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Ecogeographical Distribution of the Herpetofauna of Indio Mountains Research Station, Hudspeth County, Texas

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By

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THESIS

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ABSTRACT

Indio Mountain Research Station (IMRS) in Trans-Pecos, Texas is dominated by Chihuahuan Desert scrub vegetation, but a complexity of plant communities exist relating to elevation, slope, and geologic formations. Surrounding the Indio Mountains are desert grasslands with various desert scrub associations. This mosaic of habitats forms a unique assemblage of amphibians and reptiles. The goal of this study was to determine if the current number of amphibians, turtles, lizards, and snakes (43 species) of IMRS was accurate and identify which biotic and abiotic factors define the distribution of these species. Records from the last approximately 25 years were used to determine species presence at localities throughout IMRS. Surveys were conducted throughout IMRS in 2011. Eight sites across IMRS were sampled with walking searches and pit-fall trapping to compare their herpetofaunal communities and the vegetation community of each site was quantified. No new species were documented. *Cophosaurus texanus* and *Aspidoscelis tesselata* were the only species present at all trapping sites. Many other species were recorded throughout IMRS. Double Tank Corral, Oak Arroyo, and Squaw Spring possessed the most distinct vegetation communities. IMRS Headquarters, Prospect Pits, and Squaw Spring shared the most similar herpetofaunal communities, and Lonely Tank had the most dissimilar community. Soils, thermal environment, slope orientation, elevation, vegetation, microhabitat diversity, and water sources are factors likely limiting distribution and influencing habitat occupancy of amphibians and reptiles on IMRS. This thesis represents the current knowledge of amphibian and reptile distribution on IMRS, the major mechanisms influencing species distribution, and identifies the gaps in knowledge necessary to accurately identify population dynamics and interpret community changes on the research station. A species account of all known taxa is also presented.

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INTRODUCTION

Indio Mountain Research Station (IMRS) is a land holding of the University of Texas at El Paso (UTEP), located in the northern Chihuahuan Desert of Trans-Pecos, Texas. This property is exclusively utilized for field-based scientific research and education. Since UTEP gained full management of the land in 1992, extensive scientific surveys and studies have been conducted there. The fields of botany, entomology, geology, herpetology, and mammalogy, among others, are regularly investigated on IMRS (Johnson, 2000; Worthington et al., 2004).

During the last 19 years, several projects have been conducted on different aspects of the herpetofauna (reptiles and amphibians) occurring on IMRS (Rael et al., 1992; Gordon, 1997; Johnson and Johnson, 1999; Dominguez, 2000; Hotchkin and Riveroll, 2005; Mata-Silva, 2005; Miranda et al., 2008; Lenhart et al. 2010; Johnson et al., 2004, 2007; Mata-Silva et al., 2006, 2008, 2010a, 2010b, 2010c; several *in prep*). Herpetofaunal studies were normally performed by researchers during daytime and nighttime hours throughout yearly activity periods, from approximately late March through early November. Those surveys, literature sources, and chance encounters have provided the current list of amphibian and reptile species (six amphibians, two turtles, 15 lizards, 20 snakes) known from IMRS (Appendix 1; Worthington et al., 2004; available at www.utep.edu/indio). Areas close to the IMRS headquarters compound, which is centrally located on the property, have received the most intensive searches, so present species records are negatively correlated with the distance away from the headquarters. Earthen tank areas have also been thoroughly searched. Many of the more remote areas of IMRS have received little or no attention by researchers. Appendix 2 is a list of species whose occurrence on IMRS property is possible, based on county range maps found in Dixon (2000).

The following information is taken from Johnson (2000) and Worthington et al. (2004): IMRS consists of approximately 16,000 hectares (*ca*. 40,000 acres) and contains most of the Indio Mountains, the lower southern spur of the Eagle Mountains located directly to the north. Surrounding the Indio Mountains to the north, east, and west are rolling desert grasslands with various desert scrub associations. The Rio Grande Valley lies directly to the south and southwest of IMRS. While the majority of IMRS contains the Indio Mountains, dominated primarily by Chihuahuan Desert scrub vegetation (Leopold, 1950; Morafka, 1977; Henrickson and Johnston, 1983), it is conceivable that peripheral species not associated with the more rugged montane habitats will occur on its fringes or in relict areas.

Ecological biogeography is defined as the science "which attempts to account for present distributions and geographic variation in diversity in terms of interactions between organisms and their physical and biotic environments" (Lomolino et al., 2010). Other herpetologists have investigated the biogeography of the herpetofauna in different regions of the southwestern U.S. and northern/central Mexico (e.g., Duellman, 1965; Gehlbach, 1965; Hardy and McDiarmid, 1969; Morafka, 1977; Webb, 1984; Wilson and Johnson, 2010; among others). Those studies covered large areas containing multiple biomes and landscapes. Although IMRS is covered primarily by a Chihuahuan Desert scrub association, the property contains a complexity of plant communities relating to elevation, slope, and a variety of geologic formations (Worthington et al., 2004).

Barbault and Maury (1981) found that general distribution of Chihuahuan Desert lizards followed the distribution of plant communities and soil types. Additionally, Baltosser and Best (1990) found that in southwestern New Mexico, some lizard species utilized the available habitat in roughly the same proportions in which it occurred, while other species were more selective in

their use of habitat. The herpetofauna of Black Gap Wildlife Management Area (Axtell, 1959) and the Big Bend region of Texas (Minton, 1958) were observed occupying only certain habitat types. Lastly, Beck (1995) found that sympatric rattlesnakes in the Sonoran Desert of southeastern Arizona occupied unique habitats and microhabitats.

The ecogeographic analysis presented herein was to determine and comprehend the distribution of the herpetofauna across a Chihuahuan Desert environment. Dramatic changes in the herpetofaunal community structure are not expected across a superficially homogeneous vegetation community, but understanding interactions between a species and its physical and biotic environments will reveal the distribution of these amphibians and reptiles at a finer scale.

The protocols used in this study were approved by the UTEP Institutional Animal Care and Use Committee (# A-201004-1). The style of this paper follows that found in the Journal of Herpetology.

MATERIALS AND METHODS

Study Area. - This study was performed on IMRS (commonly referred to as Indio Ranch), centered on latitude/longitude 30.776667°N. 105.015833°W, located in southeastern Hudspeth County, Texas, about 40 km southwest of Van Horn (Fig. 1). The following description of IMRS is based on Johnson (2000) and Worthington et al. (2004; www.utep.edu/indio/).

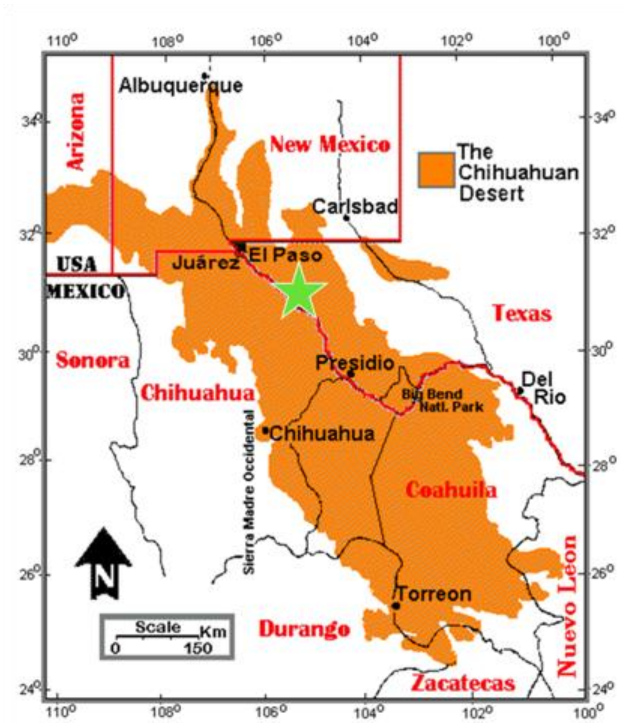

FIG. 1. Location of Indio Mountains Research Station, Hudspeth County, Texas is depicted by the star.

Vegetation of Indio Ranch is considered Chihuahuan Desert scrub (Henrickson and Johnston, 1983), and is comprised primarily by Creosotebush, Lechuguilla, Ocotillo, and Yucca associations and Tabosa-Black Grama desert grassland. Plant communities vary with elevation, slope, and geologic formations. Flora characteristic of the Big Bend region disperse along the Rio Grande Valley, thus influencing the vegetation communities on IMRS. Fragments of desert grasslands are present, possibly by encroachment of the desert grasslands that occur in the desert

flats surrounding the Indio Mountains to the north, east, and west. Surveys have identified about 375 plant species, although approximately 500 species are expected to occur on IMRS.

IMRS possesses a complex geology. The eastern slopes of the Indio Mountains are primarily Cretaceous limestone, and the western slopes contain Permian conglomerates, sandstones, and shales. Basalts, pumice, and ashfall layers in the south-central portion of IMRS indicate Tertiary volcanism. Salts and gypsum occur there as well, and clay and gravel beds are located on southern areas of the property nearest the Rio Grande. Elevation ranges from about 900 m near the Rio Grande to approximately 1640 m at several higher peaks (e.g., Squaw Peak).

Annual precipitation is typically less than 25 cm per year, with most falling during the summer monsoon season (June – September). Earthen cattle tanks remain from the former ranching industry on the property and many of them still collect water during the summer rainy season. Squaw Spring offers a permanent source of water and sometimes flows for a few hundred meters along Squaw Creek.

Herpetofaunal Community. - Records from sites regularly visited in the past were examined to document the herpetofaunal community of those areas and associated habitat types, including three areas containing pit-fall trap arrays in use prior to this study (Site 2, Squaw Spring; Site 3, IMRS Headquarters; and Site 4, Prospect Pits [Fig. 2]). Records came from observations documented in various field journals and museum specimens deposited in the Laboratory for Environmental Biology (LEB), Centennial Museum at the University of Texas at El Paso dating back to the late 1980's. Five other areas that had received few or no surveys were intensively examined using newly constructed pit-fall trap arrays and by walking searches (Site 1, Woodpecker Well; Site 5, Double Tank Corral; Site 6, Oak Arroyo; Site 7, Red Tank; and Site 8, Lonely Tank [Fig. 2]). Pit-fall traps were opened each week, usually for three days, to capture

specimens; they were checked each morning and sometimes in the evening. Additionally, visual surveys were conducted during the daytime and nighttime hours to determine the presence or absence of species at locations throughout IMRS, including pit-fall trap sites. Specimens showing significant distributional records were transported to UTEP and deposited into the LEB Collection.

Vegetation Community. - The plant community of each trap site was evaluated by a variation of the line-intercept method, as presented in Etchberger and Krausman (1997), who found that method to be the most accurate at quantifying desert plant communities. This analysis was used to determine differences in plant communities between the eight sites that contained pit-fall trap arrays. To determine the percent occurrence of plant species, eight points were randomly selected (www.random.org) at each pit-fall trap site. These points fell within a 100 m radius centered on the middle pit-fall trap at each site. Four 30 m transect lines radiated from each of those eight points in randomly selected directions (www.random.org); 32 transects total per trap site. Each plant that intercepted the 32 radiating transects was counted as a hit. Only living, perennial species of all size classes were counted, as small annuals would not provide lasting cover and structure. The percent occurrence of the vegetation was calculated by dividing the total number of hits for each plant species by the total number of hits for all species.

Trapping Sites. - Herpetofaunal searches took place across IMRS, but eight sites were chosen to allow for comparison between different areas of Indio Ranch (Fig. 2); they are described as follows:

Woodpecker Well. - This site contains five pit-fall traps, centered on 30.813999°N, 105.048784°W, and was the northernmost site investigated on IMRS, with surveys beginning in 2011 (Fig. 3). The traps are situated on a slight southeast facing slope at an elevation of 1262 m

in an area of pebbled substrate dominated by various grasses, Western White-thorn Acacia, Plumed Crinklemat, and Catclaw. Surrounding the traps are conglomerate slopes and small hills with intersecting arroyos, which appeared less vegetated than at other areas, such as Prospect Pits and IMRS Headquarters, and many contained large amounts of sand.

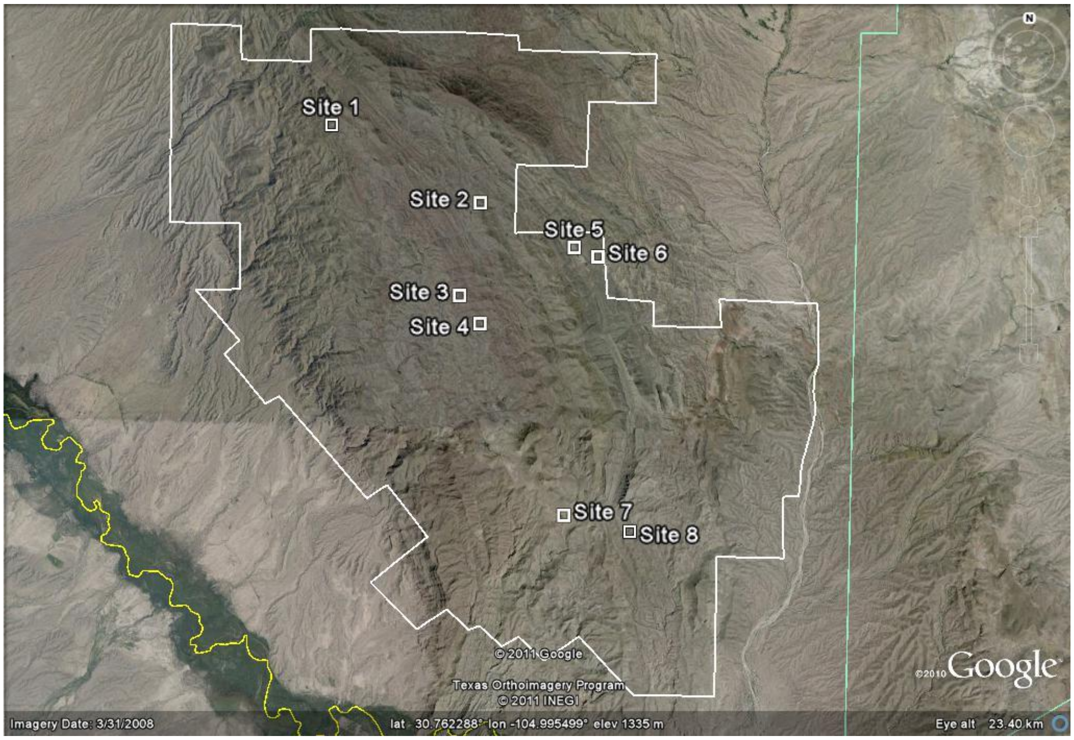

FIG. 2. Locations of the eight pit-fall trap transects on IMRS used to sample amphibians and reptiles. Site 1: Woodpecker Well; Site 2: Squaw Spring; Site 3: IMRS Headquarters; Site 4: Prospect Pits; Site 5: Double Tank Corral; Site 6: Oak Arroyo; Site 7: Red Tank; Site 8: Lonely Tank.

Squaw Spring. - Squaw Spring is a water source seeping out of ground into a large arroyo (Squaw Creek Canyon) and is the only known permanent surface water resource on IMRS (Fig. 4). There is a main spring pool near the source and water runs from there within the arroyo for variable distances depending on source flow. This wetland environment has produced a unique assemblage of dense flora, comprising a semi-riparian zone containing Southern Cattails,

Gooding's Willow, Screwbean Mesquite, and Fourwing Saltbush. The dominant vegetation bordering Squaw Spring is various grasses, Mariola, Lechuguilla, and Catclaw. The arroyo ecosystem is in a constant state of flux due to flooding from occasional heavy rains, especially during the summer monsoon season. A variety of rock types are present here, with fossiliferous limestone of Cretaceous age forming steep rock formations along the arroyo, especially near the water source. Along the open arroyo, bare rock and dense vegetation create a mosaic of open and closed canopy areas. Five pit-fall traps, centered on 30.797408°N, 105.010881°W, have been in place for over 10 years. The traps are located above the main pool at an elevation of 1270 m; mountain peaks directly adjacent to the arroyo reach as high as 1340 m.

IMRS Headquarters. - All building facilities of Indio Ranch sit on an alluvial fan at 1235 m elevation that is surrounded by conglomerate slopes and smaller limestone hills (Fig. 5). Dominate plants of this site include a variety of grasses, Creosotebush, Western White-thorn Acacia, Plumed Crinklemat, and Honey Mesquite. The soil, due to weathered conglomerate from adjacent slopes, is dominated by pebbles and clay. A total of 51 pit-fall traps, which have been in use for approximately 17 years and are centered on 30.776608°N, 105.015895°W, surround the facilities. This large array has multiple orientations with traps situated on foothills, alluvial fans, and within arroyos. This site has the most recent anthropogenic effects due to the concentration of buildings, water and electrical utilities, and vehicle demands.

Prospect Pits. - This site is adjacent to and southeast of IMRS Headquarters and has primarily the same physical characteristics (Fig. 6) as the former site. Thirty pit-fall traps centered on 30.772087°N, 105.011244°W, were put in place in 2004 on a westward orientation at 1234 m elevation. This site is a complex of heavily vegetated arroyos and very open alluvial

FIG. 3. Landscape of Woodpecker Well site.

