed kernels with least squares cross validation. Areas outside of the core habitat, but within the MCP were considered areas not actively used by the lizards (termed “non-core” habitat hereafter). Non-core habitat was our best estimate of areas within the aggregated MCP that were not actively utilized by the lizards. Using a random point generator in ArcView, 30 random points were selected in the non-core habitat area. Habitat sampling (identical to that described for each telemetry location) was conducted at each of the non-core habitat sampling locations (Appendix 1).

An area delimited by a 100-m buffer around the aggregated MCP boundary was considered habitat that was never used by lizards during the study (termed “unused” habitat hereafter). Using a random point generator in ArcView, 30 random points were generated for the unused habitat. Habitat sampling as described above was conducted at these locations (Appendix 2).

So that sampling could be conducted prior to the rapid vegetation changes that are characteristic of xeric environments, habitat sampling was conducted during and shortly after tracking. Using incomplete movement data and home ranges (based on 3 weeks of radio-tracking), vegetation sampling points were randomly selected in unused and non-core habitats. Habitat sampling on unused and non-core habitats was conducted based on these sampling points. Once the complete movement data and home ranges were mapped (after approximately 5 weeks of tracking) some of the vegetation sampling data did not fit the habitat use categories. Six vegetation plots considered core habitat, eleven vegetation plots considered non-core habitat, and six vegetation plots considered unused habitat were removed because they did not meet the pre-assigned use categories (Appendix 1).

Statistical Analysis

Distance to nearest rock and water and plant cover within 3-m plots

Because it was logistically infeasible to measure distances to features beyond 50 m, any feature farther than 50 m from the centerpoint of the sampling area was lumped into a ">50 m" category. Distance to nearest water for all sampling points was greater than 50 m and many distances to rock were greater than 50 m away. Distances to water were not analyzed. Mean distances to nearest rock feature were lumped into six categories: A (0-5 m); B (6-10 m); C (11-20 m); D (21-30 m); E (31-50 m); and F (>50 m). Because distances to nearest rock and water and plant cover classes among core habitat, non-core habitat, and unused habitat were ordinal data sets comparisons were made using PROC GENMOD in SAS v9.1 (SAS Institute Inc., Cary, NC). Odds ratios were considered significant at $p < 0.05$.

Ground cover within 1-m^2 sampling plots and distances to nearest tree and shrub and burrow abundance

Comparisons of percent ground cover among habitat classes, mean distance to nearest shrub and tree, and number of burrows within a plot were made using PROC GLM in SAS v9.1. Percentages were arcsin-square root transformed prior to analysis. Multiple mean comparisons were done using Tukey's Studentized Range Tests to control for Type I experiment-wise error rate ($p < 0.05$).

Table 1. Collar frequency, age, sex, mass and lengths of *Gambelia wislizenii* radiocollared on Cannon Ball Mesa, Colorado.

Collar Frequency	Age	Sex	Mass (g)	SVL (mm)	Tail (mm)
790	A	M	55	120	230
130	A	M	17	86	192
609	A	M	27	105	158
606	A	F	46	117	231
637	A	F	63	110	240
649	A	F	56	110	270
281	J	unk	unk	80	160

Table 2. Minimum convex polygon (MCP) and 90% Kernel home range (KHR) estimates for *Gambelia wislizenii* (ha) at Cannon Ball Mesa, Colorado.

Sex	MCP	KHR
F	27.4	27.5
F	41.6	55.2
F	3.7	4.7
M	8.4	17.9
M	10.2	11.0
M	2.5	3.4
mean	*15.6*	*20.0*
SEM	*6.3*	*7.9*

Table 3. Mean percent ground cover (± SEM) in three *Gambelia wislizenii* habitat groups.

	Core Habitat (n = 92)	Non-core Habitat (n = 19)	Unused Habitat (n = 32)
Forb	16.4 (1.2) A*	16.3 (2.8) A	7.1 (1.4) B
Grass	1.5 (0.0) A	9.7 (1.9) B	12.4 (2.5) C
Cactus	0.0 (0.0)	-	0.0 (0.0)
Litter	19.6 (1.6)	28.5 (4.3)	16.7 (3.0)
Loose Soil	52.0 (2.5)	56.8 (5.0)	51.1 (4.5)
Cryptogramic Soil	10.9 (1.6) A	8.6 (3.1)	5.1 (0.01) B
Rock	16.3 (2.1) A	6.6 (3.8) B	20.1 (4.5) A

*means with different letters within in a row represent differences with significance of $p < 0.05$

Exposure and temperature

Analysis of relationships among exposure classes and temperatures were made using PROC GLM in SAS v9.1. Multiple mean comparisons were done using Tukey's Studentized Range Tests to control for Type I experiment-wise error rate ($p < 0.05$).

