

# PROBABILITY OF OCCUPANCY OF BLUNT-NOSED LEOPARD LIZARDS ON HABITAT PATCHES OF VARIOUS SIZES IN THE SAN JOAQUIN DESERT OF CALIFORNIA

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**Abstract.**—The Blunt-nosed Leopard Lizard (*Gambelia sila*) is a California and federally listed endangered lizard species native to the San Joaquin Desert. The species has lost approximately 85% of its original native habitat. Numerous conservation efforts have been pursued to recover the species, but most of these efforts have a multispecies focus that may have limited benefits for Blunt-nosed Leopard Lizards. We surveyed 13 isolated, potential habitat patches of Blunt-nosed Leopard Lizards and we used survey data collected by others at seven sites to determine the effect of habitat patch size on the probability of occurrence of Blunt-nosed Leopard Lizards. There was a significant positive relationship between habitat patch size and presence of Blunt-nosed Leopard Lizards ( $G = 13.289$ ,  $df = 1$ ,  $P < 0.001$ ; Pearson's  $\chi^2 = 10.097$ ,  $P = 0.929$ ). Only one habitat patch smaller than 250 ha had a Blunt-nosed Leopard Lizard observation. Given these results and the relative lack of information about patch dynamics for this species, we recommend that conservation efforts pursue large habitat patches that support extant Blunt-nosed Leopard Lizard populations (e.g., Carrizo Plain, Lokern Natural Area) and expand smaller habitat patches that support the species on the San Joaquin Valley floor (e.g., Buttonwillow Ecological Reserve, Pixley National Wildlife Refuge).

**Key Words.**—conservation; endangered species; *Gambelia sila*; logistic regression; surveys

## INTRODUCTION

Conservation for some rare species depends on preserving remaining habitat that supports the species. Because resources are chronically limited for this task, resource agencies must choose which remaining habitats are best to be protected in the near term. For a variety of vertebrate species, the size of reserves affects abundance and ultimately occupancy with lower numbers as reserve size decreases (Pickett and Thompson 1978; McCoy and Mushinsky 1999; Bradford et al. 2003; Hokit and Branch 2003). For some species, abundance shows steep declines when reserve size is lower than 600 ha (Humphreys and Kitchener 1982). Based on the size and ecology of the species, some parcels of native habitat may simply be too small to support a population. Determining the lower limit of parcel size at which a species can occupy habitat is important to making the right choices of habitat to purchase and protect.

The Blunt-nosed Leopard Lizard (*Gambelia sila*; Fig. 1) is the largest lizard species in the San Joaquin Valley (Stebbins and McGinnis 2012). Due in large measure to habitat loss on the floor of the San Joaquin Valley, the Blunt-nosed Leopard Lizard was listed as endangered in 1967 pursuant to the Endangered Species Preservation Act of 1966, and subsequently listed as endangered pursuant to the California Endangered Species Act in 1971 (U.S. Fish and Wildlife Service [USFWS] 1998, 2010). Numerous conservation efforts have been planned within the range of the Blunt-nosed Leopard Lizard that protect or restore habitat features, including: 14 Habitat

Conservation Plans (HCPs); the Central Valley Project Conservation Program (CVPCP); Central Valley Project Improvement Act Habitat Restoration Program (HRP); California Department of Fish and Wildlife ecological reserves; national wildlife refuges; conservation banks; and habitat compensation for incidental take of state or federal endangered species (USFWS 2010). Most of these efforts have a multispecies focus. Specific management criteria for blunt-nosed leopards are listed for some of the above referenced conservation efforts, but the continued survival of Blunt-nosed Leopard Lizards is not a stated objective for several of them, and some conservation efforts are only coarsely evaluated (USFWS 2010).