FIG. 4. Landscape of Squaw Spring site.

FIG. 5. Landscape of IMRS Headquarters site.

FIG. 6. Landscape of Prospect Pits site.

FIG. 7. Landscape of Double Tank Corral site.

FIG. 8. Landscape of Oak Arroyo site.

FIG. 9. Landscape of Red Tank site.

FIG. 10. Landscape of Lonely Tank site.

fans. This site is dominated by various grasses, Creosotebush, Plumed Crinklemat, Prickly Pear, and Ocotillo.

Double Tank Corral. - This site has been a popular location for herpetofaunal searches since the time UTEP took active control of IMRS in 1987 (Fig. 7). Following the development of facilities at IMRS Headquarters, focus of those searches shifted there. Double Tank Corral is located between Pirtle Tank and Road Tank, and is now a large open space with some encroaching vegetation with an active seismograph station inside wooden corral fences. Road Tank, located directly north of the corral, retains water longer than other IMRS tanks after the monsoon season. Five pit-fall traps at 1333 m elevation, centered on 30.788276°N, 104.986758°W, were restored for this study approximately 100 m north of Road Tank. Pit-fall traps are situated among low hills on Creosotebush flats and inside an arroyo. The vegetation is dominated by various grasses, Prickle-leaf Dogweed, Creosotebush, Mariola, and yucca. The substrate is exposed in some areas, but otherwise contains small sedimentary and igneous rocks, with loose soil underneath. Slopes of the surrounding hills are covered with limestone.

Oak Arroyo. - This site sits at 1320 m elevation and is the first arroyo crossed after entering IMRS East Gate (Fig. 8). This arroyo courses through low hills leading up to the main Indio Mountains range. The most distinctive characteristic of this area is the presence of Littleleaf Sumac, Sandpaper Oak, and Red Berry Juniper. The vegetation community here suggests it is one of the more mesic areas of IMRS, and is dominated by various grasses, Mariola, Western White-thorn Acacia, Prickle-leaf Dogweed, and yucca. Within the heavy vegetation of the arroyo edge, five pit-fall traps, centered on 30.786180°N, 104.980686°W, were placed on a slight westward oriented slope for this study. Outside the arroyo, the ground is

covered with limestone shards and some sedimentary rock outcrops exist. The slopes of the surrounding hills are covered with small, lightly colored sedimentary rocks.

Red Tank. - Red Tank is an ephemeral water body at 1186 m elevation with the potential, given enough rain, to cover the most surface area of all ephemeral tanks on IMRS (Fig. 9). Typical of all earthen tanks on IMRS, it is surrounded by vegetation at higher densities than the surrounding desert landscape, especially Honey Mesquite. The large arroyo that feeds into the tank is also heavily vegetated. Creosotebush, various grasses, Honey Mesquite, and Plumed Crinklemat dominate the area. Some of the soil around the tank is very loose, and the ground is covered with pebbles and scattered medium light and dark stones. This site was a popular area for walking searches, but it was not until this study was initiated that five pit-fall traps, centered on 30.731135°N, 104.988794°W, were placed adjacent to the tank on Creosotebush flats with a slight southern orientation.

Lonely Tank. - Lonely Tank is another earthen tank at 1190 m elevation on IMRS, but it does not hold any water (Fig. 10). The tank is situated within a large drainage system running directly to the Rio Grande. The tank and the surrounding area are dominated by various grasses, Mariola, Creosotebush, and Honey Mesquite. Hills around the tank are dominated by various grasses and small shrubs. The slopes of those hills are very steep, loose, and covered by small lightly colored sedimentary stones, with some scattered medium red stones. Five pit-fall traps, centered on 30.728003°N, 104.972436°W, were placed at the beginning of this study around the depression of the tank, which has no specific directional orientation.

Data Analysis. - Data was analyzed to correlate the herpetofaunas of the different sites with each other. From the eight survey sites, similarity matrices, using presence/absence data, were made to compare the faunal resemblance factor (FRF) between each site (Duellman, 1965)

using the formula FRF = 2C/N1+N2, where C = number of taxa common to two areas; N1 = number of taxa present in one area, and N2 = number of taxa present second area. In this formula, a FRF value of 0 means two areas have no taxa in common, while a FRF value of 1 means that all taxa are common to both areas. An unweighted pair-group method with arithmetic averages (UPGMA) dendrogram (Sokal and Michener, 1958) was developed from the FRF values to depict the similarity relationships between sister areas on a hierarchical basis.

Species Accounts. - Species accounts are presented for all amphibians and reptiles recorded from IMRS. The accounts contain sections on ecogeographic remarks that describe known characteristics reported for each species throughout their range and distribution notes for each species on IMRS. Also, when relevant, taxonomic notes are included that identifies recent changes in family and genus names, therein listing authorities for the changes.

RESULTS

Vegetation Community. - The vegetation community at each trapping site was quantified, revealing the most abundant plant species (Table 1). Various grasses, herein regarded as a guild of ecologically and phylogenetically related species, were the dominant vegetation at all sites except Red Tank, where it was second most abundant (20.91%) to Creosotebush (43.27%). Grasses at Woodpecker Well were remarkably more abundant (76.41%) than at any other site (40.43% next highest at Squaw Spring). Prickle-leaf Dogweed was a common species at both sites near the IMRS East Gate, Double Tank Corral (17.21%) and Oak Arroyo (7.30%), but was rarely encountered at the remaining sites in the interior of the Indio Mountains proper. Otherwise, all sites shared similar common plant species, albeit at different abundance levels. Interestingly, Prickly Pear was present in relatively low numbers at all sites, except at Prospect Pits (10.39%) were it was only marginally abundant. The number of plants at different sites is variable, with Oak Arroyo (1506) and Woodpecker Well (1522) having nearly three times as many individual plants than Red Tank (550), which had the lowest number. Sites with similar numbers of total plants counted may not contain a similar vegetation structure, as is the case with Oak Arroyo and Woodpecker Well. Oak Arroyo supported eight species which comprised 82.80% of the abundance, many of which were medium and large shrubs, whereas 83.44% of the abundance at Woodpecker Well was comprised of three species, of which 76.41% were grasses. Creosotebush, commonly referenced as a major Chihuahuan Desert representative, was one of the four most abundant plant species at five of the eight trapping sites (IMRS Headquarters [22.75%]; Prospect Pits [17.77%]; Double Tank Corral [13.30%]; Red Tank [43.27%]; and Lonely Tank [10.33%]). Facilitated by the permanent wetland present there, Squaw Spring is one of the most unique trapping sites, and contains six plant species that are not found at other

trapping sites. Of areas not associated with a permanent water source, Oak Arroyo is unique from other trapping sites, given the presence of Evergreen Sumac, Red Berry Juniper, and Sandpaper Oak.

Herpetofaunal Community. - Records for the herpetofauna were obtained through historical records and surveys conducted during this study (Table 2). See Species Accounts for additional information on each species. Each site has received different amounts of survey activities, as past assessments favored certain areas (e.g., Double Tank Corral, IMRS Headquarters, and Prospect Pits) over others. Lonely Tank and Woodpecker Well received little if any attention by researchers prior to this study. No new species were documented on IMRS during this study.

Except for *Anaxyrus punctatus*, amphibian records are very sparse, with many species known only from single records over the past 20 years. Turtle records are also very limited, with only single accounts of two species (*Kinosternon flavescens* and *Terrapene ornata*), which are questionable because neither has been observed during the past 15 years. Lizards are well represented throughout IMRS. Most species present at a trapping site were regularly encountered and many were common at several sites. Of total documented species, *Cophosaurus texanus* and *Aspidoscelis tesselata* were the only species present at all trapping sites. *Aspidoscelis inornata* and *Coleonyx brevis* were only absent from Lonely Tank. Snakes are also well represented throughout IMRS. *Crotalus molossus* was observed at all but one trapping site. *Crotalus atrox*, *Hypsiglena jani*, and *Thamnophis cyrtopsis* were observed at many of the trapping sites and other areas of IMRS; the latter was apparently not restricted to places that had either permanent or ephemeral water sources as commonly seen in other species of garter snakes.

TABLE 1. Percent occurrence of vegetation species at each trapping site. The four highest percent occurrence values for each site are in bold. Classification and common names of vegetation species follow that given in Powell (1998), Powell and Weedin (2004), and Worthington et al. (2004).

	% occurrence at trapping sites							
Species	Woodpecker Well	Squaw Spring	IMRS Headquarters	Prospect Pits	Double Tank Corral	Oak Arroyo	Red Tank	Lonely Tank
Acacia constricta (Western White-thorn Acacia)	**3.88**	1.50	**17.25**	3.63	6.98	**11.49**	1.09	
Acacia greggii (Catclaw)	**2.43**	**4.58**	4.71	0.88	1.33	2.39	1.64	3.99
Agave lechuguilla (Lechuguilla)	1.25	**10.07**		0.50	0.50	4.52	1.27	
Aloysia gratissima (White Beebush)	0.13	0.58		0.88	0.58	0.53		2.58
Aloysia wrightii (Wright's Beebush)	0.79	0.17	1.83	1.25	0.17		0.18	1.76
Atriplex canescens (Fourwing Saltbush)		0.67						
Baccharis salicifolia (Seepwillow)		2.08						
Berberis trifololiata (Laredo Oregon-grape)		1.16	0.39			0.33		0.47
Condalia ericoides (Javelina-bush)			0.65	0.50	0.67	0.73		
Condalia warnockii (Warnock Condalia)					1.41	0.13		
Cylindropuntia leptocaulis (Desert Christmas Cactus)	0.39	0.17	0.52	0.13	0.33	0.33	2.55	0.12
Dalea formosa (Feather Dalea)		1.91		0.25	1.08	1.59		0.12
Dasylirion leiophyllum (Green Sotol)	0.26	3.08			1.16	4.52		0.23
Echinocactus horizonthalonius (Turk's Head)	0.26				0.17			
Echinocereus pectinatus (Rainbow Hedgehog Cacuts)						0.07		
Echinocereus stramineus (Strawberry Hedgehog Cactus)	0.53	0.75	0.26	1.00	0.17	0.20	0.73	0.35
Ephedra aspera (Mormon-tea)	0.99	1.33	0.26		0.58	1.66		0.59
Fallugia paradoxa (Apacheplume)		0.17						
Flourensia cernua (Tarbush)	0.13		0.13		1.50	0.20	0.55	0.82
Forestiera angustifolia (Desert Olive)	0.26	0.17	0.65	0.63	0.17	0.86	0.18	1.29
Fouquieria splendens (Ocotillo)	1.91	0.08	1.18	5.76	0.50	0.13	0.91	0.23
Grass spp.	**76.41**	**40.43**	**32.29**	**38.42**	**30.34**	**34.99**	**20.91**	**40.73**
Gutierrezia sarothrae (Broom Snakeweed)		0.17			0.17	0.20		0.82
Hibiscus denudatus (Palefaces)	0.92	0.33	0.39					0.12
Juniperus pinchotii (Red Berry Juniper)						0.07		
Koeberlinia spinosa (Crucifixion-thorn)			0.78	0.38		0.40		0.23

TABLE 1 (continued). Percent occurrence of vegetation species at each trapping site. The four highest percent occurrence values for each site are in bold. Classification and common names of vegetation species follow that given in Powell (1998), Powell and Weedin (2004), and Worthington et al. (2004).

	% occurrence at trapping sites							
Species	Woodpecker Well	Squaw Spring	IMRS Headquarters	Prospect Pits	Double Tank Corral	Oak Arroyo	Red Tank	Lonely Tank
Krameria grayi (White Ratany)	0.53	0.17	0.39	3.25	1.16	1.33	0.91	
Larrea tridentata (Creosote-bush)	1.18	2.83	**22.75**	**17.77**	**13.30**	0.46	**43.27**	**10.33**
Leucophyllum minus (Big Bend Silverleaf)	0.13	2.33				1.53	2.00	0.70
Mimosa borealis (Fragrant Mimosa)	0.46	3.00	0.13			0.07		
Nolina erumpens (Beargrass)		0.08			0.17	0.40		
Opuntia imbricata (Cane Cholla)	0.13						0.18	
Opuntia schottii (Dog Cholla)			0.39		4.82			
Opuntia spp. (Prickly Pear)	2.17	1.41	1.44	**10.39**	0.17	1.33	1.82	3.52
Parthenium incanum (Mariola)		**14.23**	0.78	1.38	**8.06**	**13.35**	3.45	**13.26**
Prosopis glandulosa (Honey Mesquite)		0.25	3.40	0.38			**12.91**	**10.33**
Quercus pungens (Sandpaper Oak)						0.20		
Rhus microphylla (Littleleaf Sumac)					0.08	1.20		
Rhus virens (Evergreen Sumac)						0.07		
Salix gooddingii (Goodding Willow)		1.00						
Tamarix chinensis (Saltcedar)		0.17						
Thymophylla acerosa (Prickle-leaf Dogweed)	0.13		0.26		**17.21**	**7.30**		
Tiquilia greggii (Plumed Crinklemat)	**3.15**	1.41	**5.23**	**11.39**	3.33	4.25	**4.00**	4.46
Tiquilia hispidissima (Hairy Crinklemat)					2.16	0.93		0.12
Trixis californica (American Trixis)	0.53							
Typha domingensis (Southern Cattail)		0.58						
Viguiera stenoloba (Skeletonleaf Goldeneye)	0.26	1.83	0.13		0.67	0.73	0.55	1.64
Yucca spp.	0.72	0.08	0.52	1.00	0.91	1.26	0.36	0.94
Ziziphus obtusifolia (Lotebush)	0.07	1.25	3.27	0.25	0.17	0.27	0.55	0.23
Total Number of Plants Counted	1522	1202	765	799	1203	1506	550	852

TABLE 2. Herpetofaunal records for the eight trapping sites investigated in this study.

	Trapping Sites							
Species	Woodpecker Well	Squaw Springs	IMRS Headquarters	Prospect Pits	Double Tank Corral	Oak Arroyo	Red Tank	Lonely Tank
Anaxyrus cognatus			X					
Anaxyrus debilis			X		X			
Anaxyrus punctatus	X	X	X	X	X	X	X	
Anaxyrus speciosus					X			
Gastrophryne olivacea					X		X	
Scaphiopus couchii			X	X	X			
Terrapene ornata					X			
Kinosternon flavescens							X	
Crotaphytus collaris		X	X	X	X			X
Coleonyx brevis	X	X	X	X	X	X	X	
Cophosaurus texanus	X	X	X	X	X	X	X	X
Phrynosoma cornutum								
Phrynosoma modestum	X		X	X	X			X
Sceloporus cowlesi		X	X		X	X		
Sceloporus poinsetti		X	X		X	X	X	
Urosaurus ornatus	X	X	X	X	X	X	X	X
Uta stansburiana		X	X	X			X	
Plestiodon obsoletus		X	X	X				
Plestiodon tetragrammus		X						
Aspidoscelis exsanguis		X	X	X		X		X
Aspidoscelis inornata	X	X	X	X	X	X	X	
Aspidoscelis marmorata			X	X	X		X	
Aspidoscelis tesselata	X	X	X	X	X	X	X	X
Arizona elegans								
Bogertophis subocularis			X	X			X	
Gyalopion canum								
Lampropeltis alterna			X				X	
Masticophis flagellum			X				X	
Masticophis taeniatus	X	X	X	X				
Pituophis catenifer						X		
Rhinocheilus lecontei			X	X				
Salvadora deserticola		X	X	X	X			
Salvadora grahamiae			X	X			X	
Sonora semiannulata			X	X				
Tantilla hobartsmithi			X					
Trimorphodon vilkinsonii				X	X			
Crotalus atrox		X	X	X	X		X	
Crotalus lepidus		X	X	X			X	
Crotalus molossus	X	X	X	X		X	X	X
Diadophis punctatus			X					
Hypsiglena jani			X	X				
Rena humilis	X	X	X				X	
Thamnophis cyrtopsis		X	X	X	X		X	

A single record exists for *Arizona elegans* and *Gyalopion canum*, neither of which occurred at any of the eight trapping sites. Both species were found near IMRS Headquarters, but not close enough to be counted at that site. Additionally, there is a verified specimen of

Phrynosoma cornutum from IMRS, but the area of origin is unknown. Therefore, these species are listed, but no locality is given (Table 2; but see *Species Accounts*).

Comparison of Trapping Sites. - The Faunal Resemblance Factors (FRF) for the eight trapping sites were calculated to compare sites based on taxa they had in common. Sites were compared based on the total herpetofauna (Table 3) and lizards only (Table 4). Given few snake records at previously unvisited sites, lizards were looked at separately to confirm site relationships. No sites shared all taxa.   From the FRF values, UPGMA dendrograms were

TABLE 3. FRF values and number of the herpetofauna taxa in common between the eight trapping sites. Bold numbers indicate the number of species found at each site. Numbers above the bold numbers reflect the amount of species shared between two sites, and decimals below the bold numbers are the similarity values calculated from the FRF formula FRF = 2C/N1+N2, where C = number of species shared between two sites, N1 = number of species in site 1 and N2 = number of species in site 2.