RESULTS

Radio-telemetry, Movement and Home Range

Three reproductive females, 3 adult males, and 1 juvenile longnose leopard lizards were collared (Table 1, Appendix 3), but the juvenile slipped its collar after 2 days. Adults ranged in mass from 17 to 63 g (mean = 43.6 ± 6.8 g SEM). Males averaged 33 g (± 11 g), 104 mm (± 10 mm SEM) snout-to-vent length, and 193 mm (± 21 mm SEM) tail length. Females averaged 55 g (± 5 g SEM), 112 mm (± 2 mm SEM) snout-to-vent length, and 247 mm (± 12 mm SEM) tail length (Table 1). The juvenile lizard escaped before being weighed. Radiocollar masses ranged from 1.8% to 6.5% of the lizards' body mass and fell within the tested weight loads of other radio-telemetered lizards (Knapp and Owens 2005).

Lizards were located 21-25 times over 35-38 days. All females appeared slack-bodied between June 29 and July 12 and we believe they laid their eggs during this time. Six adult lizards retained their collars until the collars were removed the first week of August. One lizard was not relocated after 5 weeks of tracking. It is unknown if this lizard was removed from the area or if the collar battery was exhausted. Several lizards displayed slight chaffing at the site of collar attachment.

Mean 90% KHR for radio-collared lizards was 20.0 ha with a range of 3.4 ha - 55.2 ha (Table 2). Furthest distance moved during radio-tracking was 1.46 km by an adult female. In 8 days this female moved 0.99 km.

Table 4. Odds ratios among *Gambelia wislizenii* core habitat areas, non-core habitat areas, and unused habitat of major vegetation types found on Cannon Ball Mesa, Colorado.

Sabina osteosperma

Habitat 1	*Habitat 2*	*Odds of Habitat 1 having less cover than Habitat 2*
Non-core	Core	4.8*
Unused	Core	4.8*
Non-core	Unused	1.0

Bromus tectorum

Habitat 1	*Habitat 2*	*Odds of Habitat 1 having less cover than Habitat 2*
Core	Non-core	10.1*
Core	Unused	21.6*
Non-core	Unused	2.1

Hilaria sp.

Habitat 1	*Habitat 2*	*Odds of Habitat 1 having less cover than Habitat 2*
Core	Non-core	18.9*
Core	Unused	12.6*
Unused	Non-core	1.5

Ephedra torreyana

Habitat 1	*Habitat 2*	*Odds of Habitat 1 having less cover than Habitat 2*
Non-core	Core	3.1*
Unused	Core	4.5*
Non-core	Unused	1.4

Artemesia spp.

Habitat 1	*Habitat 2*	*Odds of Habitat 1 having less cover than Habitat 2*
Non-core	Core	1.5
Unused	Core	2.5*
Unused	Non-core	3.7*

Atriplex spp.

Habitat 1	*Habitat 2*	*Odds of Habitat 1 having less cover than Habitat 2*
Core	Non-core	1.5
Core	Unused	5.8*
Unused	Non-core	3.8*

* $p < 0.05$

Ninety-four percent of all telemetry locations were in mesa top flat lands, while 4% were along rocky slopes at the edge of the Mesa (Appendix 2). No locations were at the valley floors below the mesas. Mean ambient temperature during radio-tracking was 33.2 ± 0.4ºC SEM (91.8ºF). Mean soil surface temperature at lizard locations in full sun, part-sun, and shade were 37.5ºC, 36.5ºC, and 34.5ºC (99.5ºF, 98.0ºF, and 94.0ºF), respectively. Sub-surface soil temperatures at lizard locations averaged 3.2ºC (± 0.3ºC SEM) lower than soil surface temperatures.

