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HABITAT CHARACTERISTICS OF PHRYNOSOMA MCALLII IN A DISTURBED ENVIRONMENT

A Thesis

Presented to

The Faculty of the Department of Biological Sciences

San Jose State University

In Partial Fulfillment

of the Requirements for the Degree

Master of Science

By

Beate Beauchamp

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ABSTRACT

HABITAT CHARACTERISTICS OF PHRYNOSOMA MCALLII IN A DISTURBED ENVIRONMENT

by Beate Beauchamp

A population of Phrynosoma mcallii was investigated at Ocotillo Wells State Vehicular Recreation Area, California, to determine if off-road highway vehicle activity influenced their habitat preferences. The habitat of Phrynosoma mcallii is usually described as desert flats with fine, aeolian sand, at the edges of, or away from dunes. At the study site the highest densities of P. mcallii were correlated with sparsely vegetated areas with large patches of silt, gravel, and concretions. These findings suggest that P. mcallii has shifted or dispersed to other habitats as a result of off-highway vehicle activity in sandy areas. Although the shift in habitat use of P. mcallii does not appear to be detrimental, its effects on the lizard should be further investigated using the linear model, describing the relationship between lizard density and key habitat features, developed in this study.

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INTRODUCTION

The horned lizard Phrynosoma mcallii occurs at low elevations in the deserts of southeastern California, extreme southwestern Arizona, and northern Baja California and Sonora, Mexico (Funk, 1981; Stebbins, 1985). Although P. mcallii was never considered abundant within its range (Norris, 1949), populations have declined even further over past decades because of continued habitat loss and destruction due to urbanization, agricultural development, and, possibly, off-road vehicle activity (Turner and Medica, 1982). Presently, P. mcallii is a California Species of Special Concern and is being considered for listing as a federally-threatened species (Salata, 1994). In lieu of listing, a conservation plan is currently being developed by various state and federal agencies. If this conservation plan meets U.S. Fish and Wildlife Service mandates, P. mcallii will not be listed.

The habitat of P. mcallii is usually described as desert flats with fine, aeolian sand at the edges of, or away from dunes (Klauber, 1932; Norris, 1949; Funk, 1981; Rorabaugh et al., 1987; Muth and Fisher, 1992). This lizard is structurally adapted to sandy environments; it has no ear openings and a dorso-ventrally flattened tail and body which allow it to "sand swim" (Norris, 1949; Stebbins, 1985).

Because P. mcallii have been observed to run with great speed in sandy environments, they are often mistaken for fringe-toed lizards, Uma spp. (Norris, 1949).

A population of P. mcallii is known to occur at Ocotillo Wells State Vehicular Recreation Area (Ocotillo Wells SVRA), California, an off-highway vehicle park. Although sandy areas are available at Ocotillo Wells SVRA, the majority of P. mcallii have been observed in areas with little or no sand present, some even in mud hills (Wone and Beauchamp, 1995). This apparent difference in habitat use makes it necessary to reevaluate the lizard's habitat preferences and determine if these observations indicate a shift in habitat use as a result of off-road vehicle (OHV) activity.

This study investigated whether OHV activity within Ocotillo Wells SVRA influenced P. mcallii habitat preferences by determining which habitat features within the area correlated to the highest densities of lizards. The results were then compared to previous habitat use observations of P. mcallii reported in the literature. Since most of the habitat descriptions of the lizard in the literature relate to substrate preferences, the primary habitat features measured were horizontal coverage of sand, hardpan, silt, concretions, gravel, rock, OHV trails and tracks (used as a measure of OHV impact), and slope. Perennial vegetation species and density were included in the analysis because these habitat features provide cover and a food source for the harvester ants (Veromessor spp. and Pogonomyrmex spp.) that the lizard eats. A linear model was developed describing the relationship between lizard density and key habitat features. The model needs to be tested, however, in other areas within the range of P. mcallii to determine if indeed a shift in habitat use has occurred because of OHV impact or if the lizard has a wider habitat preference than previously described.