	Woodpecker Well	Squaw Spring	IMRS Headquarters	Prospect Pits	Double Tank Corral	Oak Arroyo	Red Tank	Lonely Tank
Woodpecker Well	**10**	9	10	9	7	7	8	5
Squaw Spring	0.60	**20**	19	16	12	10	13	6
IMRS Headquarters	0.47	0.72	**33**	24	16	10	18	7
Prospect Pits	0.51	0.71	0.83	**25**	14	8	14	7
Double Tank Corral	0.47	0.60	0.60	0.62	**20**	8	11	5
Oak Arroyo	0.67	0.65	0.45	0.44	0.52	**11**	8	5
Red Tank	0.53	0.65	0.68	0.62	0.55	0.52	**20**	4
Lonely Tank	0.59	0.44	0.35	0.44	0.37	0.56	0.30	**7**

TABLE 4. FRF values and number of only lizard taxa in common between the eight trapping sites. Bold numbers indicate the number of species found at each site. Numbers above the bold numbers reflect the amount of species shared between two sites, and decimals below the bold numbers are the similarity values calculated from the FRF formula FRF = 2C/N1+N2, where C = number of species shared between two sites, N1 = number of species in site 1 and N2 = number of species in site 2.

	Woodpecker Well	Squaw Spring	IMRS Headquarters	Prospect Pits	Double Tank Corral	Oak Arroyo	Red Tank	Lonely Tank
Woodpecker Well	**6**	5	5	6	6	5	5	4
Squaw Spring	0.56	**12**	11	9	8	8	7	5
IMRS Headquarters	0.53	0.88	**13**	11	10	8	8	6
Prospect Pits	0.71	0.78	0.92	**11**	8	6	7	6
Double Tank Corral	0.75	0.72	0.87	0.76	**10**	7	7	5
Oak Arroyo	0.71	0.80	0.76	0.63	0.78	**8**	6	4
Red Tank	0.71	0.70	0.76	0.74	0.78	0.75	**8**	3
Lonely Tank	0.67	0.56	0.63	0.71	0.63	0.57	0.43	**6**

drawn to depict relationships between trapping sites (Figs. 11 and 12). Relationships between sites are mostly similar whether comparing all herpetofauna or only lizards. Both dendrograms agree to the top similarity relationships of Prospect Pits, IMRS Headquarters, and Squaw Spring. The tree comparing lizards (Fig. 12) resolves the unresolved relationship in the dendrogram for all species (Fig. 11). The similarity relationships in the middle sites (Red Tank, Double Tank Corral, Woodpecker Well, and Oak Arroyo) in both dendrograms differ, but both agree on placement of Lonely Tank as the most dissimilar site.

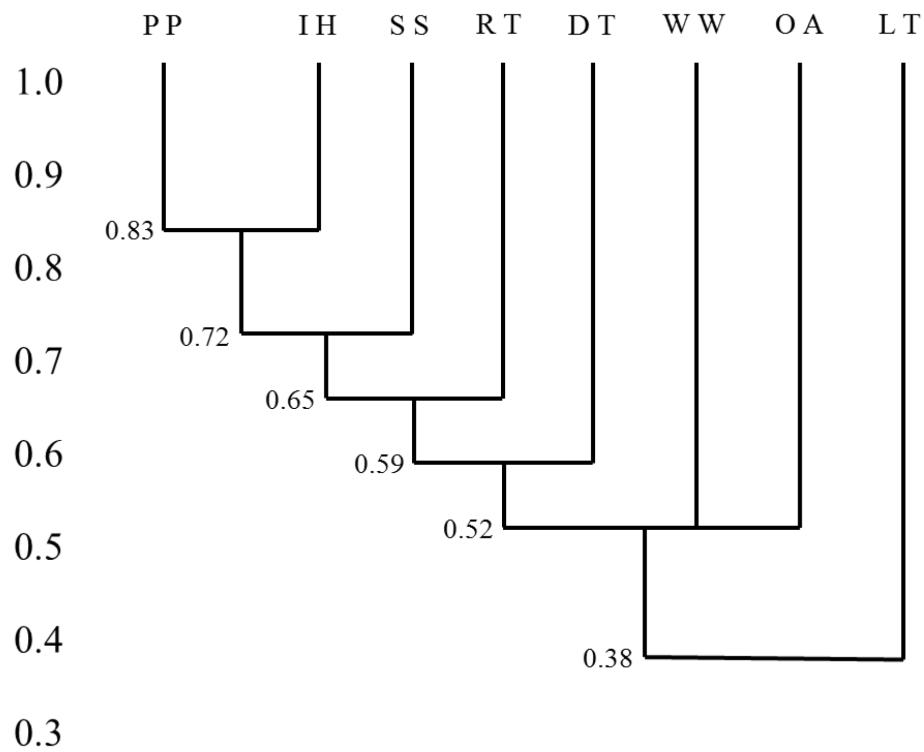

FIG. 11. UPGMA dendrogram for all the herpetofauna. Sites are abbreviated by their first initials. Values indicate the similarity coefficient. WP = Woodpecker Well; SS = Squaw Spring; IH = IMRS Headquarters; PP = Prospect Pits; DT = Double Tank Corral; OA = Oak Arroyo; RT = Red Tank; LT = Lonely Tank.

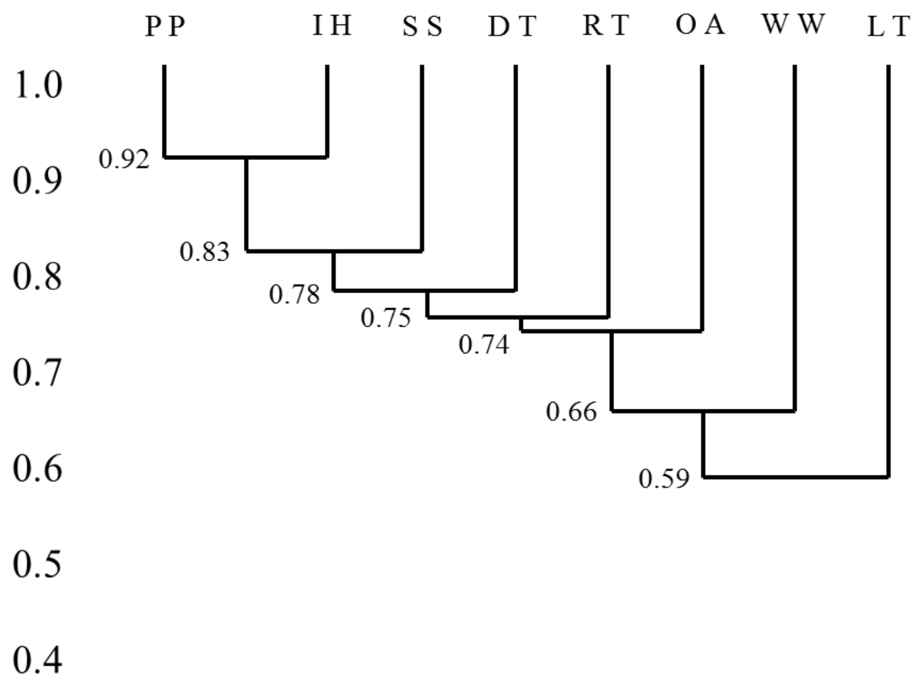

FIG. 12. UPGMA dendrogram for only lizards. Sites are abbreviated by their first initials. Values indicate the similarity coefficient. WP = Woodpecker Well; SS = Squaw Spring; IH = IMRS Headquarters; PP = Prospect Pits; DT = Double Tank Corral; OA = Oak Arroyo; RT = Red Tank; LT = Lonely Tank.

Species Accounts

Locations on IMRS listed within this section, other than the eight trapping sites described above, can be found in Appendix 3. A complete list of all locations on IMRS can be found in Worthington et al. (2004).

Class: Amphibia

Order: Anura

Family: Bufonidae

Taxonomic Note. - The genus for all bufonid toads occurring on IMRS was changed from *Bufo* to *Anaxyrus* by Frost et al. (2006).

Anaxyrus cognatus **(Great Plains Toad)**

Ecogeographic Remarks. - This widely distributed toad is typically found in grasslands throughout most of its range (Bragg, 1940; Bragg and Smith, 1943; Krupa, 1990). When this species ranges into more xeric environments, it will inhabit Chihuahuan Desert scrub, Creosotebush desert, mesquite woodland, and sagebrush plain associations (Morafka, 1977; Degenhardt et al., 1996). Bragg (1940) suggested that *A. cognatus* occupies different habitats in different portions of its range. Given the range of habitats in which it is found, it appears to be very adaptable to different environments. One of the limiting factors in the distribution of this species is likely loose or sandy soil, as it is a proficient burrower (Degenhardt et al., 1996; Lemos Espinal and Smith, 2007).

Distribution on IMRS. - Only a single record in 1991 from IMRS Headquarters exists for *A. cognatus*.

***Anaxyrus debilis* (Green Toad)**

Ecogeographic Remarks. - *Anaxyrus debilis* occurs primarily in the lower desert grasslands, canyon bottoms, and desert flats dominated by Creosotebush or mesquite (Minton, 1958; Creusere and Whitford, 1976; Degenhardt et al., 1996; Lemos Espinal and Smith, 2007). Dayton et al. (2004) found this species to be positively associated with both mixed-scrub and Creosotebush vegetation types in Big Bend National Park (also see *Discussion*). When they are available, earthen stock tanks are utilized (Axtell, 1959). However, Griffis-Kyle (2009) found *A. debilis* calling from small ephemeral water pools in close proximity to larger tanks, appearing to avoid the larger tanks that were frequented more by livestock. No size classes dig their own burrows, thus large cracks in the surface, rodent burrows, rocks, and other structures are exploited (Creusere and Whitford, 1976; Degenhardt et al., 1996).

Distribution on IMRS. - This species has been observed on the road to Squaw Spring north of IMRS Headquarters and in or near Pirtle Tank and Rattlesnake Tank.

***Anaxyrus punctatus* (Red-spotted Toad)**

Ecogeographic Remarks. - *Anaxyrus punctatus* is most commonly found in river bottoms, desert flats, and desert foothills at lower elevations (known limit is 1980 m), particularly around desert springs, ephemeral pools, and earthen tanks (Minton, 1958; Degenhardt et al., 1996; Bradford et al., 2003). Dayton et al. (2004) found this species to occur in rocky habitats more than the other amphibians in Big Bend National Park and were positively associated with mesquite thicket and water/bare habitats (also see *Discussion*). Bradford et al. (2003) reported site occupancy was affected by elevation, rockiness of the terrain, occurrence of scouring water flows, and ephemeral water and negatively associated with the extent of vegetation cover over

water and adjacent land. This species does not burrow and will retreat under structures, such as rocks (Degenhardt et al., 1996).

Distribution on IMRS. - This is the most frequently encountered amphibian on IMRS, and it has been observed at Double Tank Corral, IMRS Headquarters, along the Main Road, Oak Arroyo, Prospect Pits, Red Tank, Squaw Spring, and Woodpecker Well. *Anaxyrus punctatus* are found around many of the tanks and are equally common near pools of water remaining after rains in arroyos and rocky canyons. They are also found away from water sources on rocky hillsides and alluvial fans, and may be active even during non-rainy periods if humidity is high.

Anaxyrus speciosus (Texas Toad)

Ecogeographic Remarks. - A burrowing species, the Texas Toad favors sandy soils and is generally found in short-grass plains or mesquite grasslands (Degenhardt et al., 1996). Dayton et al. (2004) found this toad to be positively associated with mesquite thicket and water/bare habitats in Big Bend National Park (also see *Discussion*), and it occupied Tornillo and Glendale-Harkey soil types more frequently than would be expected if it were randomly using the habitat.

Distribution on IMRS. - A single record from 2006 exists from Pirtle Tank.

Family: Microhylidae

Gastrophryne olivacea (Great Plains Narrowmouth Toad)

Ecogeographic Remarks. - This is mostly a semiarid grassland species, particularly in areas with rocky cover (Lemos Espinal and Smith, 2007). Sullivan et al. (1996) reported *Gastrophryne olivacea* occupying the greatest variety of habitats, ranging from low-elevation Creosotebush flats through grasslands to oak-woodland communities, when compared to other anurans they studied in Arizona. In Big Bend National Park, it “occurs across low and mid elevation ranges, which includes a broad range of habitat types ranging from grasslands, sloped

well-drained rocky areas to clay-loam flats with relatively high water holding capacity" (Dayton and Fitzgerald, 2006).

Distribution on IMRS. - It was not until 2008 that this species was first observed at Peccary Tank. Sightings or choruses have since been made or heard at Echo Canyon Twin Tanks, Peccary Tank, Rattlesnake Tank, Red Tank, and Road Tank.

Family: Scaphiopodidae

***Scaphiopus couchii* (Couch's Spadefoot Toad)**

Ecogeographic Remarks. - In New Mexico, Degenhardt et al. (1996) reported *Scaphiopus couchii* as a resident of "arid grasslands and areas grown to creosote and mesquite, where soils are sandy and well drained." Dayton et al. (2004) found this toad to be positively associated with mesquite thicket and water/bare habitats in Big Bend National Park (also see *Discussion*), and it occupied Tornillo and Glendale-Harkey soil types more frequently than would be expected if it were randomly using the habitat. Some argue this species to be the most xeric adapted North American anuran (Degenhardt et al., 1996) and reports are available of *S. couchii* persisting in unusually harsh environments (Mayhew, 1965; Jones et al., 1983). Among its many adaptations to xeric habitats (e.g., behavioral, morphological, and physiological), a significant one is the rapid rate of tadpole metamorphosis (in as little as eight days), allowing it to utilize very short lived water pools (Mayhew, 1965).

Distribution on IMRS. - This species frequents Peccary Tank, Pirtle Tank, Rattlesnake Tank, Red Tank, and Road Tank, but is also found in areas far from large ephemeral pools, such as Prospect Pits. However, it is not commonly encountered and at least on IMRS, Red-spotted Toads seem to be more xeric adapted based on overall numbers observed away from water sources.

Class: CHELONIA

Order: Testudines

Family: Emydidae

Terrapene ornata (Ornate Box Turtle)

Ecogeographic Remarks. - *Terrapene ornata* can occupy a wide range of habitats but are most abundant in grasslands with soils suitable for burrowing (Degenhardt et al., 1996). Similarly, Dodd (2001) reports "semidesert lowlands and gravelly foothill slopes leading to surrounding mountains" as *T. ornata* habitat. Ornate Box Turtles in New Mexico were observed using Creosotebush, Tarbush, yucca, and mesquite for cover (Norris and Zweifel, 1950). Citations are available for this species occupying unusual areas and habitats containing both native and non-native dense riparian woodlands in Arizona (Messing et al., 2009), montane pine-oak forest at a high elevation (ca. 2180 m) in Arizona (Brennan and Feldner, 2003), and piñon-juniper-ponderosa woodland at higher elevations (2200 m and 2300 m) in New Mexico (Degenhardt et al., 1996).

Distribution on IMRS. - Only a single record from 1996 exists from Double Tank Corral. Ornate Box Turtles are occasionally seen crossing Green River Road south of Van Horn.

Family: Kinosternidae

Kinosternon flavescens (Yellow Mud Turtle)

Ecogeographic Remarks. - *Kinosternon flavescens* occupies shallow, quiet water sources in arid to semiarid grasslands and open woodlands, usually with vegetation and a sandy or mud bottom (Degenhardt et al., 1996; Lemos Espinal and Smith, 2007). Since this species spends most of its annual cycle buried on land, loose soils are another essential habitat requirement (Degenhardt et al., 1996). Only rarely did Degenhardt and Christiansen (1974) find this species

in permanent rivers in New Mexico, and their elevation is limited to below 1500 m (Degenhardt et al., 1996).

Distribution on IMRS. - This species is only known from a shell fragment found at Red Tank. It has been observed in a tank along Green River Road a few kilometers northeast of IMRS (Worthington et al., 2004).

Class: REPTILIA

Order: Squamata - Lizards

Taxonomic Note. - Present lizard families were determined by Frost and Etheridge (1989).

Family: Crotaphytidae

***Crotaphytus collaris* (Eastern Collared Lizard)**

Ecogeographic Remarks. - This species can be found in a variety of habitats ranging from grasslands to woodlands on level to sloping terrain (Degenhardt et al., 1996). It is most abundant in exposed rocky areas (Lemos Espinal and Smith, 2007), but riparian zones and rocky outcrops will allow it to disperse outside areas of typical abundance (Harris, 1963; Degenhardt et al., 1996). *Crotaphytus collaris* in northern Mexico primarily favored large rocks and rock pile microhabitats most (Lemos Espinal et al., 2009), and Legler and Fitch (1957) noted small cavities under rocks as common hibernacula. When comparing Creosotebush and grassland habitats in New Mexico, Menke (2003) never found this species in Creosotebush habitat. It occurs between 900 m and 2750 m elevation in New Mexico (Degenhardt et al., 1996).