Habitat

Core lizard habitat on the Mesa is characterized by low densities of trees and shrubs, with little grass and forb cover, and much bare ground (Table 3, Figures 4-9). Ten plant species were encountered at core, non-core, and unused cover sampling plots. These species were juniper, Mormon tea (*Ephedra torreyana*), sagebrush, greasewood, saltbush, skunkbush, rabbitbrush, mountain mahogany (*Cercocarpus montanus*), mountain ash (*Sorbus scopulina*), broom snakeweed (*Gutierrezia sarothrae*), cliff rose (*Cowania mexicana*), soapweed yucca (*Yucca glauca*), serviceberry (*Amelanchier* spp.), pricky pear cactus (*Opuntia phaeacantha*), galleta grass (*Hilaria* sp.), and cheatgrass (*Bromus tectorum*). Only juniper, sagebrush, saltbush, galleta grass, and cheatgrass, had significantly different cover classes and sample sizes large enough to support analysis.

Compared to non-core habitat, core habitat had more juniper and Mormon tea cover, and less cheatgrass and galleta grass cover (Table 4). Compared to unused habitat, core habitat had more juniper, sagebrush, and Mormon tea, and less galleta grass, smooth brome, and saltbush cover (Table 4).

Figure 4. Utah juniper (*Sabina osteosperma*) cover at three different *Gambelia wislezenii* habitat use categories. Only those cover categories in which the plants were classified were included.

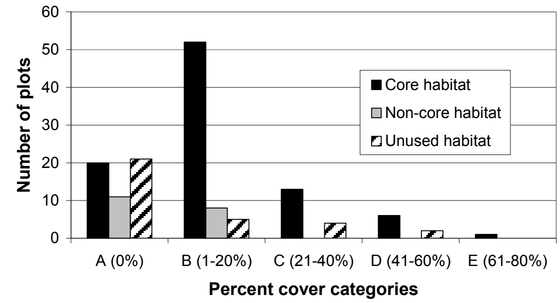


Figure 5. Mormon tea (*Ephedra torreyana*) cover at three different *Gambelia wislezenii* habitat use categories. Only those cover categories in which the plants were classified were included.

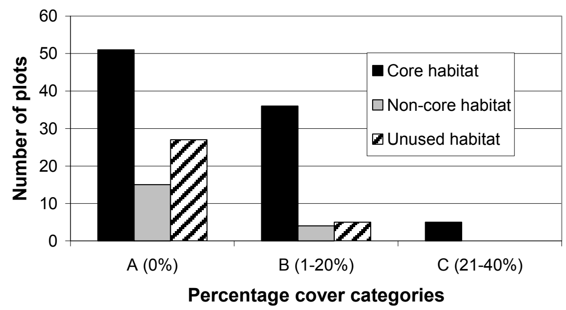


Figure 6. Sagebrush (*Artemisia* spp.) cover at three different Gambelia wislezenii habitat use categories. Only those cover categories in which the plants were classified were included.

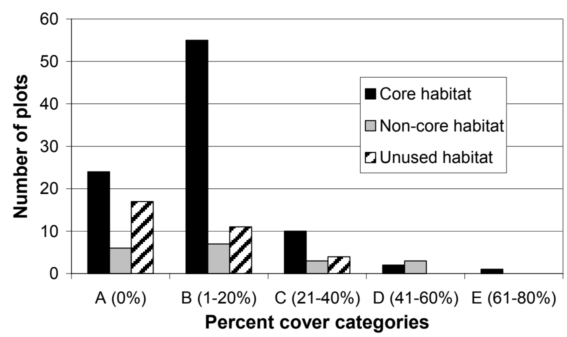
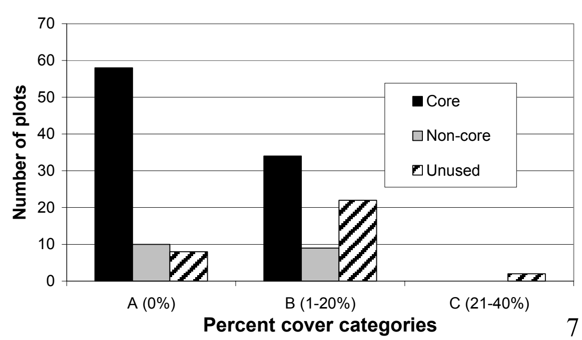


Figure 7. Saltbush (*Atriplex* spp.) cover at three different *Gambelia wislezenii* habitat use categories. Only those cover categories in which the plants were classified were included.