STUDY AREA

Ocotillo Wells State Vehicular Recreation Area is one of seven state vehicular recreation areas maintained by the Off-Highway Vehicle Division of the California Department of Parks and Recreation. It is located 144 km northeast of San Diego in the Colorado Desert of California on the boundary of Imperial and San Diego Counties (Figure 1). The 13,108 ha area is bordered on both the north and west side by Anza-Borrego Desert State Park. Pole Line Road forms the eastern and State Highway 78 the southern boundaries (Figure 2). Average annual rainfall is 87 mm. Summer temperatures range from 20° C at night to 48° C during the day. Winter daytime temperatures are typically 20° C with lows around 0° C at night. The topography of much of the SVRA is generally flat, with some areas of moderately-rugged hills, mud hills, and dune systems. The soils are mainly unconsolidated silt. Creosote bush (Larrea tridentata), burroweed (Franseria dumosa), and saltbush (Atriplex spp.) are the major plants within the SVRA (Kutilek et al., 1991).

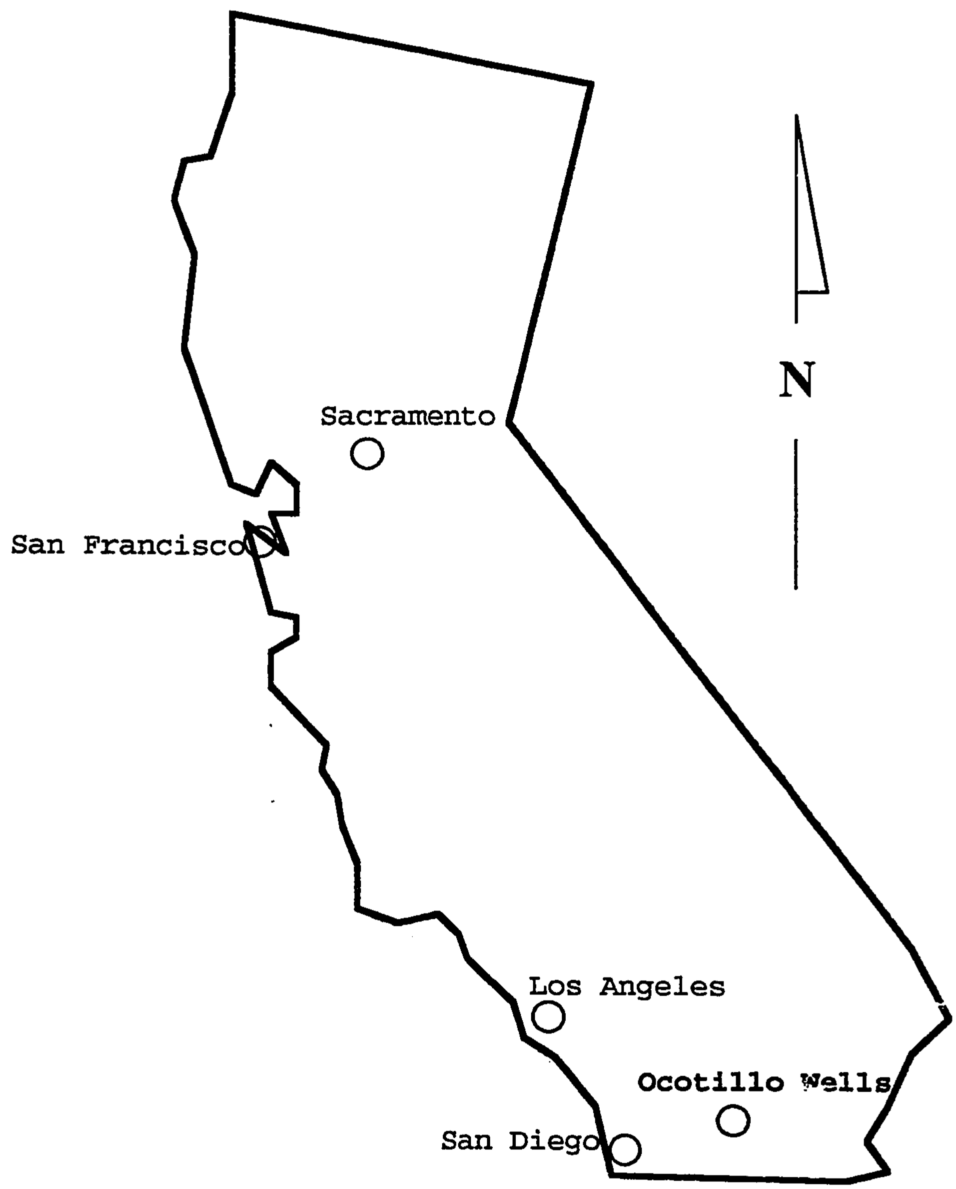

Figure 1. Location of Ocotillo Wells State Vehicular Recreation Area in California.