Distribution on IMRS. - *Crotaphytus collaris* has been observed in many areas, including Double Tank Corral, IMRS Headquarters, Lonely Tank, Prospect Pits, and Squaw Creek Canyon. The only area where it has been seen to be abundant is along the Main Road in Echo

Canyon and arroyos the road subsequently passes through. The habitat in this area is rocky, alluvial slopes dominated by various grasses, Ocotillo, Lechuguilla, and Plumed Crinklemat. Large rocks are scattered on the slopes from original road construction.

Family: Eublepharidae

Taxonomic Note. - The family Eublepharidae was removed from the family Gekkonidae by Kluge (1987).

***Coleonyx brevis* (Texas Banded Gecko)**

Ecogeographic Remarks. - The Texas Banded Gecko can be found in rocky foothills and shrub dominated flats (Degenhardt et al., 1996; Lemos Espinal and Smith, 2007). Minton (1958) observed geckos from the banks of the Rio Grande to about 1828 m at Casa Grande in the Big Bend region of Texas and considered it most abundant in moderately rocky desert. Minton (1959) collected 39 in Black Gap Wildlife Management Area: 22 from limestone slope habitat (talus, gravel, rock slabs), 10 from the floodplain, six from igneous cap rock and talus habitat, and one from the streambed.

Distribution on IMRS. - This species is commonly seen throughout the research station. *Coleonyx brevis* have been found regularly under fallen yucca logs, which are likely an important microhabitat for these nocturnal geckos, as well as dense clusters of Prickly Pear and rock crevices.

Family: Phrynosomatidae

***Cophosaurus texanus* (Greater Earless Lizard)**

Ecogeographic Remarks. - *Cophosaurus texanus* occupies desert flats and foothills with gravelly to rocky substrates at elevations between 250 – 1545 m (Degenhardt et al., 1996; Lemos Espinal and Smith, 2007). In west Texas, it was most commonly found in areas dominated by

Creosotebush or mesquite and less frequently in barren areas and where Lechuguilla and Sotol grew; while in northern Mexico, it favored Lechuguilla or Creosotebush scrub associations followed by barren areas (Punzo, 2007). No significant habitat preferences between age classes were observed (Punzo, 2007). Smith et al. (1987) reported this species as primarily found in riparian habitats (77.9%) and arroyo edges (14.2%); it favored the sandy substrate strewn with boulders of the riparian zones 69.0% of the time. Relative abundance of *C. texanus* was reduced by heavy grazing in a variety of habitats in Arizona (Jones, 1981). Bashey and Dunham (1997) reported it to be more constrained by the thermal environment at a warmer site 560 m in elevation than at a cooler site 1036 m in elevation in Big Bend National Park.

Distribution on IMRS. - This species is the most frequently encountered lizard on IMRS and is present within all areas visited thus far. No studies have investigated how *C. texanus* utilizes different habitats on IMRS, but it does not appear to avoid the inside of arroyos and you can find this species around tank areas (e.g., Lonely Tank), which are characterized by loose, sandy soil and open, sometimes barren areas. At night they will burrow under the sand on dirt roads, as they have been observed fleeing after driving over the spot they were buried.

Phrynosoma cornutum (Texas Horned Lizard)

Ecogeographic Remarks. - *Phrynosoma cornutum* has a wide range in central and southwestern United States and northern Mexico, thus, it occupies a spectrum of soil types (from the pure sands of the Gulf Coast to coarse gravels and desert pavements) and vegetation associations, including shortgrass prairie, mesquite-grasslands, shrublands, and desert scrub (Price, 1990). In xeric areas, it ranges across open deserts and grasslands on sandy to gravelly soils below 1830 m elevation (Degenhardt et al., 1996). It was found to be common in yucca, Honey Mesquite, and *Ephedra* associations around playas (Whitford and Creusere, 1977) and

grassland and Creosotebush habitats (Menke, 2003) in southern New Mexico. Burrow et al. (2001), in the Honey Mesquite woodlands of south Texas, found that *P. cornutum* are active in areas of bare ground and herbaceous vegetation in the morning and evenings, but retreat to woody canopy cover and litter during the heat of the day. They go on to say this activity period and their seasonal activity periods mirrored that of their main prey, harvester ants (*Pogonomyrmex* spp.), which also utilize herbaceous areas for feeding (Holldobler and Wilson, 1990) and mound building (DeMers, 1993). Similarly, Whiting et al. (1993) indicated that vegetation density, the presence of foraging harvester ants, and open, partially vegetated habitat (which facilitate locomotion, foraging, and thermoregulation) account for its spatial distribution.

Distribution on IMRS. - Only a single record (Sul Ross State University, SRSU-89) exists as reported by Axtell (1996), who only lists the locality as "Indio Ranch (Cotton Trust of UTEP)". The exact collection site is unknown, but presumed to be near Double Tank Corral (Worthington et al., 2004).

Phrynosoma modestum (Roundtail Horned Lizard)

Ecogeographic Remarks. - The preferred habitat of this cryptic species varies between arid to semi-arid grassland, flats, and scrubland (Degenhardt et al., 1996; Whiting and Dixon, 1996). Rocky and gravelly soils are preferred, as confirmed by its absence from the sandy zones of the Llano Estacado in northwestern Texas and eastern New Mexico (Degenhardt et al., 1996; Whiting and Dixon, 1996). It can be found at elevations between 180 to 2225 m (Hodges, 2009). Baltosser and Best (1990) found this species in open yet structurally diverse areas in New Mexico. Munger (1984) noticed it foraging for ants away from the colony entrance.

Distribution on IMRS. - The relatively small size and cryptic nature of *Phrynosoma modestum* make this species hard to find, but a few individuals were observed or captured in pit-fall traps

each year. Individuals have been found at Double Tank Corral, Lonely Tank, IMRS Headquarters, Prospect Pits, Woodpecker Well, and on Purple Sage Mine Road. Small bushes and dense grasses seem common at most areas of capture. Habitats in which it has been found include hill tops, along a large arroyo, and an earthen tank.

Sceloporus cowlesi **(Southern Plateau Lizard)**

Taxonomic Note. - *Sceloporus cowlesi* was elevated from a subspecies of *S. undulatus* by Leache and Reader (2002).

Ecogeographic Remarks. - The Southern Plateau Lizard inhabits a wide range of habitat types, including woodlands, forests, boulder fields, and xeric habitats (Degenhardt et al., 1996; Babb and Leache, 2009). Depending on where it occurs, it can be arboreal, saxicolous (inhabiting or living among rocks), terrestrial, or a combination thereof (Mosauer, 1932; Degenhardt et al., 1996). Debris, rock piles, and yuccas are sought by this lizard in sagebrush or desert grassland habitats, and riparian corridors determine its distribution in xeric environments (Degenhardt et al., 1996). At White Sands National Monument in New Mexico, Hager (2001) found *Sceloporus cowlesi* predominately in the dune habitat (62%) and less often (34%) in the transition zone (ecotone) between dunes and the flats in May, June, and October, and in equal proportions from July to September. Hager (2001) also observed its close association with vegetation, but suggested that loose soil of the dunes may be more important to *S. cowlesi* because dunes contained the lowest frequency of vegetation compared to other areas. Some authorities report its affinity to arroyos and canyons (Mosauer, 1932; Minton, 1958; Axtell, 1959). In New Mexico, elevations from 900 m to 2750 m are inhabited where suitable habitat occurs (Degenhardt et al., 1996).

Distribution on IMRS. - This lizard is seen infrequently on IMRS, and records exist from Squaw Creek Canyon, Double Tank Corral, Oak Arroyo, and near IMRS Headquarters. Most sightings have been made in proximity to more heavily vegetated arroyos. Numerous observations were made at Oak Arroyo during this study.

Sceloporus poinsetti **(Crevice Spiny Lizard)**

Ecogeographic Remarks. - *Sceloporus poinsetti* is found in rocky areas of mesquite-grasslands, desert shrublands, oak-piñon-juniper woodlands, and spruce-fir forests (Degenhardt et al., 1996). Across their range, it can be found from elevations of 231 m to 2743 m (Webb, 2009). Mosauer (1932) found it "sharply restricted," as have others (Ballinger, 1973; Minton, 1958), to rocky areas containing large stones with linear fissures and crevices. Even in forest habitats, where it will also utilize larger tree trunks, it is most often found on rocks (Ortega et al., 1982). *Sceloporus poinsetti* will usually only venture one or two meters away from a crevice retreat and often occur in groups of 3 to 6 or more individuals centered around favorable microhabitats (Ballinger, 1973). Ballinger et al. (1977) reported an ontogenetic shift in diet from primarily carnivorous early in life to substantially herbivorous in adults (42% by volume prior to the summer rains). This could explain habitat preferences of adults as previously mentioned and reported lack of habitat restriction exhibited by immature individuals (Mosauer, 1932). Axtell (1959) found this lizard on a variety of rock types on Black Gap Wildlife Management Area.

Distribution on IMRS. - This species is found on rock formations that contain extensive fissures and crevices, which are most often found inside arroyos and on outcrops. Even small groupings of rocks (less than two meters in diameter) unconnected to larger formations have harbored *S. poinsetti*. Smaller rock formations and the fringes of larger formations in close proximity to vegetation are likely optimal habitat for adults considering their herbivorous diet.

This species has been found on igneous, limestone, and conglomerate formations on IMRS. Only during periods of dispersal is this species found outside its expected habitat. Records exist from Squaw Spring, along the road to Squaw Spring, Bailey Evans Arroyo, Echo Canyon, Agate Hill, Red Tank, Double Tank Corral, and Oak Arroyo.

***Urosaurus ornatus* (Tree Lizard)**

Ecogeographic Remarks. - *Urosaurus ornatus* is a widespread species in the southwestern United States and northern Mexico (Degenhardt et al., 1996). In many areas it has arboreal tendencies and is a resident of woodlands, forests, and riparian zones (Vitt et al., 1981; Morrison et al., 1995; James and M'Closkey, 2002). It reportedly occurs between elevations near sea level to 2440 m (Haase, 2009). However, in xeric environments with abundant rocky habitat it is most often found on rocks at low to moderate elevations (Degenhardt et al., 1996). In the Chiricahua Mountains of southeastern Arizona, Smith (1996) found *U. ornatus* to use slopes (north and south-facing) and habitats of covered woods and open rock slides in proportion to their occurrence on the study site. When considered separately, males and females did not differ in their use of slopes or habitats. In Arizona, where it occupied mesquite and other vegetation, M'Closkey et al. (1990) noted this lizard to be more abundant on dry washes than flatland habitats.

Distribution on IMRS. - A limited amount of searching on rocky outcrops across Indio Ranch will typically yield a Tree Lizard. *Urosaurus ornatus* commonly utilizes crevices in rock formations, but are not limited to formations with crevices. Individuals have been found on groups of large boulders and outcrops lacking crevices, but shaded by vegetation. Additionally, it has been observed on isolated rock structures less than one meter in diameter. Tree lizards do not appear to discriminate against conglomerate, igneous, or sedimentary rock types. *Urosaurus*

ornatus will also utilize dense vegetation present in arroyos, but to a lesser degree than rock structures. They can also be seen on buildings and fences around IMRS Headquarters.

Uta stansburiana (Side-blotched Lizard)

Ecogeographic Remarks. - It is difficult to pin-point the preferred habitat of *Uta stansburiana*, as this species has been reported from hillsides, boulders, desert washes, sand dunes, and sagebrush flats (Tinkle, 1967). Tinkle (1967) considers its geographic distribution to be generally limited by grasslands, tall mountains (>1828 m elevation), elevations and latitudes too cold for the species, and interspecific competition. Side-blotched Lizards reach their greatest densities in west Texas in areas of rolling sand dunes with a sparse 20% cover of desert vegetation (Tinkle, 1967; Milstead and Tinkle, 1969). In southwestern New Mexico, Baltosser and Best (1990) reported its association with Honey Mesquite and Creosotebush on rocky to sandy soils; they noticed a shift in late summer to areas dominated by Snakeweed, perhaps due to flowering that increased prey abundance. In Baja California Sur, Mexico, Galina-Tessaro et al. (2003) found *U. stansburiana* to be the most abundant lizard in areas with 11% to 50% vegetation cover and sandy to coarse soil types. Despite its occurrence in relatively open areas, it is found mostly under available vegetation (Peterson and Whitford, 1987; Galina-Tessaro et al., 2003). Increase in grass cover after livestock (Castellano and Valone, 2006) and shrub (Peterson and Whitford, 1987) removal favored this species.

Distribution on IMRS. - This species is found only a few times each year. Its uncommon occurrence may be due to limited sandy substrate and grassy cover, or by interspecific competition, although its abundance has not been directly studied. *Uta stansburiana* is captured occasionally in pit-fall traps at Prospect Pits, where most traps are situated on alluvial fans above intersecting arroyos. The limited trapping success could suggest this lizard utilizes arroyo sides

and bottoms characterized by dense vegetation and sandy to fine gravel soils, respectively. It has also been seen at Squaw Spring and Red Tank, which has looser soils than the surrounding habitat.

Family: Scincidae

Taxonomic Note. - The genus name of all skinks occurring on IMRS was changed from *Eumeces* to *Plestiodon* independently by Smith (2005) and Brandley et al. (2005).

***Plestiodon obsoletus* (Great Plains Skink)**

Ecogeographic Remarks. - The following is adapted from Degenhardt et al. (1996): Great Plains Skinks can be found in Chihuahuan Desert scrub, desert-grasslands, riparian zones, and woodlands up to elevations of 2300 m in New Mexico; its preferred substrate is sandy to gravelly soils. This species is always found within mesic microclimates and is mostly associated with major river systems in New Mexico. It is primarily fossorial and often uses rodent burrows.

In the southwestern part of its range, *Plestiodon obsoletus* is largely confined to the rugged terrain of mountain slopes and canyons, and is rare or absent in the desert plains (Fitch, 1955). Fitch (1955) found the largest populations in areas with perennial grass cover and suggested this type of cover created a mesic microclimate, offering favorable conditions to the skink while foraging. Menke (2003) did not consider this skink to prefer a particular habitat in southern New Mexico when comparing a grassland, Creosotebush flat, and the ecotone between them, but noted that their presence in the more open Creosotebush habitat was always near a large clump of grass or an arroyo. Whitford and Creusere (1977) reported a local radiation of *P. obsoletus* from the mesic mountain slopes to Creosotebush dominated bajadas and mesquite habitats. They attributed this to the expansion of mesic areas following above average rainfall.

Distribution on IMRS. - *Plestiodon obsoletus* is trapped infrequently. Its occurrence at Squaw Spring is expected due to the semi-riparian habitat and higher moisture available there. Outside of Squaw Spring, this species undoubtedly closely follows arroyos, although it has been collected on the alluvial fans between arroyos. Additional records exist from the IMRS Headquarters area and Prospects Pits.

***Plestiodon tetragrammus* (Four-lined Skink)**

Ecogeographic Remarks. - *Plestiodon tetragrammus* is a resident of many habitats, from semiarid grasslands to thornscrub to pine-oak woodlands, at elevations from sea level to 2300 m (Lieb, 1990; Degenhardt et al., 1996). In New Mexico, records of this skink come from riparian habitats characterized by loose, rocky soils, numerous tree species, and abundant leaf litter (Degenhardt et al., 1996). Morafka (1977) considered it a resident of desert riparian associations. Four-lined Skinks must avoid desiccation by limiting their activity to heavily vegetated areas and by hiding underneath available ground cover (Degenhardt et al., 1996). This skink was reported by Zweifel (1958) in Coahuila, Mexico, which was associated with a spring.

Distribution on IMRS. - Records for *P. tetragrammus* on IMRS exist only from a supposed relict population in the vicinity of Squaw Spring (Johnson and Jonson, 1999). It appears to maintain its relict population there by using the semi-riparian habitat formed along that permanent wetland.

Family: Teiidae

Taxonomic Note. - The genus of all members of whiptail lizards found on IMRS was changed from *Cnemidophorus* to *Aspidoscelis* by Reeder et al. (2002).

Aspidoscelis exsanguis (Chihuahuan Spotted Whiptail)

Ecogeographic Remarks. - This whiptail occurs primarily in Chihuahuan Madrean woodlands, with a known elevational range from 760 to 2440 m (Wright and Lowe, 1968; Stuart, 1991). It will follow major drainages out of these woodlands to lower lying semiarid grasslands, Chihuahuan Desert scrub, and densely vegetated floodplains (Wright and Lowe, 1968; Stuart, 1991; Degenhardt et al., 1996). In southern Arizona, Echternacht (1967) observed *Aspidoscelis exsanguis* outside of woodland habitats utilizing shaded areas and avoiding more open areas, particularly during the warmest hours. Medica (1967) reported this whiptail preferred a wetter habitat during a dry year, but did not expand its range into previously unoccupied areas during a wet year, unlike the other species of *Aspidoscelis* studied.

Distribution on IMRS. - The Chihuahuan Spotted Whiptail can be common within certain areas of Indio Ranch, such as Oak Arroyo, the jeep trail from Double Tank Corral to Squaw Spring, and Squaw Creek Canyon. These areas are likely some of the most mesic sites on IMRS, as indicated by the cooler temperatures typical of the deep canyons and semi-riparian habitat along Squaw Creek Canyon, and by the presence of Red Berry Juniper along the jeep trail from Road Tank to Squaw Spring and around Oak Arroyo. There are a few records from IMRS Headquarters and only one record (11 July 2011) from Prospect Pits, but this species does not appear to be a permanent member of the lizard community at those sites. Instead, they are likely lizards that dispersed down arroyos connected to the previously mentioned sites. The adjacent Eagle Mountains to the north support woodlands, so *A. exsanguis* may be more abundant in the mesic environment of that range.