Core habitat locations were closer to trees than non-core habitat and unused areas, but further from rock than non-core habitat (Table 5 and 6). There were fewer burrows in core and unused habitat areas than in non-core areas (Table 7).

Figure 8. Galleta grass (*Hilaria* spp.) cover at three different *Gambelia wislezenii* habitat use categories. Only those cover categories in which the plants were classified were included.

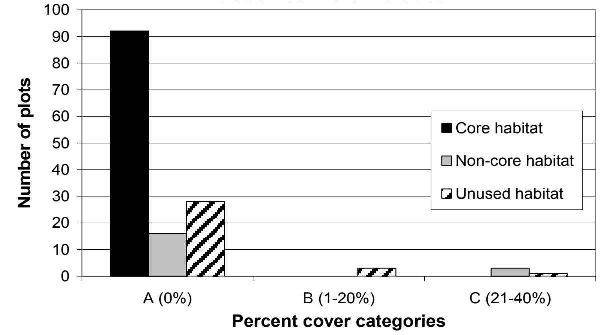
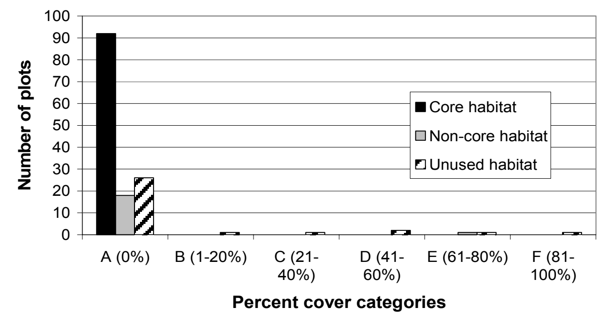


Figure 9. Cheatgrass (*Bromus tectorum*) cover at three different *Gambelia wislezenii* habitat use categories. Only those cover categories in which the plants were classified were included.



Discussion

Home ranges of longnose leopard lizards on the Mesa are larger than home range estimates from other areas within the lizard's range (Tanner and Krogh 1974). Even the smallest estimated MCP was larger than previously recorded home ranges (2.5 ha vs. 2.35 ha, Tanner and Krogh 1974). The largest home range (41.6 ha MCP, 55.2 ha KHR) was of a female that moved 1.5 km east of where she was collared. Once she moved to the new area, she remained there for the next three weeks. In contrast, a similar-sized female moved little over the course of the study (KHR = 4.7 ha). Mean male and female home ranges were not significantly different (T-test p = 0.26), but sample sizes are small. The long-distance movements seen in one female are not extraordinary, but such movements only have been reported in juvenile males (806 m over 14 days and 1186 m over 20 months, Parker and Pianka 1976).

Longnose leopard lizards spent much time near trees (predominately juniper) and in areas with moderate juniper

Table 5. Odds ratios among *Gambelia wislizenii* core habitat areas, non-core habitat areas, and unused habitat for distance to rock features on Cannon Ball Mesa, Colorado.

Habitat 1	*Habitat 2*	*Odds of Habitat 1 having rock features more proximate than Habitat 2*
Unused	Core	1.8
Core	Non-core	4.0*
Unused	Non-core	7.2*

* p < 0.05

Table 6. Mean distance to feature (± SEM) in three *Gambelia wislizenii* habitat groups.

	Core Habitat (n = 98)	Non-core Habitat (n = 19)	Unused Habitat (n = 32)
Shrub	2.1 (0.2)	2.7 (0.5)	2.5 (0.3)
Tree	6.9 (0.4) A*	15.4 (1.5) B	16.5 (2.2) B

*means with different letters within in a row represent differences with significance of p < 0.05

Table 7. Mean number of burrows (± SEM) in three *Gambelia wislizenii* habitat groups.