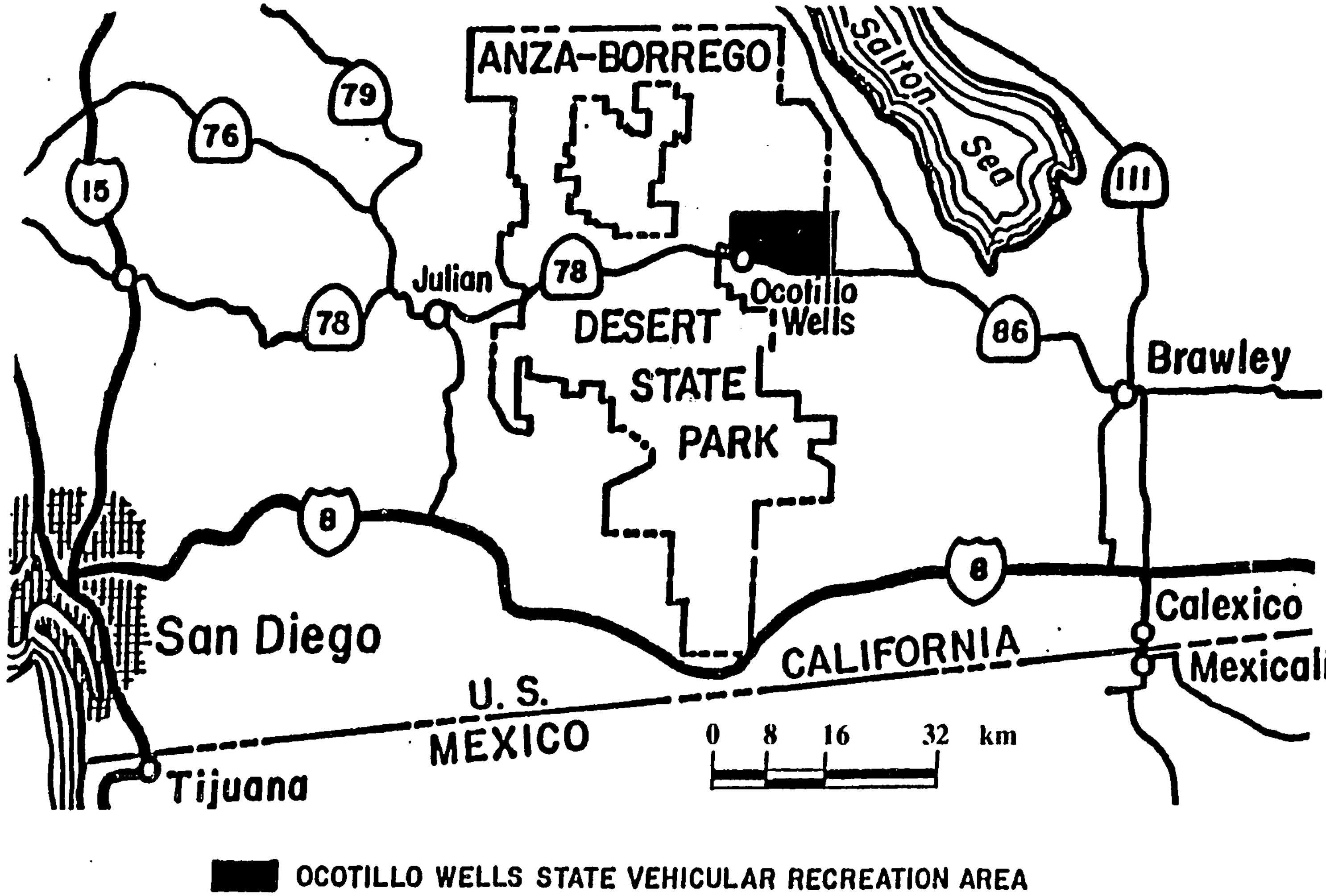

Figure 2. Location of Ocotillo Wells State Vehicular Recreation Area in southern California.

METHODS

Relative densities (number/m^2) of P. mcallii were estimated within ten 1200 X 400 m randomly established plots at Ocotillo Wells SVRA in June and July, 1995. This design was chosen over more numerous, but smaller plots to increase the resolution of the sampling design. The plots were surveyed by two observers walking twenty 400 m x 2 m belt transects, 20 m apart. The surveys were conducted between the hours of 0530 and 1100 h, when P. mcallii is known to be active. Every plot was sampled four times in June and July 1995. All P. mcallii encountered and captured along the transects were numbered ventrally with an indelible marker.