Aspidoscelis inornata (Little Striped Whiptail)

Ecogeographic Remarks. - Aspidoscelis inornata is a resident of various grassland associations with low growing shrubs, but also thrives in overgrazed areas invaded by *Salsola* (Russian Thistle) and *Gutierrezia* (Snakeweed) (Wright, 1966). Christiansen et al. (1971) noted their use of grass clumps as refugia when pursued. It is usually found in areas with sandy soils, but occurs on gravelly to rocky substrates in Trans-Pecos Texas (Persons and Wright, 2009). Christiansen (1969) reported this lizard overwinters approximately 30 cm underground. *Aspidoscelis inornata* occurs up to 2300 m elevation in New Mexico, but is most common between 900 and 1600 m (Persons and Wright, 2009). Best et al. (1983) found it to be one of the most common species on and adjacent to a lava field in central New Mexico.

Distribution on IMRS. - The Little Striped Whiptail is common throughout IMRS. Of the sites studied in this paper, Woodpecker Well has the highest percent occurrence of grass (Table 1), but this species does not appear in larger numbers here. We have observed this lizard to be active longer into the hottest hours of the day compared to other lizards, so it could be locally abundant in warmer microclimates, such as fields of dark igneous rock.

Aspidoscelis marmorata (Western Marbled Whiptail)

Ecogeographic Remarks. - Aspidoscelis marmorata occupies areas of open desert with sandy to rocky soils between 900 m and 1575 m elevation (Tinkle, 1959; Zweifel, 1962; Dixon, 2009). Reduction of shrubs and increase in grass cover is not favorable to this species (Zweifel, 1962; Peterson and Whitford, 1987). Menke (2003) reported that *A. marmorata* preferred either grassland (with up to 30% cover) or Creosotebush habitat over the ecotone between them. Characteristic vegetation in areas of occurrence includes mesquite and Creosotebush (Zweifel, 1962; Baltosser and Best, 1990; Garcia-de la Pena et al., 2004; Cordes and Walker, 2009). In

southern New Mexico, Peterson and Whitford (1987) reported the Western Marbled Whiptail to forage in litter under mesquite more than expected, and suggested that the characteristics of litter under vegetation (e.g., prey abundance) were more important to this active forager than the amount of plant cover. A seasonal shift from mesquite and Creosotebush associations to dense Snakeweed stands was reported in late summer, perhaps due to flowering and increase in prey abundance, in southwestern New Mexico (Baltosser and Best, 1990).

Distribution on IMRS. - The occurrence of this whiptail on Indio Ranch closely follows the patterns reported by others (see above). Mata-Silva (2005) found this to be the most abundant whiptail at Prospect Pits. While they may be locally abundant, they are not as widespread as other whiptails. Records for *A. marmorata* exist from Double Tank Corral (but was not seen there during this study), IMRS Headquarters, Prospect Pits, and Red Tank. These sites are dominated by open alluvial fans, arroyos with Honey Mesquite and other densely spaced vegetation, and Creosotebush flats. Single sightings have been made near Squaw Creek Canyon and on the east side of IMRS.

***Aspidoscelis tesselata* (Colorado Checkered Whiptail)**

Ecogeographic Remarks. - Across its semiarid and arid range, *Aspidoscelis tesselata* is a habitat generalist and occurs in piñon-juniper, yucca-grasslands, mesquite-Creosotebush, and Cottonwood-Salt Cedar-willow vegetation associations (Zweifel, 1965; Whitford and Creusere, 1977; Price, 1986). Lemos Espinal and Smith (2007) reported its strong affinity to riparian areas in Chihuahua, Mexico. The known elevational range of this species is from 250 to 1829 m (Price, 1986). Wright and Lowe (1968) considered rocky substrates common among its habitats, but it also occurs on gravelly and sandy soils (Price, 1986). Best et al. (1983) reported it to be common on and near a lava field in central New Mexico.

Distribution on IMRS- This is the most commonly encountered whiptail and second most encountered lizard, after *Cophosaurus texanus*, on IMRS. It is a conspicuous lizard, but it is not always the most abundant whiptail species (see *Aspidoscelis marmorata* account). It was present at all the sites studied for this paper. It was even observed on top of a mountain at an elevation of 1340 m. Restrictions in the distribution of this whiptail on Indio Ranch are not evident.

Order: Squamata - Snakes

Taxonomic Note. - Family names used herein follow those of the Center for North American Herpetology website (www.cnah.org).

Family: Colubridae

***Arizona elegans* (Glossy Snake)**

Ecogeographic Remarks. - The Glossy Snake prefers semiarid to arid grasslands and shrublands with sandy to loamy soils, with or without rocks (Degenhardt et al., 1996; Ernst and Ernst, 2003). It can be found in a variety of habitats, such as creosote-mesquite, chaparral, sagebrush, grassland, and oak-hickory associations, from elevations below sea level to approximately 2200 m, with most occupying lower elevations (Ernst and Ernst, 2003). It also occupies sand dunes and, in Trans-Pecos Texas, Creosotebush flats (Werler and Dixon, 2000). Mendelson and Jennings (1992) reported a decrease in abundance associated with succession of semidesert grassland to Chihuahuan Desert scrub in southwestern New Mexico and southeastern Arizona. This species burrows into loose substrate or retreats to rodent burrows and under rocks (Werler and Dixon, 2000).

Distribution on IMRS. - Arizona elegans has only been found on one occasion west of IMRS Headquarters.

Bogertophis subocularis (Trans-Pecos Rat Snake)

Ecogeographic Remarks. - *Bogertophis subocularis* occurs between 457 and 1600 m in rocky mountain ranges of Chihuahuan Desert scrub and into higher elevation woodlands throughout most of its range (Degenhardt et al., 1996; Werler and Dixon, 2000). It forages widely, and if prey and deep microhabitats are available, this species occupies a variety of soil and rock types (Degenhardt and Degenhardt, 1965; Degenhardt et al., 1996).

Distribution on IMRS. - *Bogertophis subocularis* has been found at Black Diamond Mine, Echo Canyon, IMRS Headquarters, Prospect Pits, and Red Tank. A robust population occurs in the vicinity of Flat Top Mountain, Peccary Tank, and Rattlesnake Tank.

The following is based on radiotelemetry studies on this species on IMRS by Arturo Rocha (*in prep*): The average home range for *B. subocularis* is 58.8 ha. This snake predominately utilizes rocky slopes (44%), but can also be found on alluvial flats (23%), alluvial slopes (19%), and arroyos (14%). Microhabitats included under vegetation (37%; Green Sotol, *Yucca* spp., *Opuntia* spp., Lechuguilla), rocks (30%), burrows (18%), and litter (15%). Rock crevices serve as hibernacula for this species.

Gyalopion canum (Western Hook-nosed Snake)

Ecogeographic Remarks. - *Gyalopion canum* is primarily a Chihuahuan Desert inhabitant, and in Texas has been found primarily in mesquite, mesquite-creosote, creosote-agave, persimmon-shin oak, oak-juniper, and piñon-juniper (in Big Bend National Park) associations (Werler and Dixon, 2000). In New Mexico and elsewhere, Degenhardt et al. (1996) found this snake most often in grassy foothills at intermediate elevations, with some individuals dispersing into higher woodland habitats up to 2100 m elevation and lower desert habitats of 950 m elevation. It may

retreat under loose soils (as indicated by their upturned snout), rocks, or dead vegetation (Werler and Dixon, 2000).

Distribution on IMRS. - One *G. canum* was found on Indio Ranch in a large arroyo next to Snail Hill (near IMRS Headquarters) in 2003, with no subsequent records.

***Lampropeltis alterna* (Gray-banded Kingsnake)**

Ecogeographic Remarks. - This secretive kingsnake is found on hillsides and mountains of Chihuahuan Desert scrub and Madrean woodland in Trans-Pecos Texas from elevations of 450 to 2257 m (Miller, 1979; Ernst and Ernst, 2003; Ingrasci et al., 2008). Werler and Dixon (2000) reported habitat at the eastern end of its range to consist of ground covered with small rocks in acacia-Lechuguilla associations with open, fissured limestone hills. Miller (1979) collected most of his specimens at the top of three hills near the head of arroyos in Val Verde County, Texas.

Distribution on IMRS. - Two Gray-banded Kingsnakes were found in 1997, one in an arroyo at the base of the conglomerate mountains southeast of the IMRS headquarters and the other in the large arroyo (the trailing end of Eagle Canyon) east of Red Tank. No other individuals have been found. The dirt roads of Indio Ranch mostly course between large mountains, and most searches in the past at night occurred on the roads or nearby. Given limited success finding this species and citations above, future searches at higher elevations may yield more individuals.

***Masticophis flagellum* (Coachwhip)**

Ecogeographic Remarks. - The wide-range of *Masticophis flagellum* includes a large spectrum of habitats, from pine and palmetto flatlands to oak woodlands to thornscrub, but in semiarid and arid regions, it is typical of grasslands, savannahs, and scrublands (Ernst and Ernst, 2003). Within New Mexico, Creosotebush desert, short-grass prairie, and shrub dominated flats are occupied at lower elevations below 900 m; while sagebrush desert and piñon-juniper woodlands

harbor Coachwhips up to 2200 m (Degenhardt et al., 1996). Axtell (1959) reported it showed a preference for habitat with little vertical relief on Black Gap Wildlife Management Area and collected five from the floodplain, one from the streambed, and one from low, limestone gravel hills. Johnson et al. (2007) found this snake occupied areas of open oak savannah more than closed canopied, early-successional pine forest in eastern Texas. In the eastern Mojave Desert of California, Secor (1995) reported a 57.9 ha ± 13.2 ha activity range for *M. flagellum*, which repeatedly traveled approximately 1 km while foraging. Though is it typically an active forager, Jones and Whitford (1989) observed it adopting an ambush feeding strategy while under the cover of mesquite during mid-summer in southern New Mexico.

Distribution on IMRS. - This species has been documented near many localities on Indio Ranch: Campo Bonito, Carpenter Mine, IMRS Headquarters, Peccary Tank, and Red Tank.

The following is based on radiotelemetry studies on this species on IMRS by Vicente Mata-Silva (*unpub. data*): One male Coachwhip was studied for 11 months. This individual had an activity range of 192 ha and preferred habitats of alluvial and sandstone slopes dominated by grasses and small shrubs. It often utilized burrows to escape the hottest parts of the day. The hibernaculum of this snake was situated on a northwest facing slope.

Masticophis taeniatus (Striped Whipsnake)

Ecogeographic Remarks. - Across western North America, *Masticophis taeniatus* inhabits grassland, woodland, montane, and desert habitats (Parker, 1982). Over most of its range it is an upland snake, occupying rock and brush covered mountains, foothills, escarpments, and basins at elevations to 3077 m (Stumpel, 1995), but usually below 2000 m (Degenhardt et al., 1996; Ernst and Ernst, 2003). In New Mexico, it is chiefly a foothills species that avoids open desert flatlands (Degenhardt et al., 1996). Similarly, this species is distributed across northern Arizona

in open brushy habitats and on rocky hills in grasslands (Brennan and Holycross, 2009). Minton (1958) observed multiple individuals using rock crevices and brush piles as microhabitats.

Distribution on IMRS. - Striped Whipsnakes are a quick moving species, making observations difficult. Records for this snake exist from Echo Canyon, IMRS Headquarters, Peccary Tank, Prospect Pits, Squaw Spring, and Woodpecker Well.

Pituophis catenifer **(Gopher Snake)**

Ecogeographic Remarks. - The Gopher Snake occupies a full spectrum of habitats across its extensive range (Ernst and Ernst, 2003). In New Mexico, it can be found living on sedimentary soils to rocky terrain in desert areas at 900 m elevation to mixed coniferous forests at 2800 m elevation (Degenhardt et al., 1996). Minton (1958) observed this species in a variety of habitats in the Big Bend region of Texas, particularly in grasslands and the less arid sections of desert flats. Mendelson and Jennings (1992) considered this species unaffected by succession of semidesert grassland to Chihuahuan Desert scrub in southwestern New Mexico and southeastern Arizona. Kapfer et al. (2008) observed *Pituophis catenifer* to favor open, rocky bluff sides during their active season and for hibernacula, despite the availability of adjacent grassland or prairie habitats, in Wisconsin. Kapfer at al. (2009) found males and females to associate with microhabitats of non-woody herbaceous vegetation, and males to also seek rock cover, woody debris, and woody vegetation cover; however, the weak strength of their analysis may indicate that macrohabitat preferences determine habitat selection. Hall et al. (2009) reported increased percent coverage of invasive Cheatgrass (*Bromus tectorum*) and the subsequent loss of shrub coverage decreased the relative abundance of *P. catenifer*, possibly due to locomotion restriction or lower prey abundance.

Distribution on IMRS. - *Pituophis catenifer* is regularly seen on Green River Road south of Van Horn. The few records for this snake on IMRS are from the East Gate and the jeep trail from Double Tank Corral to Squaw Spring. This snake does not appear to be a large part of the snake community of Indio Ranch. The only record from the interior of the property is from Peccary Tank.

***Rhinocheilus lecontei* (Longnose Snake)**

Ecogeographic Remarks. - *Rhinocheilus lecontei* generally avoids rocky mountain habitats, living primarily in dry areas with sandy to gravelly soils in grasslands, thornscrub, woodlands, or deserts (Degenhardt et al., 1996; Werler and Dixon, 2000; Brennan and Holycross, 2009). In the Trans-Pecos, it has been observed in mesquite-Creosotebush, Catclaw-Black Grama, and Catclaw-Tobosa associations (Jameson and Flury, 1949; Milstead, 1950). Longnose Snakes are proficient burrowers in loose substrates but prefer rock, debris, or burrow microhabitats when they are present, and occupy elevations between 900 m and nearly 1900 m in New Mexico (Degenhardt et al., 1996).

Distribution on IMRS. - *Rhinocheilus lecontei* have been found at IMRS Headquarters and on Purple Sage Mine Road, and is trapped infrequently at Prospect Pits. Based on available records, it probably prefers alluvial fan and arroyo habitats, and likely exploits crevices, fallen yucca logs, and mammal burrows.

***Salvadora deserticola* (Big Bend Patchnose Snake)**

Ecogeographic Remarks. - The Big Bend Patchnose Snake is a resident of desert flats, arroyos, foothills, and mesas characterized by Chihuahuan Desert scrub and sandy to gravelly soils (Ernst and Ernst, 2003). Minton (1958) suggests this snake replaces *Salvadora grahamiae* on the desert flats. In New Mexico, Degenhardt et al. (1996) considers this species to occur

mostly within the range of Creosotebush, both geographically and elevationally, but it can be found between 950 m and 1600 m elevation. Lemos Espinal and Smith (2007) observed it in oak forests and stands of willow and aspen in the Sierra de San Luis of Chihuahua, Mexico.

Distribution on IMRS. - Salvadora deserticola is the more common patchnose snake on IMRS. Numerous observations have been made along River Road between its junction with the Main Road and Red Tank. Additional sightings have been made on the jeep trail from Double Tank Corral to Squaw Spring, the road to Squaw Spring north of IMRS Headquarters, the Main Road below Echo Canyon, and Purple Sage Mine Road. This snake is commonly seen around IMRS Headquarters.

***Salvadora grahamiae* (Mountain Patchnose Snake)**

Ecogeographic Remarks. - Salvadora grahamiae is largely restricted to mountains and foothills up to elevations of approximately 2200 m (Minton, 1958; Degenhardt et al., 1996). It is likely to be found on rocky or wooded mountain slopes, which it seems to prefer over alluvial plains and lowland deserts (Axtell, 1959; Morafka, 1977; Werler and Dixon, 2000; Brennan and Holycross, 2009). When it occurs at lower elevations, it resides in the uneven terrain at the base of mountains, in canyons, along arroyos, or on rocky flats (Degenhardt et al., 1996). Degenhardt et al. (1996) only rarely found *Salvadora deserticola* and *S. grahamiae* in sympatry, but reports from Axtell (1959) and Werler and Dixon (2000) do not make it appear to be an uncommon situation.

Distribution on IMRS. - The Mountain Patchnose Snake has been recorded from the same areas as *S. deserticola*: IMRS headquarters, Peccary Tank, Prospect Pits, Red Tank, and Squaw Spring. The two species possibly partition habitat on IMRS, with *S. grahamiae* occupying steep, rocky slopes and *S. deserticola* occupying the alluvial fans and Creosotebush flats. While the

elevation of IMRS (approximately 1000 m to 1640 m) is within the preferred range of *S. grahamiae*, it is less abundant than *S. deserticola*. Perhaps *S. grahamiae* is more common in the higher, adjacent Eagle Mountains, with individuals extending down to Indio Ranch representing a peripheral population.