Blunt-nosed Leopard Lizards inhabit relatively flat, sparsely-vegetated areas of the San Joaquin Desert (Germano et al. 2011) including the valley floor, Carrizo Plain, Elkhorn Plain, Cuyama Valley, and surrounding foothills (Germano and Williams 1992; USFWS 1998). Vegetation communities associated with the Blunt-nosed Leopard Lizard include alkali sink scrub, saltbush (*Atriplex* spp.) scrub, Ephedra scrub, and native and non-native grasslands (Germano and Williams 2005; USFWS 2010). Habitat loss from agricultural, energy, and urban development pose the greatest threat to Blunt-nosed Leopard Lizards (USFWS 2010). Germano and Williams (1992) estimated that the Blunt-nosed Leopard Lizard had lost 80–85% of its native range at the time of their publication, and the most recent five-year status report for the species (USFWS 2010) reports that an additional 35,000 acres of permanent impacts and 10,000 acres of temporary disturbance have been authorized. Remaining habitat for the species, especially on the valley floor, is highly



**FIGURE 1.** Female Blunt-nosed Leopard Lizards (*Gambelia sila*) from the Lokern Natural Area of the San Joaquin Desert, California. (Photographed by David J. Germano).

fragmented and limited to southern Merced County south to Kern, San Luis Obispo, and northern-most Santa Barbara and Ventura counties (USFWS 1998, 2010).

Few large, continuous patches of habitat now occur on the floor of the San Joaquin Valley. Many parcels of natural habitat are relatively small and isolated. Criteria for recovery of the Blunt-nosed Leopard Lizard include identification of conservation areas, minimum population size and densities, and best management practices (USFWS 1998). There have been no estimates of the minimum habitat patch size that would be required to support a minimum viable population (MVP) for Blunt-nosed Leopard Lizards. Shaffer (1981) defined a MVP as the “the smallest isolated population having a 99% chance of remaining extant for 1,000 years despite the foreseeable effects of demographic, environmental, and genetic stochasticity, and natural catastrophes.” A population model from 1989 tried to estimate the viability of Blunt-nosed Leopard Lizard populations through 50 years (Marybeth Buechner, unpubl. report), but it was deemed to have poor accuracy (Germano and Williams 1992). No other MVP estimates have been attempted for Blunt-nosed Leopard Lizards. An understanding of minimum habitat patch size for Blunt-nosed Leopard Lizards is necessary to model the population dynamics of this species.

We surveyed patches of potential Blunt-nosed Leopard Lizard habitat in the southern San Joaquin Valley to begin to estimate the minimum patch size required by this species. We also used recent survey data on Blunt-nosed Leopard Lizards by environmental companies and we reviewed information from the California Natural Diversity Database (CNDDDB). Because habitats have been fragmented for many years, we assumed that even one individual on site would indicate that the patch of habitat was large enough to support a long-term population of leopard lizards. We used these data in a logistic regression analysis to determine the probability of occurrence of Blunt-nosed Leopard Lizards at various habitat patch sizes.

## METHODS

We surveyed 13 isolated, potential habitat patches for Blunt-nosed Leopard Lizards. We also incorporated survey results provided by personnel of two environmental companies that were conducted in the past few years in isolated, potential habitat patches of Blunt-nosed Leopard Lizards. We reviewed CNDDDB records for Blunt-nosed Leopard Lizard occurrences in isolated habitat patches. The survey data and CNDDDB record review identified seven additional habitat patches for analysis

that met our criteria for isolation. In total, we evaluated 20 isolated habitat patches for presence of Blunt-nosed Leopard Lizards.

We considered habitat patches isolated if the habitat was surrounded by one or more of the following features: a marked two-lane road, active agriculture or other ground disturbance (e.g., recent disking), water or canal, high density oil or other mineral extraction, or urban or residential development. All sites surveyed were considered moderate to good habitat based on soil and vegetation structure. We did not group or eliminate habitat patches based on specific vegetation or other habitat characteristics (e.g., soil type) because the number of parcels available to be surveyed was limited and Blunt-nosed Leopard Lizards occur on all habitats in the Valley except riparian and marsh (Montanucci 1965; Germano and Williams 1992, 2005). Habitat patches with evidence of historic disturbance (e.g., disking, former oil well pads) were not excluded if saltbush or other shrubs had been reestablished on the site and a source population was within 500 m because Blunt-nosed Leopard Lizards have been observed on previously disturbed habitat patches with suitable habitat features such as the Button-willow Ecological Reserve (pers. obs.). We estimated the size of habitat patches (in ha) using imagery from Google Earth (2013).