Substrate types (Table 1), horizontal coverage of the substrate, and slope were measured in each plot using nine randomly placed 50 m line-intercept transects (Brower et al., 1989). All substrate measurements were measured to the nearest ten cm. The angle of the slope of the transect line was measured with an inclinometer to the nearest 0.5° every ten meters along the transect line. Average substrate patch size and the associated standard deviation were calculated from the line-intercept data. Average substrate patch size was calculated by totaling all distances covered by the substrate and dividing by the total number of patch occurrences. Distance to the nearest perennial plant species

Table 1. Substrate types measured along the line transects at Ocotillo Wells State Vehicular Recreation Area, July 1995.

Substrate Type	**Description**
Sand	Layer of sand $\geq$ 3 cm in depth.
Hardpan	Solid hard packed surface, can be covered with a layer of sand less than 3 cm in depth.
Rocky	Substrate covered with rocks $\geq$ 5 cm in diameter.
Gravel	Substrate covered with gravel $\leq$ 5 cm in diameter.
Silt	Fine friable sedimentary soil.
Concretions	Hard, rock or slab-shaped cemented silt.
Track	Path or track made by off-highway motor vehicles.

and species of perennial was measured using the point-quarter method (Brower et al., 1989) in conjunction with the line-intercept transects. Distance to the nearest perennial was measured to the nearest ten cm at the 0, 25, and 50 m mark of the transect line. Average distance to the nearest perennial, plant richness (number of plant species) and evenness (measure of plant distribution and complexity) were then calculated from these data. Average distance to the nearest perennial was calculated by totaling all the distances to the nearest perennial and dividing by the total number of distance measurements (108 measurements/plot). Perennial vegetation richness was calculated by adding the number of plant species within a plot, evenness by Pielou's J method (Brower et al., 1989).

Principal Component Analysis (Tabachnick and Fidell, 1989) was used to provide quantitative descriptions of the habitat characteristics within each plot. Prior to analysis, percentage data were transformed by the arcsin of the square root. Principal Component Analysis (PCA) assumes a linear relationship between the variables. It also requires that the data used for analysis are continuous and normally distributed, and that there are at least five observations per variable. None of the variables can be highly correlated ($r > \pm 0.600$) for this analysis. Of the 18 habitat variables measured or calculated, only six variables met all the assumptions of the PCA. Mean width of OHV trail or track could not be included in the PCA because it was negatively correlated to mean patch size of silt (r = -0.740), sparse perennial vegetation (r = -0.700) and mean patch size of concretions (r = -0.630). The variables used for the PCA were mean distance to perennials and mean patch sizes of concretions, silt, gravel, sand, and hardpan. Only component loadings with absolute values $\geq$ 0.300 were interpreted as biologically significant.

A Pearson Product Moment Correlation Coefficient (Zar, 1984) was used to determine if there is a correlation between P. mcallii density and the factor scores generated by the PCA. The factor scores, which represented quantitative habitat descriptors, were interpreted using the component loadings from the PCA. The higher a component loading value, the more important the variable is in explaining the variance observed in the measured habitat features.

Linear regression was used to develop a model which predicts the relative density of P. mcallii given key habitat features. Only factor scores of the variables important in the PCA loadings were included in the analysis. Phrynosoma mcallii density was the dependent variable in the model. Ninety-five percent confidence limits were calculated for the linear regression.

RESULTS

Relative densities of P. mcallii within each plot (480,000 m^2/plot) at Ocotillo Wells SVRA varied from zero to eleven (Table 2). The total number of P. mcallii found in all ten study plots was fifty-six.

The PCA yielded three habitat descriptors (factors) that explained 78.7% of the variance observed in the measured habitat features (Table 3). Factor 1 explained 36.1% of the variance in the dataset and describes an area with increasing patches of silt, gravel, concretions, and sparse perennial vegetation. Factor 2 explained 25.5% of the variance and describes a gradient in habitat characteristics from large patches of sand, hardpan, concretions, and silt to sparse perennial vegetation. The third factor explained 17.1% of the variance and describes a gradient in habitat characteristics with increasing patches of hardpan to large patches of gravel and sparse perennial vegetation.