***Sonora semiannulata* (Ground Snake)**

Ecogeographic Remarks. - Sonora semiannulata can be found living in grass or brushy associations in plains, valley, and foothill habitats (Morafka, 1977; Degenhardt et al., 1996; Werler and Dixon, 2000; Brennan and Holycross, 2009). They have been recorded up to approximately 1829 m in elevation in the Guadalupe Mountains, but higher mountain slopes are avoided, as well as poorly drained soils (Degenhardt et al., 1996; Werler and Dixon, 2000). Degenhardt et al. (1996) reported this species maintained dense populations on the rocky slopes of low hills or valley sides in New Mexico. They also noted their preference for “flat shallow rocks which warm quickly in the sun” that may cover holes or contain crevices connected to deeper retreats. In Oklahoma, Kassing (1961) observed Ground Snakes retreating to depths of more than 25.4 cm or deep into crevices in response to dry, hot summer conditions.

Distribution on IMRS. - Ground Snakes are found a few times each year, mostly in pit-fall traps. Records exist only from IMRS Headquarters and Prospect Pits. These areas contain predominately conglomerate rock, limiting the amount of flat rocks that would facilitate thermoregulation. Whether this effects their distribution on Indio Ranch is unknown, but there are plenty of crevices *S. semiannulata* can utilize in areas of conglomerate rock.

***Tantilla hobartsmithi* (Southwestern Blackhead Snake)**

Ecogeographic Remarks. - Tantilla hobartsmithi is a secretive and fossorial snake, occurring primarily in riparian, grassland, chaparral, and woodland communities (Cole and Hardy, 1983).

In New Mexico, Degenhardt et al. (1996) found them between elevations of 900 m to 1600 m and considered the limestone covered hills and valley sides of the lower Pecos drainage to harbor robust populations. In the Chisos Mountains of Big Bend National Park, Degenhardt et al. (1976) found them at elevations up to 1962 m. This snake is most abundant in chaparral and semidesert grassland habitats in Arizona (Brennan and Holycross, 2009). It shows a preference for rocky situations, where it will seek shelter under rocks, but will also retreat under ground litter or underground (Axtell, 1959; Degenhardt et al., 1996; Werler and Dixon, 2000).

Distribution on IMRS. - Tantilla hobartsmithi are only occasionally found, chiefly from under yucca logs or in pit-fall traps. Observations have been made in the vicinity of IMRS Headquarters, Peccary Tank, and Squaw Creek Canyon. Their absence from Prospect Pits is curious, given the large pit-fall trap array there and its proximity to IMRS Headquarters, but future trapping will likely produce a snake. As with *Sonora semiannulata*, it is unknown whether this species would be more abundant in areas not dominated by conglomerate rocks.

***Trimorphodon vilkinsonii* (Chihuahua Lyre Snake)**

Taxonomic Note. - *Trimorphodon vilkinsonii* was elevated from a subspecies of *T. biscutatus* by LaDuc and Johnson (2003).

Ecogeographic Remarks. - Though it can occasionally be found on desert flats, this snake mostly occurs on the rocky terrain of mountains, mesas, hills, canyons, and arroyos of mountain ranges mainly along the Rio Grande Valley (Degenhardt et al., 1996; LaDuc and Johnson, 2003). Soon after it was opened, Banicki and Webb (1982) collected 22 individuals along Trans-Mountain Road, a paved four-lane divided highway reaching 1600 m elevation, in the Franklin Mountains located in El Paso, Texas, which contains a Chihuahuan Desert scrub association and

various rock types. In Big Bend National Park, *Trimorphodon vilkinsonii* have been found at elevations below 950 m to over 1800 m (Degenhardt et al., 1996).

Distribution on IMRS. - This snake has only been found on two occasions, the first at Double Tank Corral in 1992 and the second in 2008 on the conglomerate mountain side behind Prospect Pits. According to records from other locations (see above), it can occur well above the elevational limits present on IMRS (approximately 1640 m). Perhaps unique physical and environmental conditions at the summit of mountains, rather than strict elevational zones, determine the distribution of this species. Further searches at higher elevations will likely yield additional *T. vilkinsonii*.

Family: Crotalidae

***Crotalus atrox* (Western Diamondback Rattlesnake)**

Ecogeographic Remarks. - Across its wide range in southcentral and southwestern United States and northern half of Mexico, *Crotalus atrox* inhabits a wide variety of habitats, but is a typical resident of dry to arid lowland areas, usually in shrub dominated flats, dry washes, rocky outcrops, and desert foothills (Minton, 1958; Pough, 1966; Klauber, 1972; Degenhardt et al., 1996; Werler and Dixon, 2000). It typically occupies areas below 1500 m elevation, but records exist up to 2135 m elevation (Degenhardt et al., 1996). In southeastern Arizona, Beck (1995) found the Western Diamondback Rattlesnake to predominately seek rocky slopes (43%) for hibernacula. In the spring, it moved to Creosotebush flats to spend its active season, with some preference for arroyos during the monsoon season. He also found it to use shrub, rock/crevice, burrow, and packrat nest microhabitats in equal proportions, but used mainly shrub shelters during the monsoon season. Mendelson and Jennings (1992) found this rattlesnake to exhibit a significant increase in relative abundance correlated with the succession of semidesert grassland

to Chihuahuan Desert scrub in southeastern Arizona and southwestern New Mexico. Hamilton and Nowak (2009) reported *C. atrox* utilizing hibernacula with insolation (solar radiation) values lower than or similar to their surroundings, depending on elevation.

Distribution on IMRS. - This is one of the most commonly encountered snakes on Indio Ranch and has been observed at several locations: Double Tank Corral, IMRS headquarters, Mesquite Tank, Peccary Tank, Prospect Pits, Rattlesnake Tank, Red Tank, and Squaw Spring. Robust populations of this species exist around Peccary Tank and Rattlesnake Tank. This snake may prefer those tanks since the dense vegetation surrounding them is closer to the water source than at others (e.g., Red Tank, Road Tank).

The following is based on radiotelemetry studies on this species on IMRS by Vicente Mata-Silva (*unpub. data*): *Crotalus atrox* are common in lower areas of IMRS with less relief, such as alluvial fans and foothills. Common microhabitats used by Western Diamondback Rattlesnakes are under shrubs and underground in mammal burrows. Hibernacula are typically located underground in alluvium on southeast facing slopes.

Crotalus lepidus (Rock Rattlesnake)

Ecogeographic Remarks. - *Crotalus lepidus* is a typically montane rattlesnake usually associated with rocky situations, such as boulder fields, rock outcroppings, and talus slides (Minton, 1958; Armstrong and Murphy, 1979; Degenhardt et al., 1996; Werler and Dixon, 2000). In populations occurring in pine-oak forests, it appears to prefer open areas exposed to direct sunlight (Degenhardt et al., 1996). Rock Rattlesnake have been found from 556 m elevation in Texas to 2597 m elevation in New Mexico, and may be occasionally observed in low-lying desert habitats, though the expansive desert flats surrounding mountain ranges effectively prevent dispersal (Degenhardt et al., 1996; Werler and Dixon, 2000). In Big Bend

National Park, different environmental conditions resulted in two populations exhibiting unique ecology and life history traits: body temperature, energy budget, feeding frequency, frequency of surface activity, and size (Beaupre, 1995a; Beaupre, 1995b; Beaupre, 1996).

Distribution on IMRS. - *Crotalus lepidus* is largely restricted to arroyo systems on IMRS dissecting both steep slopes and alluvial fans. Records for this secretive snake exist from Echo Canyon, IMRS Headquarters, Peccary Tank, Prospect Pits, Purple Sage Mine, Red Tank, and Squaw Spring. It is likely as widespread as *Crotalus molossus*, given their similar habitat requirements, though they do prefer different microhabitats. Given its affinity to the dense vegetation of arroyo edges, this species possibly reaches the Rio Grande Valley by dispersal along arroyos descending from the Indio Mountains to the Rio Grande.

The following is based on radiotelemetry studies on this species on IMRS by Vicente Mata-Silva (*in prep*): Rock Rattlesnakes occupy arroyos (55%), alluvial rocky slopes (17%), rocky slopes (15%), alluvial slopes (10%), and alluvial flats (3%) on Indio Ranch. Common microhabitats used by this species are under shrubs (43%) and under rocks (19%). Vegetation was the principal form of ground cover in most microhabitats. Hibernacula are chiefly rock crevices; eight of 12 individuals chose overwintering sites on a southeast facing slope, which was determined to be the warmest slope orientation during the winter months. *Crotalus lepidus* seek hibernacula on mountain slopes at higher elevations, but subsequently descend to arroyos at lower elevations, where they spend their active season.

***Crotalus molossus* (Black-tailed Rattlesnake)**

Ecogeographic Remarks. - This rattlesnake is a habitat generalist but is predominately a montane species, where they occupy rocky areas, especially in riparian habitats (Armstrong and Murphy, 1979; Degenhardt et al., 1996; Werler and Dixon, 2000; Brennan and Holycross, 2009).

When they occur outside mountainous areas, they will follow arroyos leading out of the mountains (Klauber, 1972; Degenhardt et al., 1996). Pough (1966) and Minton (1958) found them most abundant in the mountains and foothills, but Minton (1958) also recorded individuals from the Rio Grande Valley. The known elevational range is from 350 m in Arizona to 3150 m in New Mexico (Beck, 1995; Degenhardt et al., 1996). Axtell (1959) found them on a variety of rock types on Black Gap Wildlife Management Area. Beck (1995) reported *Crotalus molossus* using rocky slopes during the winter and rocky habitats during their active season, with a radiation to all habitats (rocky slopes, arroyos, Creosotebush flats, and rocky flats) during the late wet summer and fall. In Arizona, *C. molossus* hibernacula were higher in insolation (solar radiation) than surrounding areas (Hamilton and Nowak, 2009) and located in crevices of steep, southwest oriented slopes, although caves or mammal burrows were also utilized at other localities (Werler and Dixon, 2000).

Distribution on IMRS. - Black-tailed Rattlesnakes have been observed throughout Indio Ranch. This species is mostly observed in alluvial or rocky arroyos, where it will seek cover under rocks or dense vegetation. It will also utilize rocky outcrops situated on the slopes of hills and mountains.

The following is based on radiotelemetry studies on this species on IMRS by Vicente Mata-Silva (*unpub. data*): *Crotalus molossus* are common on rocky slopes on the hills and mountains of IMRS. They mostly seek microhabitats underneath rocks. Rock crevices on south to west facing slopes are chosen as overwintering sites, which are usually situated at slightly higher elevations than areas used during the active season.

Family: Dipsadidae

Diadophis punctatus **(Ringneck Snake)**

Ecogeographic Remarks. - Diadophis punctatus is widespread across North America, and occupies woodlands, grasslands, and deserts (Ernst and Ernst, 2003). In more xeric areas, they are especially partial to mountainous woodlands at higher elevations, as high as 2200 m in New Mexico (Morafka, 1977; Degenhardt et al., 1996; Werler and Dixon, 2000; Brennan and Holycross, 2009). Moisture at or below the surface is necessary at all inhabited areas, and if these conditions are met, it can be found at lower elevations within desert grasslands (Degenhardt et al., 1996). This snake avoids desiccation and predation by thermoregulating under warmed rocks or debris, rather than in the open (Degenhardt et al., 1996).

Distribution on IMRS. - Diadophis punctatus is rarely encountered, and most observations are from pit-fall traps or under yucca logs. This snake has only been found in the vicinity of IMRS headquarters and Peccary Tank. Populations are likely largest around the tanks and possibly Squaw Spring, given higher moisture levels at these sites.

Hypsiglena jani **(Chihuahua Night Snake)**

Taxonomic Note. - *Hypsiglena jani* was elevated from a subspecies of *H. torquata* by Mulcahy (2008).

Ecogeographic Remarks. - This snake can be found living in semiarid to arid habitats, such as grasslands, savannahs, thornscrub, foothill and mountain slopes, and montane woodlands, where they will use rock, litter, and vegetation microhabitats (Degenhardt et al., 1996; Werler and Dixon, 2000). They occur up to 2200 m elevation in New Mexico (Degenhardt et al., 1996). Minton (1958) found them in rocky places in Creosotebush and Lechuguilla associations of the desert and foothills in the Big Bend region of Texas, and occasionally in sandy washes.

Distribution on IMRS. - Records for the Chihuahuan Night Snake exist in the vicinity of the IMRS Headquarters, Peccary Tank, Prospect Pits, and Rattlesnake Tank. They are fairly common, and are often found in pit-fall traps and under yucca logs. Numerous observations have been made near earthen tank and in pebble-covered conglomerate slope habitats.

Family: Leptotyphlopidae

Taxonomic Note. - The genus for the blind snake occurring on IMRS was changed from *Leptotyphlops* to *Rena* by Adalsteinsson et al. (2009).

***Rena humilis* (Western Blind Snake)**

Ecogeographic Remarks. - This species occupies desert or grassland habitats with soil suitable for burrowing, and are often found along the steep, rocky slopes of major drainages (Degenhardt et al., 1996; Werler and Dixon, 2000; Brennan and Holycross, 2009). *Rena humilis* occurs within the Pecos, Rio Grande, and Gila River drainages from 900-1425 m elevation in New Mexico (Degenhardt et al., 1996). Minton (1958) found them throughout desert flats and foothills in the Big Bend region of Texas. No records on hibernacula are available but their burrows deep in the soil would likely suffice; however, it may stay active all year throughout most of its range (Degenhardt et al., 1996).

Distribution on IMRS. - Its small size and secretive nature make this species difficult to find, but it occurs throughout Indio Ranch, with records from the northernmost site (Woodpecker Well) and southernmost site (Red Tank) of this study. Additional records exist from IMRS Headquarters, Peccary Tank, and Squaw Spring. Their absence from Prospect Pits is curious, given the large pit-fall trap array there and its proximity to IMRS Headquarters, but future trapping will likely produce an individual. The ground across Indio Ranch is covered with

pebbles and small stones, but the soil underneath is apparently suitable for their fossorial tendencies. Many have been observed or captured in very open habitats.

Family: Nactricidae

Thamnophis cyrtopsis (Blackneck Garter Snake)

Ecogeographic Remarks. - *Thamnophis cyrtopsis* occupies habitats from desert flats to montane woodlands, where they are usually associated with permanent or ephemeral water sources, especially in rocky canyons or valleys (Minton, 1958; Axtell, 1959; Degenhardt et al., 1996; Werler and Dixon, 2000; Brennan and Holycross, 2009). They are closely tied to water sources given their chiefly amphibian diet and susceptibility to desiccation (Fleharty, 1967). It prefers rocky landscapes, generally avoids sandy low-land areas, and can be found from elevations from sea level in Texas to 2400 m in New Mexico (Degenhardt et al., 1996; Werler and Dixon, 2000). In Arizona, Jones (1990) observed a preference for streams, but less flowing water in the summer resulted in the usage of pools.

Distribution on IMRS. - Records for the Blackneck Garter Snake are available from the vicinity of East Well, Double Tank Corral, IMRS Headquarters, Peccary Tank, Prospect Pits, Rattlesnake Tank, and Red Tank. This snake can be quite abundant around the water source at Squaw Spring or any of the tanks. When *T. cyrtopsis* occurs away from larger permanent or ephemeral water bodies, it is common in rocky canyons and arroyos, where it will utilize the pools remaining after rains. It seems to be well adapted for survival in xeric conditions on IMRS.

DISCUSSION

Vegetation changes in the Chihuahuan Desert, and its effect on the herpetofauna. - Over the past 150 years, the landscape of southwestern North America has experienced a shift from grasslands to shrublands (Buffington and Herbel, 1965; Van Auken, 2000). Overgrazing by livestock is considered one of the major factors leading to desertification of southwestern North America, with reduction of grass biomass resulting in encroachment of native shrubs or woody plants once present at low densities (Fleischner, 1994; Van Auken, 2000). Similarly, Powell (1998) reported "paleoecological and contemporary ecological data suggest that the desert scrub has gained its present distribution to a large extent through invasion of eroded grassland." Cattle ranching once occurred on IMRS (Worthington et al., 2004), and it is likely that stocking rates negatively impacted the landscape. The resulting change in vegetation structure would have been the most severe modern change experienced by the IMRS landscape. This alteration likely resulted in the last major restructuring of the herpetofaunal community on IMRS. It is unknown if any species disappeared from the Indio Mountains as a result, but broken terrain likely maintained landscape heterogeneity, allowing most elements of the herpetofaunal community to persist albeit with change in abundance at the species level (Jones, 1981).

Presently, Chihuahuan Desert scrub on IMRS is typically an open mosaic of grasses and shrubs (Table 1). Most herpetofaunal species on Indio Ranch are widely adaptive and occupy a suite of habitats across their range, so there are no indicator species of any particular vegetation associations. Furthermore, no empirical studies of relative abundance and few studies of habitat usage and preference of the IMRS herpetofauna are available. Thus, it is difficult to establish the ecological trajectory of the herpetofaunal communities on IMRS at present time.