**TABLE 1.** Presence / absence of Blunt-nosed Leopard Lizards (*Gambelia sila*) on 20 habitat patches of various sizes in the San Joaquin Valley, California.

Habitat Patch Size (ha)	Blunt-nosed Leopard Lizards Observed
19	No
42	No
43	No
63	No
69	No
80	No
96	No
102	No
130	No
173	No
181	No
238	Yes
246	No
259	Yes
315	No
374	No
397	Yes
667	Yes
1706	Yes
4415	Yes

We surveyed for lizards on isolated, potential habitat patches in 2010 using meandering transects across a site for five non-consecutive days. We conducted surveys from late April through early July at optimal temperatures for adult leopard lizard activity (Germano and Williams 2005). Surveys of Blunt-nosed Leopard Lizards for only five days have been found to detect 90% of first observations of Blunt-nosed Leopard Lizards and there is a 95% chance of detecting Blunt-nosed Leopard Lizards if they occur at a site (Germano 2009). We believed that the low possibility of missing a lizard on a site if we surveyed for more days was compensated for by being able to survey more sites in a year.

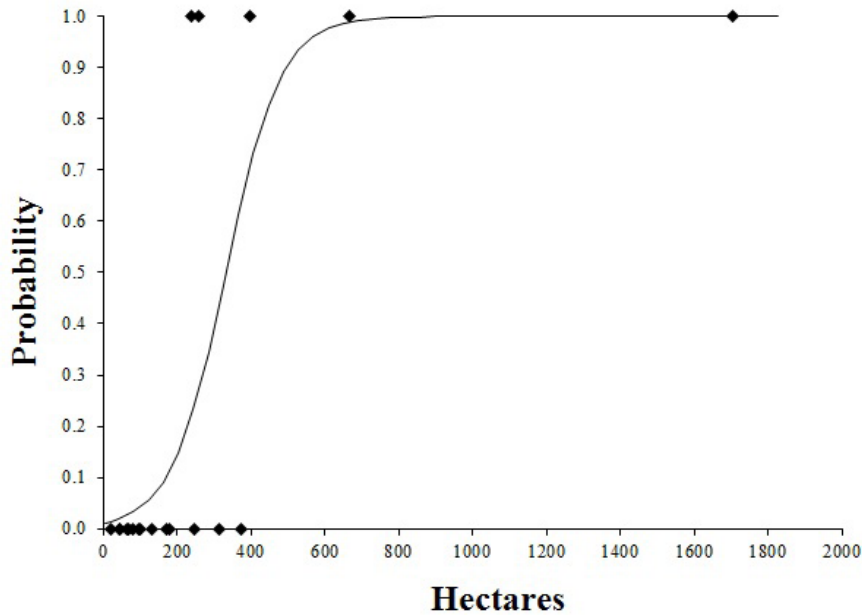
We compared survey data for Blunt-nosed Leopard Lizards and CNDDDB records to historical aerial photos on Google Earth. If historical aerials indicated a parcel was isolated before and after the date of a survey or CNDDDB occurrence, we considered the habitat patch was isolated at the time of survey or CNDDDB occurrence. Blunt-nosed Leopard Lizard surveys conducted by personnel of the environmental companies followed the California Department of Fish and Wildlife approved survey methodology. The CNDDDB only documents positive results and negative results are not recorded. Protocols are not reported in the occurrence records. We used logistic regression ( $\alpha = 0.05$ ) to determine the probability of occurrence of Blunt-nosed Leopard Lizards based on varying patch size of natural habitat.