Phrynosoma mcallii densities were positively correlated to the first factor of the PCA ($r = 0.841$). High lizard density (high factor 1 score) was correlated with large patches of concretions, gravel, and silt, and sparse perennial vegetation. Areas with low lizard density (low factor 1 score) were correlated with small patches of concretions, gravel, and silt, and denser perennial

Table 2. Number of *Phrynosoma mcallii* found at the ten plots (480,000 m^2/plot) at Ocotillo Wells State Vehicular Recreation Area during the June and July 1995 sampling.

Study site	Number of lizards/plot
Alkali Trail	11
Bank Wash	6
Black Butte	4
Commune Road	9
County line	1
Gas Dome	8
Palo Verde	1
San Felipe	0
Shell Reef	11
Tule Wash	5

Table 3. Principal Component Analysis loadings on a subset of habitat variables sampled at Ocotillo Wells State Vehicular Recreation Area, July 1995. Only component loadings with absolute values ≥ 0.300 are interpreted as biologically significant.

Variables	Factor 1	Factor 2	Factor 3
Percent Variance	36.079	25.474	17.137
Cumulative % Variance	36.079	61.553	78.690
Mean patch size of concretions	**0.828**	**0.308**	0.086
Distance to perennials	**0.752**	**-0.456**	**0.359**
Mean patch size of gravel	**0.625**	0.239	**-0.505**
Mean patch of silt	**0.621**	**0.457**	0.191
Mean patch size of sand	-0.276	**0.892**	-0.153
Mean patch size of hardpan	-0.246	**0.405**	**0.759**

vegetation. Factors 2 and 3 did not correlate with lizard densities (r = 0.040 and r = -0.080, respectively).

The linear model describes a positive relationship of lizard density to key habitat features as: _P. mcallii_ density = 5.603 + 3.460 * Factor score (Figure 3). The slope of the model (3.46) was significantly greater than zero ($P < 0.002$). All plots except two fell within the 95% confidence interval.

Lizard density = 5.603 + 3.460 * Factor score. r = 0.841

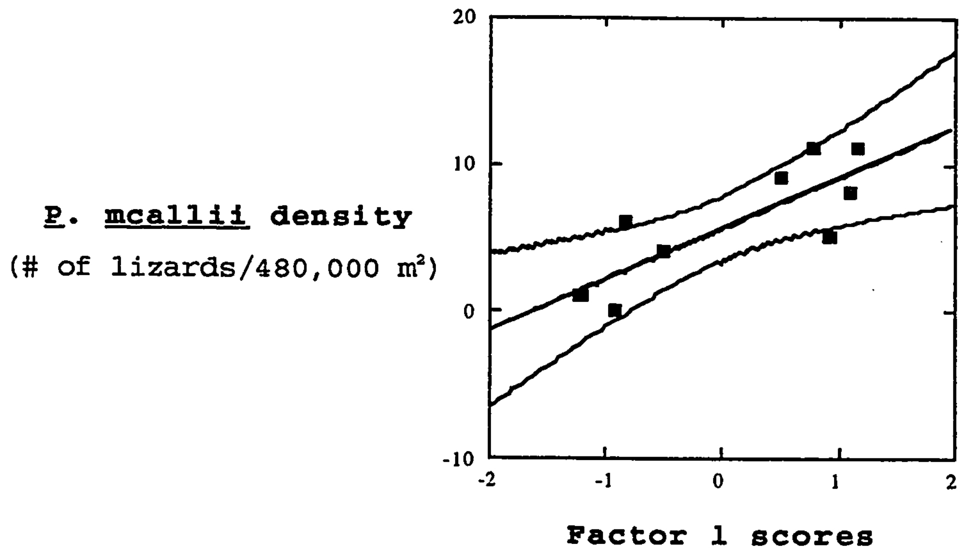

Figure 3. Phrynosoma mcallii density as a function of Factor 1 scores generated from the Principal Component Analysis of key habitat features measured at Ocotillo Wells State Vehicular Recreation Area, July 1995. Ninety-five percent confidence limits were calculated for the linear regression. A high factor 1 score correlates to a sparsely vegetated areas with large patches of concretions, gravel, and silt. Low factor 1 scores correlate to areas with denser vegetation and small patches of concretions, gravel, and silt.