Pianka (1966, 1967) suggests lizard abundance and diversity is positively correlated with complexity of vegetation structure in arid systems, a concept supported by many ecosystem management studies (Reynolds, 1979; Germano and Hungerford, 1981; Jones, 1981; Werschkul, 1982; Peterson and Whitford, 1987; Castellano and Valone, 2006). Microhabitat diversity rather than macrohabitat type is often perceived as a more significant factor in determining lizard communities (Pianka, 1967; Schoener, 1974; Vitt et al., 1981). Generally, increase in vegetation structure complexity benefits opportunistic "sit-and-wait" foragers, whereas "widely foraging" species benefit either slightly or not at all (Castellano and Valone, 2006). In addition, widely foraging species, such as *Aspidoscelis*, may only be minimally affected by habitat disturbance (Wright and Lowe, 1968; Castellano and Valone, 2006). The literature of reptile response to vegetation succession is dominated by lizards as model organisms, although Mendelson and Jennings (1992) and Hall et al. (2009) discuss snake community change in response to landscape transition to shrubland and grassland, respectively.

Cophosaurus texanus is a sit-and-wait forager, whereas *Aspidoscelis inornata* and *A. tesselata* utilize an active foraging strategy (Pianka, 1966; Jones, 1981). The presence of these two foraging strategies in abundant and widespread lizard species (Table 2) suggests the current landscape of IMRS has retained or developed some level of heterogeneity in its vegetation structure as described by Pianka (1966). *Urosaurus ornatus* is also widespread, but their primarily rocky habitat and shortage of larger trees on IMRS limit their interaction with vegetation, thereby making their abundance misleading when considering only vegetation structure.

Grazing intensity determines the long-term vegetation trends in arid systems, while intermittent climatic events (e.g., drought) substantially impact the short-term rate and direction

of change (Fuhlendorf et al., 2001). Valone et al. (2002) found vegetation differences in ungrazed areas to be related to the number of years since livestock exclusion, as a 20 year absence of livestock yielded an area identical to the grazed area outside a fence, but exclusion of livestock for 39 years resulted in nearly four times higher grass cover. Despite a difference in composition of the plant community at the 39 year exclosure site, they found few differences in total plant coverage and species richness. However, characteristics unique to different regions (e.g., edaphic factors) can limit the return of perennial grasses to ungrazed areas (Valone et al., 2002).

Ranching continued on Indio Ranch as late as the early 1980's, and the grasses have subsequently experienced a noticeable recovery (Jerry D. Johnson, *pers. comm.*). The slow process of grass recovery (Valone et al., 2002) has likely gradually affected the herpetofaunal community by increasing vegetation structural complexity. As perennial grasses continue to recover on IMRS, the herpetofaunal community on IMRS may increase in abundance, species richness, and habitat usage until the vegetation community reaches a climax equilibrium. However, response will differ between species, as studies of livestock removal indicate large positive responses in some species are coupled with neutral or negative responses by others (Jones, 1981; Peterson and Whitford, 1987; Castellano and Valone, 2006). For instance, members of the genus *Phrynosoma* are unaffected in grazed habitats (Fair and Henke, 1997) as open, partially vegetated habitat facilitates locomotion, foraging, and thermoregulation (Whiting et al., 1993). Reduction of shrubs and increase in grass cover does not favor *Aspidoscelis marmorata* (Zweifel, 1962), as this transition reduces foraging areas, escape sites, and the area visible to foraging *A. marmorata* (Peterson and Whitford, 1987). Conversely, increase in grass cover was shown to positively affect *C. texanus* (Jones, 1981) and *Uta stansburiana* (Peterson

and Whitford, 1987; Castellano and Valone, 2006). It should also be expected that expansion of grasses after the cessation of grazing on IMRS could positively affect movement of the species that potentially occur on the property (Appendix 2) and species that are known from only a few fringe areas, such as *Anaxyrus speciosus* and *Terrapene ornata.*

Distribution on IMRS. - From the current herpetofaunal records (Table 2), the IMRS Headquarters, Prospect Pits, and Squaw Spring trapping sites have the most similar community and Lonely Tank has the most dissimilar community from all other trapping sites (Figs. 11 and 12). Limited rainfall in 2011 seemed to restrict snake activity on IMRS given the scarcity of snake records as compared to previous years. Consequently, the current list of snakes at each trapping site is undoubtedly incomplete for Woodpecker Well, Double Tank Corral, Oak Arroyo, and Lonely Tank. However, lizards were easily observed across IMRS in 2011. New pit-fall arrays constructed for this study contained five traps each, and I feel this, combined with walking searches, was adequate to determine lizard presence, with the possible exception of those that are normally not observed on the surface. It is unknown how first-year pitfall traps affect capture rate of inconspicuous species. However, few lizard species were observed at a trapping site that had not been captured by pit-fall traps. The dendrograms comparing herpetofaunal similarity between sites (Fig. 11) and similarity of only lizards between sites (Fig. 12) supported similar relationships and closely grouped adjacent trapping sites (IMRS Headquarters with Prospect Pits and Double Tank Corral with Oak Arroyo), which would be expected to share similar amphibian and reptile species (Johnson et al., 2010).

Even though further surveying of the previously mentioned sites is necessary, Lonely Tank did exhibit some curious species absences. Lonely Tank was the only trapping site at which I was unable to document *Anaxyrus punctatus*, *Coleonyx brevis*, and *A. inornata*, yet these

species were all present at nearby Red Tank. Unlike the other trapping sites, Lonely Tank is situated in a large drainage between tall, steep hills. Although this site is connected to small arroyos through which species could easy disperse, its geographic position for some reason may limit frequency of movement into the area.

Proximity to desert flats surrounding the Indio Mountains, ephemeral water sources, and distinctive vegetation make Double Tank Corral and Oak Arroyo unique areas within IMRS. *Anaxyrus speciosus* and *Terrapene ornata*, and potentially *Phrynosoma cornutum*, are typically associated with grasslands and have only been documented from the Double Tank Corral area. This area and others on the periphery of IMRS potentially hold more grassland species (Appendix 2), especially areas on the eastern portion along Green River, which likely serves as a major corridor for species of amphibians and reptiles. Squaw Spring is another unique area on IMRS. The deep canyon system and permanent wetland provide a mesic habitat that supports lizard species uncommon throughout IMRS, such as *Aspidoscelis exsanguis*, *Sceloporus cowlesi*, *Plestiodon obsoletus*, *P. tetragrammus*, and *Uta stansburiana*.

An interesting aspect of the lizard community on IMRS was discovered in this study. Among whiptail lizards, either two or three species were present at each site. The records for four species at IMRS Headquarters and Prospect Pits were discussed in the Species Accounts. *Aspidoscelis exanguis* and *A. marmorata* did not both have a lasting presence at any site. This is attributable to a preference for mesic areas by *A. exsanguis* and open areas dominated by Creosotebush and Honey Mesquite by *A. marmorata*.

Mechanisms of Habitat Use. - Many species are distributed throughout IMRS, but at a finer scale have a connected but patchy distribution determined by preferred habitat characteristics. This is a more localized process than metapopulation theory, which refers to “a

network of semi-isolated populations with some level of regular or intermittent migration and gene flow among them, in which individual populations may go extinct but then be recolonized from other populations'' (Meffe and Carroll, 1994). Instead, I am referring to the deliberate avoidance of particular habitat characteristics within an individual's active range. This applies more to lizards (Baltosser and Best, 1990) and snakes (Landreth, 1973; Weatherhead and Prior, 1992), as many amphibians do occur in metapopulations (Marsh and Trenham, 2001; Dayton et al., 2004). Distribution of species on IMRS mirrors that described by other authors, as *A. marmorata* prefers open areas covered by Creosotebush and Honey Mesquite (Zweifel, 1962; Dixon, 2009; this study); *Crotalus lepidus* is largely restricted to arroyo systems and uses microhabitats non-randomly (Mata-Silva, *in prep*); *Phrynosoma modestum* prefers more open areas (Whiting et al., 1993; this study); and *S. cowlesi* appears restricted to densely vegetated arroyo edges (Mosauer, 1932; Minton, 1958; Axtell, 1959; this study). Our understanding of habitat use by the herpetofauna on IMRS is largely general, excluding *Bogertophis subocularis* (Rocha, *in prep*) and all rattlesnake species (Mata-Silva, *in prep*, *unpub. data*), so investigation of species level ecology will probably reveal additional species with fine-scale habitat restrictions. During periods of dispersion these species could be found outside of their expected habitat, but most of their activities will be restricted to certain habitat types. Species with few records on IMRS cannot conclusively be said to occur throughout the property, but they could face similar restrictions, and perhaps their scarcity is testament to the lack of favored habitats (see *Species Accounts*).

Every species is limited by multiple environmental factors over time and its geographic distribution (Lomolino et al., 2010). Some factors influencing herpetofaunal habitat restrictions include microhabitat diversity (Pianka, 1967), vegetation (Peterson and Whitford, 1987), thermal

environment (Huey, 1991; Row and Blouin-Demers, 2006), soil type (Creusere and Whitford, 1976), and water sources (Dayton et al., 2004). Research specific to IMRS has identified additional environmental properties that are important to habitat usage. Mata-Silva (*in prep*) reported the estimated number of available slope orientations on IMRS as facing southwest (17%), south (16%), east (15%), west (15%), southeast (14%), northeast (10%), northwest (9%), and north (4%). Additionally, he showed different slope orientations to differ in their mean winter temperatures; from highest to lowest: southeast, south, southwest, east, west, northeast, north, and northwest. The significance of these findings was *C. lepidus* usually chose southeastern slopes, the warmest but less abundant slope orientation, as overwintering sites on IMRS. Selection of southern facing slopes for overwintering sites has been reported for many other rattlesnake species (Brown, 1982; Macartney et al., 1990; Beck, 1995).

Conversely, *A. tesselata* and *C. texanus* are widespread throughout IMRS and distributional restrictions are not evident, perhaps with the exception of an elevational restriction for the latter. Similarly, in the Guadalupe Mountains, Zweifel (1965) found *A. tesselata* in sympatry with all species of *Aspidoscelis* occurring on IMRS and with *C. texanus*.

Both arroyos and riparian habitats possess vegetation that is structurally diverse and species rich, but arroyos differ from riparian habitats in that they do not contain permanent wetlands or species restricted to them (Jorgensen and Demarais, 1998). Vitt (1991) expected arroyos and uplands in desert environments to support different species due to differences in vegetation and substrates, although Jorgensen and Demarais (1998) did not report this type of species structuring in New Mexico. In addition, the dense vegetation of arroyo edges would be expected to provide cooler microclimates than upland habitats. Nevertheless, arroyo and canyon systems exist in stark contrast to the surrounding landscape and are likely very important as

dispersal routes. These corridors could aid in the dispersal of species into, within, and outside of the Indio Mountains proper.

Amphibian and reptile species limited by physical features of the Indio Mountains could utilize arroyos to disperse into the interior of the property. These corridors would be particularly suitable to grassland species. Though it is not a strictly grassland or montane form, *A. exsanguis* provides a good example of utilization of arroyos to disperse into uncharacteristic habitats. Wright and Lowe (1968) and Degenhardt et al. (1996) reported that *A. exsanguis* is typical of mesic habitats, and populations occupying such habitats on mountains will follow major drainages into desert vegetation at lower elevations. *Aspidoscelis exsanguis* is common in some areas of IMRS (see *Species Accounts*), but has rarely reached IMRS Headquarters and Prospect Pits in the interior and has never been accounted for at Woodpecker Well and Red Tank. Routine pit-fall trapping does not indicate *A. exsanguis* to be a regular member of the lizard community at IMRS Headquarters and Prospect Pits. Those records are probably individuals who utilized the cooler microclimate maintained by dense vegetation in arroyos to disperse from areas where they are common into unoccupied areas. Sparse records of *Anaxyrus cognatus*, *Arizona elegans*, *Gyalopion canum*, and *S. cowlesi* near IMRS Headquarters could be explained by the same process, although factors facilitating dispersal would be unique to each species.

Similarly, species could use arroyos to disperse out of mountains to the flat desert habitat surrounding IMRS. These corridors would be particularly important to facilitate movement of montane species out of their preferred environment. *Crotalus lepidus* chiefly occupies sloping arroyos (55%) on IMRS (Mata-Silva, *in prep*), so suitable habitat further down would likely not be avoided, even in flatlands. Degenhardt et al. (1996) reported it could occasionally be observed in low-lying desert habitats, but considered the expansive desert flats surrounding

mountain ranges to effectively prevent dispersal. *Crotalus molossus* will also follow arroyos leading out of mountainous areas (Klauber, 1972; Degenhardt et al., 1996), and Minton (1958) recorded individuals from within the Rio Grande Valley. Similar radiations could occur in *Diadophis punctatus* (Degenhardt et al., 1996), *P. obsoletus* (Fitch, 1955; Menke, 2003), and *Trimorphodon vilkinsonii* (Degenhardt et al., 1996; LaDuc and Johnson, 2003).

In addition to environmental factors, competition could also determine habitat occupancy. Competition must only be considered as one variable influencing communities (Barbault and Maury, 1981). The species structuring of *Aspidoscelis* mentioned above largely reflects habitat variables, but upwards to three species will be syntopic, thus increasing potential competition. Behavioral differences (Echternacht, 1967; Price, 1992), different foraging behaviors (Echternacht, 1967), and unstable populations (Scudday, 1971) have been suggested as mechanisms reducing competition between species of *Aspidoscelis*. Despite large prey overlap of *A. marmorata* and *A. tesselata* on IMRS, Mata-Silva (2005) considered the abundance of termites and other prey to limit competition. Hotchkin and Riveroll (2005) and Mata-Silva (2005) provided a summary of competition in *Aspidoscelis*. Maury (1995) suggested *C. texanus* is not in competition with other lizards with a similar diet since resource portioning is partially determined by differences in body size (SVL) and jaw length. All rattlesnake species can be found in the same area on IMRS, but they generally separate themselves by elevation, habitat, and microhabitat usage (Vicente Mata-Silva, *pers. comm.*). Influence of competition on each species on IMRS is beyond the focus of this study, but the potential for competition is present and could be a factor in habitat usage.

Limiting Factors of Distribution on IMRS. - Due to the importance of wetlands in their life history, amphibians often have patchy distributions, especially in arid regions where suitable

habitat is scarce and fragmented (Dayton et al., 2004; Gray et al., 2004). Many amphibians are also reliant on specific terrestrial habitat components that provide foraging opportunities and refugia, thus, suitable amphibian habitat is determined by both aquatic and terrestrial components (Pope et al., 2000; Porej et al., 2004). Different ecologies of amphibians on IMRS necessitate a variety of terrestrial habitats, but aquatic habitats are likely more limiting to amphibian distribution on IMRS because of reproductive behavior.

Squaw Spring is the only permanent water source, and there are approximately ten ephemeral tanks that retain water across the property. The aquatic habitats present in arroyos after rains, though very short lived, probably aid in amphibian dispersal, but the large distances between established water bodies (e.g., earthen tanks) make colonization and gene flow (Wang, 2009) difficult. Amphibians are capable of dispersing over far distances, as Szymura and Barton (1991) found Fire-bellied Toads (*Bombina bombina*) to disperse as far as 11 km in rare instances. Rates of dispersal depend on the species (Marsh and Trenham, 2001) and likely its environment. Arid conditions on IMRS may necessitate dispersing amphibians to be able to live and breed in the aquatic habitats in arroyos, as it could take multiple generations to traverse the large expanses to a water body. If a species could live and breed in arroyos, the need to colonize earthen tanks would seem unnecessary, but earthen tanks could be more favorable to amphibians. Standing water remains longer in tanks than in arroyos (*pers. obs.*), allowing more time for tadpole metamorphosis, and the water holding ability of soils at earthen tanks translates to slower percolating water loss in the soils, which would reduce fatality by desiccation (Creusere and Whitford, 1976; Dayton et al., 2004). This effect already seems to have been observed, as the grassland species *A. cognatus* and *A. speciosus* have each been observed once, with only the former dispersing into the interior of the Indio Mountains. Marsh and Trenham (2001) discussed

that habitat isolation, or the distance between habitats, has often been found to significantly impact amphibian populations in disturbed areas more than in undisturbed areas. They suggest the impact of isolation effects may indicate the level of landscape disturbance. The altered vegetation community on IMRS from past grazing could help explain the absence of several grassland amphibians (Appendix 2). However, all amphibians on IMRS are typical of grassland habitats within their range, and since some are well represented on IMRS, terrestrial habitat characteristics must play a role as a barrier to dispersal to certain species more than others.

Creusere and Whitford (1976) and Dayton et al. (2004) found soil type to play an important role in amphibian presence or absence. Dayton et al. (2004) also reported that the influence of vegetation on amphibian distribution is uncertain because of the relationship between soil type and vegetation. Soil type could be a major terrestrial habitat component that limits amphibian distribution on IMRS, particularly for burrowing species given the gravelly to rocky substrates across IMRS.