	Core Habitat (n = 91)	Non-core Habitat (n = 19)	Unused Habitat (n = 27)
Number of burrows	1.5 (0.2) A*	3.5 (0.6) B	1.8 (0.5) A

*means with different letters within in a row represent differences with significance of p < 0.05

cover and minimal shrub cover. On multiple occasions lizards were seen roosting in the lower branches of junipers. There was only one record of a lizards being located in the limbs of a shrub (cliff rose). In Nevada, longnose leopard lizards have been found in the branches of desert-thorn (*Lycium*) foraging on the berries (Tanner and Krogh 1974). It is possible fresh juniper berries provide a valuable metabolic resource. Several shrubs (sagebrush, saltbush, Mormon tea) were used frequently, but it is unclear if these shrubs were preferred because we have little information about the spatial distribution of these vegetation types on the Mesa. Longnose leopard lizard densities appear to be high in areas with some shrub cover. In southeastern Oregon longnose leopard lizard abundance was highest in areas with moderate (31-42%) mixed shrub cover (Steffen and Anderson 2005).

Figure 10. Gravid female longnose leopard lizard emerging from burrow. Photograph by Rob Schorr.

Ground cover of living vegetation at lizard telemetry locations was sparse (mean < 20%). Litter cover (mean ~20%) and cryptogamic crusts (mean ~10%) were the only other non-bare ground categories. At lizard core habitat areas vegetative ground cover on the Mesa was less than at longnose leopard lizard habitats in southwestern New Mexico (mean of 33%, Baltrosser and Best 1990). Studies along the bajada of San Simon Cienega found longnose leopard lizards utilizing more open habitats than other desert lizards, but occupied areas with moderate shrub cover (Baltrosser and Best 1990).

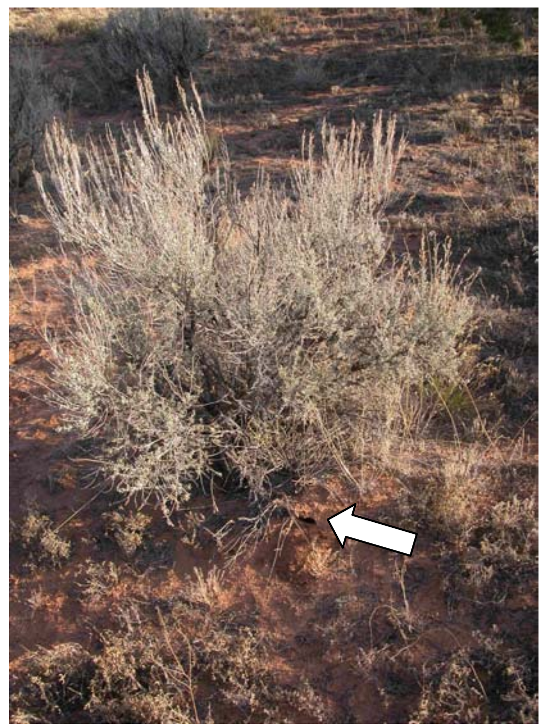


Figure 11. Burrow used by gravid female longnose leopard lizard (in Figure 10). Burrow location marked with an arrow. Photograph by Rob Schorr

True to other investigations of longnose leopard lizard habitat, lizards were found in areas with much bare ground. On the Monument, lizard locations were comprised of 66% (± 1.6% SEM) bare ground (percent rock and percent loose soil combined). McCoy (1967) found individuals in sparse stands of cheatgrass, galetta grass, and alkali sacaton (*Sporobolus airoides*). Lizards on the Mesa appeared to avoid areas with anything but minimal grass cover. Areas that were never visited (unused habitat) and areas nearby, but not utilized (non-core habitat) had higher grass cover than the core habitat areas. It is believed that longnose leopard lizards will avoid areas with dense cover of grass (Stebbins 1985).

Rock outcrops along the Mesa rim were rarely (< 5% of observations) visited by radio-collared lizards. Bury (1977) found a few individuals using rocky areas near Bridge Canyon, Colorado, but most observations of longnose leopard lizards are on flatlands (McCoy 1967, Parker and Pianka 1976, Lambert 2004). Recent efforts to locate longnose leopard lizards in valley regions and rocky cliffs of the Monument have not been successful (Lambert 2004). Although our attempts to radio-collar lizards did not include searches in valley bottoms, some searching did include the rock cliffs surrounding the mesa tops. All radio-collared lizards were close enough to rock areas to utilize them, but only a few observations were made of lizards in those areas, and those observations were made at the top of the Mesa and not along the steeper slopes below the Mesa. Our assessments of lizard use of rocky slopes and valley bottoms are confounded by the limited search areas of our study. Since much of our collar-attachment searching was conducted in areas known to support the highest densities of lizards (mesa tops) there was not equal effort to find and collar lizards off the mesa tops.