DISCUSSION

The results showed that at Ocotillo Wells SVRA, sparsely vegetated areas with large patches of silt, gravel, and concretions support higher densities of P. mcallii than areas with small patches of silt, gravel, concretions, and dense vegetation. These results contradicted the findings of Klauber (1932), Norris (1949), Rorabaugh et al. (1987), and Muth and Fisher (1992) who described P. mcallii habitat as mostly sandy, while Turner and Medica (1982) showed the lizard to be positively correlated to perennial density. There are several possible explanations for the results in this study.

Previous studies based P. mcallii habitat preferences primarily on scat counts, since they are easier to find and more numerous than individual lizards, but two problems confound the use of scat as an indicator of lizard density. Scats are easier to see on sandy substrate because of their black color, but in gravely flats or concretions they blend in and are easily overlooked (pers. obs.). Most of the scats, therefore, would be observed in sandy areas, giving the impression that P. mcallii preferred sandy substrate. Second, no study has shown P. mcallii densities to be correlated to the number of scats observed. Scat can be used to some extent as an indicator of P. mcallii presence, but the absence of scat does not preclude P. mcallii from an area (pers. obs.). Muth and Fisher (1992), though, used actual lizard counts to arrive at the conclusion that the preferred substrate was sandy. Therefore, despite the problems of using scat to determine habitat use, some evidence supports the observations that sand is P. mcallii's preferred substrate.

Another possible explanation for the differences in observed habitat preferences involves the variation in perennial density. Phrynosoma mcallii is more easily seen on sandy substrate (pers. obs.), making it necessary for the lizard to have other means of escaping predation besides relying on cryptic coloration. These lizards have been observed to run for short distances (Norris, 1949; Wone and Beauchamp, 1995) or to hide in burrows (Wone and Beauchamp, 1995). These predation escape strategies are most effective if there is cover nearby, as is the case in areas with dense perennial vegetation and burrows at the bases of the plants; this would explain why Turner and Medica (1982) reported P. mcallii density on sandy substrates (measured by scat counts) to be positively correlated to perennial density.

A possible hypothesis why these lizards are found in habitats other than sandy ones is that they have shifted or dispersed to different habitats as a result of OHV activity. In Ocotillo Wells SVRA, most of the sandy areas are heavily impacted by OHV activity (pers. obs.). Bury et al. (1977) showed that there is a loss of terrestrial vertebrates where OHVs operate due to either direct mortality or destruction of plants and burrows that the animals need for food or cover. Phrynosoma mcallii could have dispersed into less impacted areas, which for the most part are sparsely vegetated with large patches of silt, gravel, and concretions in or near mud hills. A measure of OHV impact (i.e. mean width of OHV trails or tracks intercepting the transect) was among the variables that had to be excluded from the PCA because of cross-correlations. Mean trail or track width was inversely correlated to mean patch sizes of silt, concretions, and distance to perennials. Thus, the areas where most of P. mcallii are found also have narrower OHV riding trails or tracks. It is not clear, however, if the lizards are found in these areas because of habitat preferences or reduced OHV activity.

It appears, though, that the other habitats which P. mcallii now occupy are just as suitable. Gravely substrates, concretions, or silt provide a complex background which makes visual detection of the lizard difficult and there are ample hiding places in crevices, behind rocks and concretions, or even in shadows. Further, P. mcallii are often found perched on rocks or concretions in the mornings to thermoregulate (pers. obs.).

To test the hypothesis that P. mcallii has shifted to other habitats as a result of OHV activity, the linear model developed in this study should be tested in a control area with a similar variety of habitats as Ocotillo Wells SVRA. The model can be used to predict lizard densities in the control areas given key habitat features. Habitat preferences can be inferred from the number of lizards found in an area. Should the results of that study show that the habitat preferences are the same at the control site as they are at Ocotillo Wells SVRA, it would indicate that: 1) in areas with a variety of habitats P. mcallii is not restricted to sandy areas, and 2) OHV impact does not appear to be a factor in the preference of P. mcallii habitats. Such a finding would imply that this horned lizard might be found in other areas within its range that were not previously considered suitable and, therefore, not surveyed. On the other hand, should the results of the study show that the model only applies to Ocotillo Wells SVRA, then the conclusion would be that P. mcallii has shifted or dispersed to other habitats because of OHV activity. This would require a more detailed study to determine the degree of impact on the P. mcallii population and whether the population is stable in spite of OHV impact.

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