The mountainous terrain of IMRS is undoubtedly a barrier to the distribution of the two documented turtle species. Dodd (2001) reported gravelly foothill slopes as *T. ornata* habitat. There is only a single record for this species near Double Tank Corral, so it is unclear if this area of IMRS is too far removed from the desert flats along Green River or if the habitat of this area restrains adequate foraging, refugia selection, or hibernacula opportunities. Some observations of *T. ornata* have been made in montane situations at high elevations, but all were in mesic woodlands (Degenhardt et al., 1996; Brennan and Feldner, 2003; Messing et al., 2009). *Kinosternon flavescens* undoubtedly could survive in the conditions present at earthen tanks habitats on IMRS (Christiansen and Bickham, 1989). Yellow Mud Turtles are known to wander long distances overland (Mahmoud, 1969), and Degenhardt and Christiansen (1974) give an

example of a large population that occupied a pond at least five miles from any other ephemeral pond and at least 30 miles from the nearest permanent stream. For *K. flavescens* to colonize Red Tank, the site of the only record, they would have to travel from populations on the desert flats south and west located in or near the Rio Grande Valley, or perhaps further. Large arroyos would be a likely route, as they could burrow in loose soil and sand along arroyos for refuge during the heat of the day. However, the record for Red Tank could have been from an individual released by ranch or mine workers, as this species is more easily encountered in tanks along Green River Road, the principal access road to IMRS.

Concerning lizards, *P. obsoletus* and especially *P. tetragrammus* are mainly restricted to mesic areas with vegetation cover that prevents desiccation (Degenhardt et al., 1996). The only known population of *P. tetragrammus* on IMRS has been documented from the semi-riparian zone and permanent wetland at Squaw Spring, and it is considered a relict at this site. Szaro and Belfit (1986) reported species typically associated with riparian areas failed to invade a riparian zone created after damming of a creek in the Sonoran Desert. They suggested isolation from other habitats prevented colonization of this new riparian area. *Plestiodon tetragrammus* may have been more widespread on IMRS prior to loss of grass cover, which would have created a more mesic microclimate (Fitch, 1955; Creusere and Whitford, 1976). Following perennial grass loss, its preferred microclimate was reduced to Squaw Spring. Zweifel (1958) reported a relict population associated with a spring in Coahuila, Mexico. If dispersal from other riparian areas were possible, then other species associated with riparian habitats could be present at Squaw Spring as well, but this skink is the only species known to occur solely at that location.

Other lizards occurring on IMRS face fewer distributional limitations. Except for *C. texanus* and *A. marmorata*, the highest elevation on IMRS, approximately 1640 m, is not higher

than the known elevational limit for any lizard species occurring there. However, other mountain ranges could have a significantly different physical environment than that on IMRS at similar elevations. For example, 1640 m elevation marks the summit of the highest point on IMRS, yet at another locality, 1640 m elevation could only be the foothills or base of a mountain. Environmental differences related to elevation have been reported by many authors. Enright et al. (2005) reported several temperate associated plant species limited to mountain peaks of a range in Pakistan. Janzen (1967) found higher elevations to remain cooler than lower elevations, a process also shown on IMRS by De La Cerda (2011). Furthermore, Powell (1998) reported precipitation generally increased and temperature generally decreased with higher elevations of Trans-Pecos, Texas. Therefore, elevation on IMRS could restrict lizard distribution if the physical environment of mountain summits is not amenable to certain species.

Some factors could contribute to the relative abundance of certain lizard species at particular sites, such as mesic areas for *A. exsanguis* (Echternacht, 1967), rock cover for *Crotaphytus collaris* (Lemos Espinal et al., 2009), and open areas for *Phrynosoma cornutum* and *P. modestum* (Baltosser and Best, 1990; Burrow et al., 2001).

Similarly, few snake species reach their elevational limit on IMRS. *Bogertophis subocularis* and *Salvadora deserticola* both fall short with a known distribution up to 1600 m elevation, and *Rena humilis* occurs up to 1425 m elevation (Degenhardt et al., 1996). The same elevational restrictions of lizards on IMRS could also apply to snakes. Snakes generally associated with grasslands, such as *A. elegans*, *G. canum*, *Pituophis catenifer*, and *Rhinocheilus lecontei*, remain rare or uncommon, but their ability to disperse into mountainous areas is documented (Degenhardt et al., 1996; Worthington et al., 2004). Succession of semidesert grassland to Chihuahuan Desert scrub negatively impacted *A. elegans*, but did not affect *P.*

catenifer, a habitat generalist (Mendelson and Jennings, 1992). Thus, the infrequent observation of *P. catenifer* on IMRS is likely caused by characteristics of the montane environment rather than altered vegetation associations, which is also likely influencing the distribution of other typically grassland snakes. Substrate is probably one such characteristic limiting those typical grassland species, as only *P. catenifer* does not exhibit fossorial tendencies. The soil is amenable to other fossorial species, such as *Rena humilis*, but larger species that burrow may experience difficulty exploiting the primarily gravelly to rocky substrate on IMRS. In addition to active burrowing, snakes with fossorial tendencies utilize burrows made by other species, ground litter, and rocks as retreats (Degenhardt et al., 1996; Werler and Dixon, 2000). Still, fossorial snakes are uncommon on IMRS, but could be locally abundant in favorable habitats, such as steep, rocky slopes of major drainages (Degenhardt et al., 1996; Werler and Dixon, 2000).

Understanding changes to herpetofaunal communities. - Long-term studies of herpetofaunal populations are important to making conclusions about population changes (Tinkle, 1979; Seigel et al., 1995). Long-term studies help determine population dynamics, which in the short-term could produce inconclusive or misleading results (Seigel et al., 1995). Studies have associated population fluctuations of amphibians and reptiles with changes in rainfall patterns, prey availability, and reproductive output (Pianka, 1966; Whitford and Creusere, 1977; Price, 1990; Anderson, 1994; Seigel, 1995; Dayton and Fitzgerald, 2006). Additionally, numerous studies have revealed seasonality of habitats, microhabitats, and foraging behavior used by the herpetofauna of different areas (Whitford and Creusere, 1977; Vitt et al., 1981; Baltosser and Best, 1990; Anderson, 1994; Beck, 1995; Burrow, 2001; Hager, 2001; Mata-Silva, *in prep*). A complete understanding of the autecology of herpetofaunal species will allow for thorough investigation into factors affecting their population dynamics.

Future Directions

On IMRS, the lack of empirical studies on relative abundance and ecology of its herpetofauna make it difficult to determine response to various factors. Geographic variation in the ecology of species (Drummond and Burghardt, 1983; Weatherhead and Prior, 1992; Punzo, 2007) necessitates a thorough understanding of each species in this northern Chihuahuan Desert scrub montane environment. Since the herpetofauna on IMRS are subjected to extreme temperatures, variable rainfall events, environmental and climatic change and related vegetation succession, long-term studies investigating abundance and ecology at the community and species level will be useful benchmarks to determine community response to a changing environment, such as global warming, effects of fire, and habitat degradation by human pressures. It is hoped that the study presented herein will be a starting point for future studies associated with ecogeography and related ecological investigations of an interesting assemblage of amphibians and reptiles in the Chihuahuan Desert.

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APPENDIX

APPENDIX 1. Native amphibians and reptiles reported from IMRS by Worthington et al. (2004). The following classification and common names follow that recommended by the Center for North American Herpetology (www.cnah.org).

Class	Order	Family	Species	Common Name
Amphibia	Anura	Bufonidae	*Anaxyrus cognatus*	Great Plains Toad
			Anaxyrus debilis	Green Toad
			Anaxyrus punctatus	Red-spotted Toad
			Anaxyrus speciosus	Texas Toad
		Microhylidae	*Gastrophryne olivacea*	Great Plains Narrowmouth Toad
		Scaphiopodidae	*Scaphiopus couchii*	Couch's Spadefoot Toad
Chelonia	Testudines	Emydidae	*Terrapene ornata*	Ornate Box Turtle
		Kinosternidae	*Kinosternon flavescens*	Yellow Mud Turtle
Reptilia	Squamata	Crotaphytidae	*Crotaphytus collaris*	Eastern Collared Lizard
	(Lizards)	Eublepharidae	*Coleonyx brevis*	Texas Banded Gecko
		Phrynosomatidae	*Cophosaurus texanus*	Greater Earless Lizard
			Phrynosoma cornutum	Texas Horned Lizard
			Phrynosoma modestum	Roundtail Horned Lizard
			Sceloporus cowlesi	Southern Plateau Lizard
			Sceloporus poinsetti	Crevice Spiny Lizard
			Urosaurus ornatus	Tree Lizard
			Uta stansburiana	Side-blotched Lizard
		Scincidae	*Plestiodon obsoletus*	Great Plains Skink
			Plestiodon tetragrammus	Four-lined Skink
		Teiidae	*Aspidoscelis exsanguis*	Chihuahua Spotted Whiptail
			Aspidoscelis inornata	Little Striped Whiptail
			Aspidoscelis marmorata	Western Marbled Whiptail
			Aspidoscelis tesselata	Colorado Checkered Whiptail
	(Snakes)	Colubridae	*Arizona elegans*	Glossy Snake
			Bogertophis subocularis	Trans-Pecos Rat Snake
			Gyalopion canum	Western Hook-nosed Snake
			Lampropeltis alterna	Gray-banded Kingsnake
			Masticophis flagellum	Coachwhip
			Masticophis taeniatus	Striped Whipsnake
			Pituophis catenifer	Gopher Snake
			Rhinocheilus lecontei	Longnose Snake

APPENDIX 1 (continued). Native amphibians and reptiles reported from IMRS by Worthington et al. (2004). The following classification and common names follow that recommended by the Center for North American Herpetology (www.cnah.org).

Class	Order	Family	Species	Common Name
		Colubridae (cont.)	*Salvadora deserticola*	Big Bend Patchnose Snake
			Salvadora grahamiae	Mountain Patchnose Snake
			Sonora semiannulata	Ground Snake
			Tantilla hobartsmithi	Southwestern Blackhead Snake
			Trimorphodon vilkinsonii	Chihuahua Lyre Snake
		Crotalidae	*Crotalus atrox*	Western Diamondback Rattlesnake
			Crotalus lepidus	Rock Rattlesnake
			Crotalus molossus	Black-tailed Rattlesnake
		Dipsadidae	*Diadophis punctatus*	Ringneck Snake
			Hypsiglena jani	Chihuahua Night Snake
		Leptotyphlopidae	*Rena humilis*	Western Blind Snake
		Nactricidae	*Thamnophis cyrtopsis*	Blackneck Garter Snake

APPENDIX 2. Native amphibians and reptiles that potentially occur on IMRS based on county range maps provided by Dixon (2000); species that have specific habitat requirements not found on IMRS are not included and * denotes species not reported for Hudspeth County, but are in surrounding counties. The following classification and common names follows that recommended by the Center for North American Herpetology (www.cnah.org).

Class	Order	Family	Species	Common Name
Amphibia	Anura	Bufonidae	*Anaxyrus woodhousii*	Woodhouse's Toad
			Rana berlandieri	Rio Grande Leopard Frog
		Scaphiopodidae	*Spea bombifrons*	Plains Spadefoot
			Spea multiplicatus	New Mexico Spadefoot
	Caudata	Ambystomatidae	*Ambystoma mavortium*	Barred Tiger Salamander
Reptilia	Squamata			
	(Lacertilia)	Crotaphytidae	*Gambelia wislizenii*	Longnose Leopard Lizard
		Phrynosomatidae	*Holbrookia maculata*	Lesser Earless Lizard
			Sceloporus magister	Desert Spiny Lizard
		Teiidae	*Aspidoscelis neomexicana*	New Mexico Whiptail
			Aspidoscelis septemvittata	Plateau Spotted Whiptail
	(Serpentes)	Colubridae	*Pantherophis emoryi*	Great Plains Rat Snake
			Lampropeltis splendida	Desert Kingsnake
			*Lampropeltis triangulum**	New Mexico Milksnake
			Tantilla nigriceps	Plains Blackhead Snake
		Crotalidae	*Crotalus scutulatus*	Mojave Rattlesnake
			Crotalus viridis	Prairie Rattlesnake
			*Sistrurus catenatus**	Massasauga
		Dipsadidae	*Heterodon kennerlyi*	Mexican Hognose Snake
		Leptotyphlopidae	*Rena dissecta*	New Mexico Blind Snake
		Natricidae	*Thamnophis marcianus*	Checkered Garter Snake

APPENDIX 3. Gazetteer for locations on IMRS mentioned within this paper. Names and descriptions were taken from Worthington et al. (2004).

Agate Hill. - Small hill composed of igneous rock along River Road, W of Flat Top Mountain (30º 44’25”N, 105º 00’10”W), 1215 m elevation.

Bailey Evans Canyon. - The canyon and arroyo directly north of dormitory and bathroom building at IMRS Headquarters. The arroyo eventually terminates in the Rio Grande near The Box.

Black Diamond Mine. - Abandoned mine, circa 1.75 air km SE of IMRS Headquarters; developed by Walter Rossman in the late 1940’s; consists of a ~30 m deep vertical shaft (30º 46’05”N, 105º 00’05”W), 1260 m elevation.

Campo Bonito. - Abandoned at a partially dismantled windmill on the River Road, circa 3.2 road km S of junction with Eagle Canyon Road (30º 42’28”N, 104º 58’08”W), 1122 m elevation.

Carpenter Mine. - Abandoned mine and mining company headquarters (ruins only) on Purple Sage Mine Road, circa 2 air km SSW IMRS Headquarters; ruins and mine near 30º 45’38”N, 105º01’22”W, 1200 m elevation; yielded a small amount ore containing 2.5% copper.

East Gate. - Principal access gate to IMRS on Main Road, 5.12 road km W of junction with Green River Road, just E of Double Tanks Corral (30º 47’12”N, 104º 58’35”W), 1320 m elevation.

East Well. - Defunct well and metal tank on east side of Indio Mountains, circa 3.3 air km SE of East Gate (30º46’05”N, 104º 57’10”W), 1223 m elevation.

Echo Canyon Twin Tanks. - Two adjacent seasonally dry impoundments along Main Road in Echo Canyon, just NE of junction with road to Black Diamond Mine (30º 46’25”N, 105º 00’00”W), circa 1170 m elevation.

Echo Canyon. - Southwest draining canyon along Main Road on east side of Indio Mountains below Indio Pass.

Flat Top Mountain. - Mesa and ridge system NNW of Red Tank; maximum elevation is 1337 m on the southern end (30º 44’20”N, 104º 59’35”W).

Green River Road. - Gravel road forming main access to IMRS from the east; passes through Wolf Creek Ranch S of Scott’s Crossing and extends into O’Connor Ranch (locked gate); follows bed of Green River to vicinity of The Box.

Main Road. - Gravel road from Green River Road, through East Gate, Echo Canyon, to Indio Ranch House, and then NNW toward North Gate, Oxford Canyon, and Squaw Spring.

Mesquite Tank. - Tank near Bailey Evans Arroyo located circa 2.78 km WSW of IMRS Headquarters (30.76167ºN, 105.03085ºW), 1167 m elevation.

Peccary Tank. - Seasonally dry impoundment along River Road, circa 2.88 road km S of IMRS Headquarters (30º45’20”N, 105º 00’15”W), 1194 m elevation.

Pirtle Tank. - Southeasternmost of the two seasonally dry impoundments in the Double Tank Corral area adjacent to the Main Road near the junction with Eagle Canyon Road (30º 47’05”N, 104º 59’00”W), 1314 m elevation.

Purple Sage Mine Road. - Gravel road extending SSW from Main Road S of IMRS Headquarters to Carpenter and Purple Sage Mines.

Rattlesnake Tank. - Seasonally dry impoundment at head of small east draining canyon circa 1 air km ENE of summit of Red Mountain and 0.25 km W of River Road (30º 44’47”N, 105º 00’30”W), 1179 m elevation.

River Road. - Gravel road running from Green River near The Box north via South Gate, Campo Bonito, The Narrows, Agate Hill, and finally junctioning with Main Road circa 1 air km S of IMRS Headquarters.

Road Tank. - Northernmost of two seasonally dry impoundments near Double Tank Corral, near the head of jeep trail/track leading to upper Squaw Spring Canyon; it often has water early and/or late in the year (30º 47’13”N, 104º 59’08”W), 1314 m elevation.

Squaw Creek Canyon. - Major arroyo draining southwest to the Rio Grande; head is circa 3 air km NNW of Double Tank Corral area; contains Squaw Spring.

VITA

Ross Couvillon was born in Houston, Texas on 12 February 1989. He is the first of three children of Rory and Ingrid Couvillon. Ross graduated from Lamar High School in Houston, Texas in May 2007. He continued his education at Texas A&M University in College Station, Texas, and graduated in December 2009 with a Bachelors of Science in Wildlife and Fisheries Sciences. During this period, Ross's interest in field research began. In the fall of 2010, he became a graduate student in the Department of Biological Sciences under the direction of Dr. Jerry D. Johnson at the University of Texas at El Paso. In 2011 he received a grant from the East Texas Herpetological Society and co-authored two natural history notes. His research interests include wildlife ecology (particularly herpetology), conservation, and management. Following graduation, Ross intends to establish a career which will allow him to pursue these interests.

Ross is a member of the Society for the Study of Amphibians and Reptiles, Southwestern Association of Naturalists, and Turtle Survival Alliance.

Permanent Address: Ross will be relocating to Oklahoma City, Oklahoma after graduation for a short period of time, following which he will remain in the southern United States.

This thesis was typed by Ross O. Couvillon.