## RESULTS

Blunt-nosed Leopard Lizards were observed on six of the 20 evaluated habitat patches (Table 1). Habitat patches with Blunt-nosed Leopard Lizard observations ranged from 238 to 4,415 ha. Only one habitat patch smaller than 250 ha had a Blunt-nosed Leopard Lizard observation (Table 1). Four of the remaining six habitat patches with Blunt-nosed Leopard Lizard observations were greater than 400 ha. Habitat patch size was predictive of the occurrence of Blunt-nosed Leopard Lizards ( $G = 13.29$ ,  $df = 1$ ,  $P < 0.001$ ; Pearson's  $\chi^2 = 10.10$ ,  $P = 0.929$ ). The model had a y intercept of -4.497 and a slope of 0.01354. The relationship has a steep prediction curve between 200 and 400 ha (Fig. 2). Based on this model, there is only a 4.14% chance of Blunt-nosed Leopard Lizards occurring on a habitat patch  $\leq 100$  ha, a 14.3% chance of occurrence at 200 ha, a 56.0% chance at 350 ha, and a 90.7% chance of occurrence at 500 ha.

## DISCUSSION

The size of habitat patches has been found to be important in several species where this parameter has been studied. For the Florida Scrub Lizard (*Sceloporus woodi*), abundance, survivorship, and recruitment were positively associated with the size of eight scrub patches in Florida that varied in size from eight to 256 ha (Hokit



**FIGURE 2.** Probability of occurrence of Blunt-nosed Leopard Lizards (*Gambelia sila*) based on presence/absence surveys of habitat patches of varying sizes in the San Joaquin Valley, California.

and Branch 2003). Also in Florida scrub habitat, 11 of 18 species of vertebrates were positively correlated with area of habitat, although several rare species maintained relatively large numbers in small habitat patches (McCoy and Mushinsky 1999). The occupancy of Red-spotted Toads (*Bufo punctatus*) in southern Nevada increased with increased patch size (Bradford et al. 2003). Humphreys and Kitchener (1982) found that mammals, birds, and lizards that were restricted to native habitat in Australia declined in abundance as area of habitat decreased, and these declines were steep when reserve area was smaller than 600 ha.

Pickett and Thompson (1978) described nature reserves and patches of habitat as habitat islands in which, similar to true islands, the area affects the rate of extinction and that small populations, or populations necessarily confined to small areas, will be more subject to extinction. As habitat patch size is reduced, the risk of extinction increases primarily due to reduced population size (Pickett and Thompson 1978). It may be true that for some species, small reserves (< 40 ha) can be valuable (Shafer 1995). In the San Joaquin Valley, some rare annual plants and the endangered Tipton kangaroo rat (*Dipodomys n. nitratooides*) can persist on habitat patches < 40 ha (pers. obs.). However, for most animal species, small patch size likely will reduce population size below the minimum viable population, making it unlikely the population can survive the catastrophic and stochastic events expected to occur over time (Shaffer 1981). For these species, small patch size greatly increases the deleterious effects of habitat edge. In five studies of amphibian and reptile species, the effect of edge on species inhabiting forest habitats was either negative (16 instanc-

es) or neutral (three instances), never positive (Ries et al. 2004). The average home range size of Blunt-nosed Leopard Lizards in the Lokern area of the southern end of the valley ranges from 2.85 to 9.36 ha, depending on methodology, year, and sex, with some individuals having home ranges up to 31.5 ha (unpubl. data). Average daily distances moved by these lizards ranged 65.5 to 108.4 m with the greatest daily movement as high as 316 m (unpubl. data). Therefore, it is not surprising that the wide-ranging Blunt-nosed Leopard Lizard is more likely to be absent as habitat patch size decreases.