Previous accounts of longnose leopard lizard habitat have commented on the abundance of rodent burrows. Telemetered lizards were seen utilizing burrows within the study area (Figures 10 and 11), but mean abundance was lower in core habitat areas than in unused areas. It is possible that areas of higher burrow abundance may be areas of greater competition or predation from snakes and rodents. One western rattlesnake (*Crotalus viridus*) and one striped whipsnake (*Masticophis taeniatus*) were seen during the study, and several pinyon mice (*Peromyscus truei*) were captured east of the core habitat areas.

On three occasions collared longnose leopard lizards were seen consuming lizards. The only species confirmed as a diet item on the Mesa was the sagebrush lizard (*Sceloporus graciosus*). It is likely that the leopard lizards were consuming other diet items, such as invertebrate prey, but it is believed southern populations of longnose leopard lizards ingest more vertebrate prey than northern populations (Pianka 1970, Parker and Pianka 1976, Pietruszka et al. 1980). During the study collared lizards (*Crotaphytus collaris*), northern plateau lizards (*Sceloporus undulatus*), tree lizards (*Urosaurus ornatus*), side-blotched lizards (*Uta stansburiana*) and western whiptails (*Cnemidophorus tigris*) were seen on the Mesa.

The aggregated MCP, which incorporates telemetry locations for all six lizards, is 121 ha. Incorporating the juvenile lizard that dropped its collar and an additional longnose leopard lizard that was seen, but not captured, an approximate density of lizards on the Mesa is 8 individuals per 121 ha (6/100 ha, 2.4/100 ac). Lizard densities are lower than those seen in other parts of the range. In the deserts of southern Nevada, Turner *et al.* (1969) found densities ranging from 1-2 adults/ac (100-200/100 ac, 247-494/100 ha). They believe that leopard lizard reproduction was associated with higher spring rainfall, which produced good *Lycium* mast production. Densities in northern Utah were even higher (19/ha, 8/ac; Parker and Pianka 1976) than those in southern Nevada. Comparatively, the Mesa does not support the densities seen in other areas of the longnose leopard lizard's range. However, our density estimates are deflated some by the use of the MCP, which includes areas that were not actively utilized by the radio-collared lizards. Longnose leopard lizard populations on the Mesa are at the edge of the eastern distribution of this species, and it is possible that there are limiting resources that prevent densities from increasing to the levels seen in other areas. Our density estimates can provide preliminary guidance on size of areas utilized by small longnose leopard lizard populations. However, such conservation planning exercises should incorporate other factors, such as habitat suitability within the area, and should attempt to understand how land use practices impact lizards and their habitat.

Longnose leopard lizards on the Mesa utilize habitats that have expanses of low forb and grass cover with low-to-medium cover of shrubs and trees. Maintaining such a system may involve efforts to limit the expansion of cheatgrass into core lizard activity areas, while maintaining the distribution of juniper and shrubs. These trees and shrubs may provide thermoregulatory habitats, resting habitats, cover from prey, and concealed areas for ambushing prey (Montanucci 1976). Habitat structure and composition that provides all life history habitat requirements need to be maintained for persistence of longnose leopard lizard populations. Habitat manipulations may clarify the impact particular resources play in sustaining lizard populations. For example, manipulations of grass cover and shrub cover may elucidate the impact dense stands of grass have on lizard abundance and distribution. Conducting such manipulations in various areas throughout longnose leopard lizard distribution may uncover specific habitat needs that are universal to lizard populations.

ACKNOWLEDGMENTS
We thank Kathleen Nickell, Eric Freels, Kristen Philbrook, Paul Morey, Carolyn Gunn, and Judith Franklin of the Dolores Public Lands Office, San Juan Public Lands, for their assistance in data collection and project support. We thank LouAnn Jacobson, Monument Manager of the Canyons of the Ancients National Monument, for her support. The project could not have conducted without the funding and support from the Bureau of Land Management. We thank Chris Gaughan, Jeremy Siemers, and Robert Weidmann of CNHP for their assistance in the field. We thank Drs. John Cossell, Jr., of Northern Nazarene University and David J. Germano of University of California, Bakersfield for their insights and suggestions.