Three of the seven habitat patches with Blunt-nosed Leopard Lizards in our study were larger than 405 ha, and a fourth patch was 397 ha. However, at least two habitat patches smaller than 405 ha, including the 397 ha habitat patch, may actually be part of habitat patches > 405 ha. The Kerman Ecological Reserve and Buttonwillow Ecological Reserve are bisected by Seventh Standard Road and Highway 180, respectively. Both roads are paved, two-lane roads that receive moderate to heavy traffic. Based on our criteria for isolation, a two-lane road was considered a barrier. This criteria resulted in two habitat patches for the Kerman Ecological Reserve of 397 ha and 315 ha, and two habitat patches for the Buttonwillow Ecological Reserve of 667 ha and 259 ha. However, Blunt-nosed Leopard Lizards have been observed crossing roads similar to Seventh Standard Road (Kacey O'Malley, pers. comm.). Traffic volume on Seventh Standard Road, though, has increased greatly in the past decade (pers. obs.) because trucks use it to connect I-5 and Highway 99, and likely lizards have trouble crossing this road now. Although Highway 180 and similar roads may pose ongoing threats to Blunt-nosed Leopard

Lizards occupying adjacent habitat, they may not be significant movement barriers if traffic volume is relatively low. If the habitat patches of Kerman Ecological Reserve are combined, the habitat patch size increases to 712 ha.

According to Soulé (1987, cited in Shafer 1995), the estimated population size of vertebrate species to achieve a 95% survival expectation varies between 200–20,000 individuals, with a median of 2,000 individuals. If Soulé's median estimate for a population to persist 200 years is assumed for Blunt-nosed Leopard Lizards, then it would require a population of at least 2,000 individuals. An early estimate of density (Tollestrup 1979) was 3.2 Blunt-nosed Leopard Lizards per ha (1.3/ac). At this density, at least 623 ha of habitat would be needed to support Soulé's median estimate using the simplest of calculations (number of individuals/individuals per ha). However, densities of adult Blunt-nosed Leopard Lizard can be as high as 4.35/ha to 16.0/ha in exceptional years, which does not even include hatchling densities that can range from 23.9 to 35.6 lizards/ha (Germano and Williams 2005). Based only on these adult densities, and if only the sheer number of lizards determined long-term occupancy, then habitat patch size could be as small as 125 ha.

The number of Blunt-nosed Leopard Lizards at a site varies markedly over relatively short time spans (Germano and Williams 2005; Germano et al. 2012). Therefore, in years when abundances are low, a small patch size may not support enough adults to overcome stochastic events such as an unusually cold, wet winter or an increase in predators over a short time span. A large habitat patch will contain more lizards in low density years and will be more resilient to stochastic events.

Although we did not use Occupancy Modeling to determine presence of lizards at a site, we believe that our data are a good start to determining sizes of habitat that will support leopard lizards. We are assuming that the 0.907 probability of lizards occurring on a patch of 500 ha means that Blunt-nosed Leopard Lizards will persist at a site this size long into the future if the site is not altered. Conversely, smaller patch sizes have a rapidly decreasing likelihood of lizard occurrence and may not support a population of Blunt-nosed Leopard Lizards long-term. Although our sample size is not large, we did not find leopard lizards on any patch smaller than 238 ha. Remaining small habitat patches in the southern San Joaquin Valley will likely not be useful to recovering the Blunt-nosed Leopard Lizard unless they are linked to much larger areas of contiguous habitat. Given these results and the relative lack of information about patch dynamics for this species, we recommend that conservation efforts pursue large habitat patches that support extant Blunt-nosed Leopard Lizard populations (e.g., Carrizo Plain, Lokern Natural Area) and expand smaller habitat patches that support the species on the San Joaquin Valley floor (e.g., Buttonwillow Ecological Reserve, Pixley

National Wildlife Refuge). Additional efforts using Occupancy Modeling to refine habitat patch size would be helpful also.

Size of patches will not matter, however, if appropriate habitat management is not followed to maintain suitable habitat conditions. Blunt-nosed leopard lizards, and many other small vertebrates in the San Joaquin Valley, do not tolerate persistent high cover of herbaceous plants (Germano et al. 2001, 2012). Grazing by livestock, or some other mechanism to remove herbaceous ground cover in high cover years, must be used on sites to provide proper conditions for lizard persistence.

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