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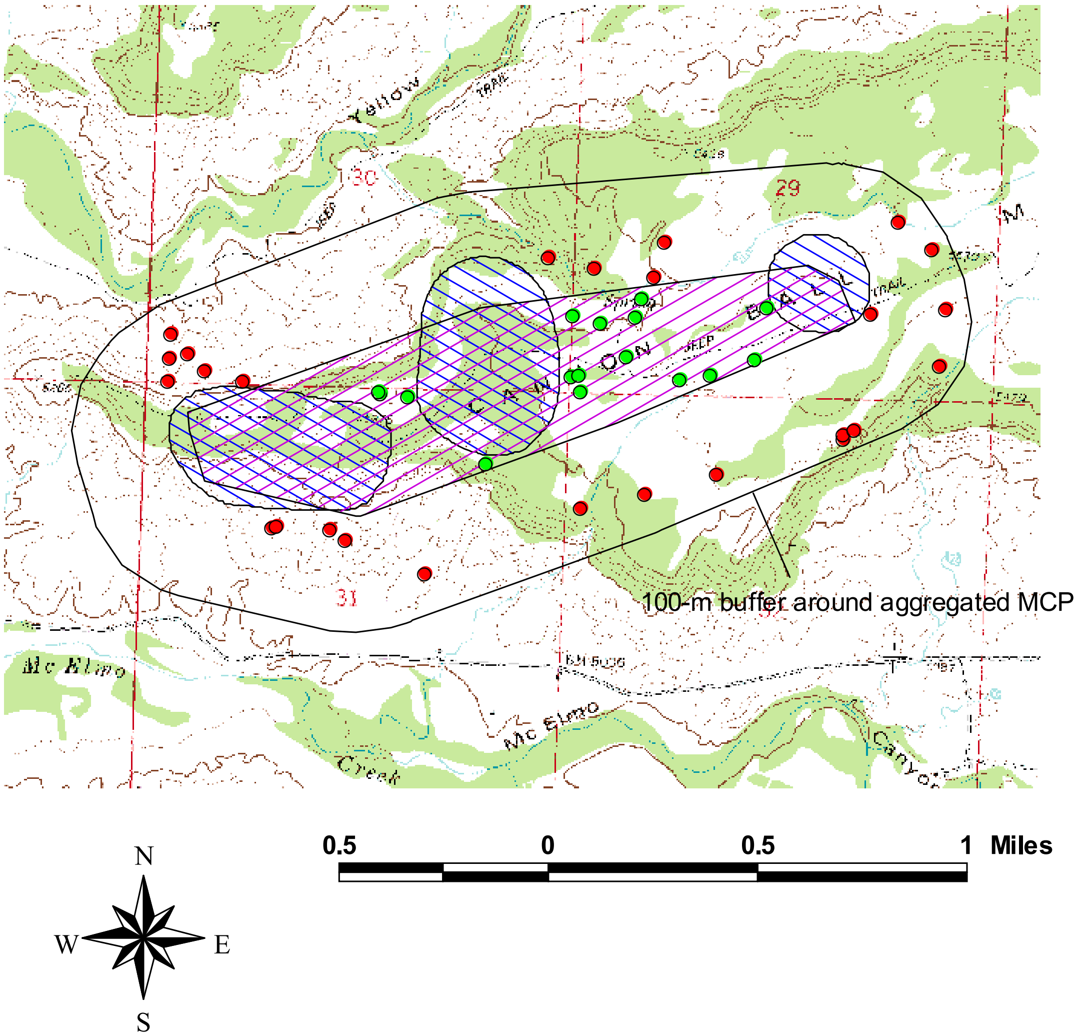
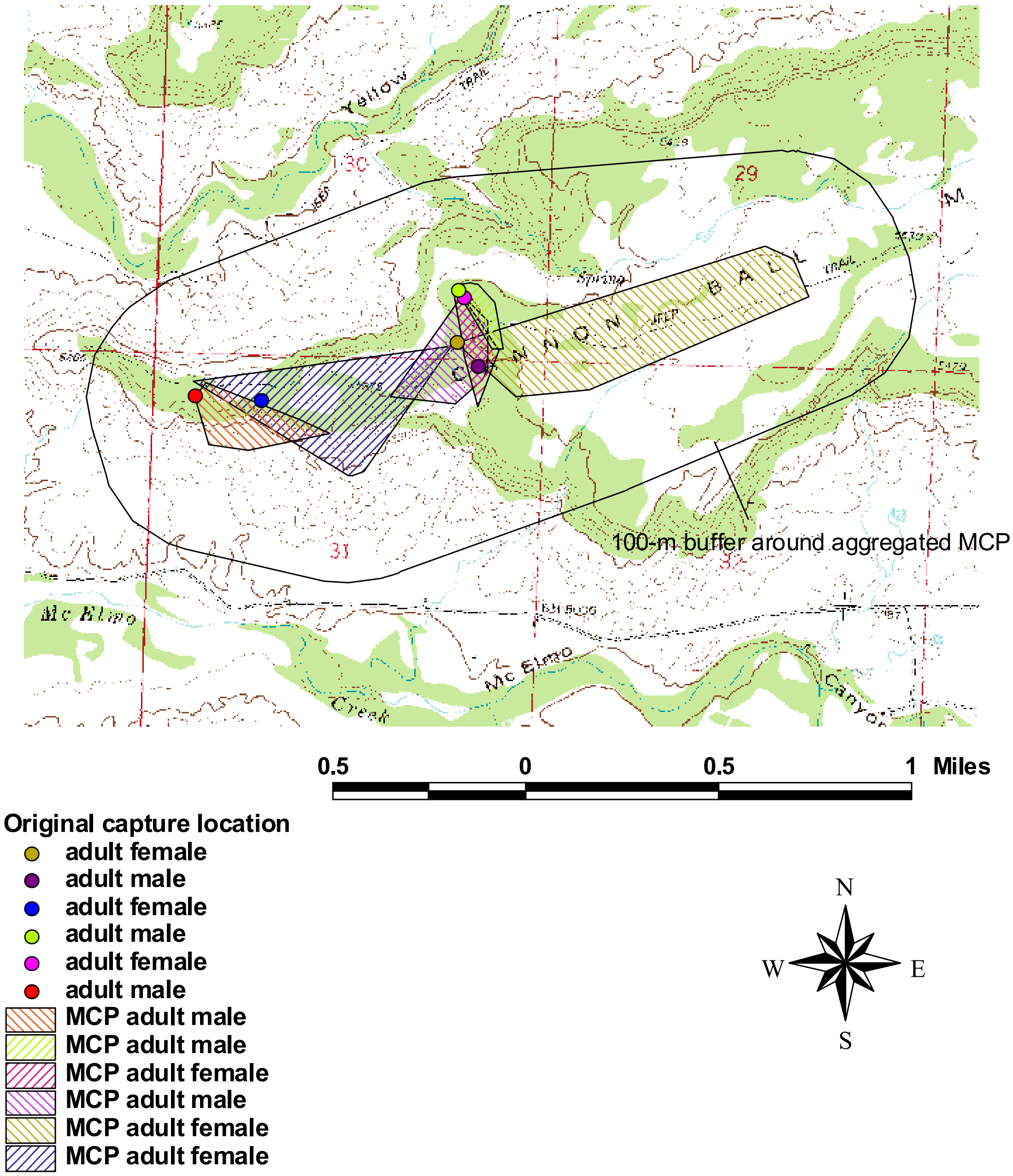
Appendix 1. Habitat sampling points and aggregated home range estimates for all radiocollared longnose leopard lizards on Cannon Ball Mesa, Montezuma County, Colorado.



● Random habitat points outside MCP
● Random habitat points within MCP and outside 90% KHR
Aggregated Minimum Convex Polygon for all longnose leopard izard locations
Aggregated 90% Kernel Home Range for all longnose leopard lizard locations

Appendix 2. Capture locations and minimum convex polygon representations of individual home ranges for radio-collared longnose leopard lizards on Cannon Ball Mesa, Montezuma County, Colorado.



Appendix 3. Age, sex, date of capture and location of capture for all radio-collared longnose leopard lizards on Cannonball Mesa, Montezuma County, Colorado. UTM zone is Zone 12 and datum is NAD 1983.

Age	Sex	Date of capture	UTM north	UTM east
adult	male	20 June, 2006	4134690	679240
adult	male	21 June, 2006	4134500	678070
adult	male	20 June, 2006	4135000	679130
adult	female	21 June, 2006	4134980	679160
adult	female	21 June, 2006	4134500	678340
adult	female	19 June, 2006	4134790	679140
juvenile	unknown	29 June, 2006	4134690	679800