FLAT-TAILED HORNED LIZARD MONITORING REPORT

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And special thanks to all the horny toads that put up with our presence.

Cover Photo: hatchling flat-tailed horned lizard in the North Algodones Dunes Wilderness Area. April 2002. Tyler Grant.

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Abstract: No significant trends ($p > .05$) in flat-tailed horned lizard (Phrynosoma mcallii) detection rates were found in three areas of Imperial County, California from 1979 to 2001. The number of lizards sighted per transect in 2001 (0.14) did not differ significantly ($p = .42$) from the number sighted per transect in 1979 (0.11). These results could reflect lack of a major change in the population size or the insensitive nature of the methodology resulting from the difficulty of detecting this species.

Between 1979 and 2001, flat-tailed horned lizards were encountered 3.9 times more frequently ($p = 0.01$ to 0.08) in the Limited Use and Navy lands of West Mesa (0.128 lizard/transect) than in adjacent Open Areas (0.033 lizard/transect). By contrast, the lizard encounter rate in the Open Areas of the Algodones Dunes (0.04 lizards per transect) did not vary significantly from that in the Wilderness Area (0.00 lizards per transect), however this comparison was hampered by the low sample size in the Wilderness ($n = 11$). In 2001, transects with lizards did not have significantly less vehicle track coverage (6.8%) or routes (2.2/mile) than transects without lizards (8.7%, 2.4 routes/mile) ($p = 0.38$ and 0.77, respectively). Chi-square analyses of the association between lizard sightings and routes or lizard sightings and vehicle track coverage were not significant ($p = .28$ and $p > .5$, respectively). Logistic regression found a slight reduction in the odds of a lizard being detected with increasing vehicular impacts (odds ratio = 0.9824) but this relationship was of low statistical significance ($p = 0.5$). Overall, no consistent relationship between vehicle impacts and flat-tailed horned lizard detection rates was found.

In 2001, the percentage of the surface covered with vehicle tracks was estimated on West Mesa at 11.4%, on the eastern Yuha Desert at 10.5% and on southern East Mesa at 4.8%. The mean number of routes per mile detected on West Mesa was 4.4, 1.8 on the eastern Yuha and 0.7 per mile on East Mesa. In a separate study, the mean number of routes per mile detected on 15 transects in West Mesa increased from 1.6 in 1985 to 8.2 in 2001, a 423% increase. Routes and graded roads detected increased by 23% in the eastern Yuha Desert and by 47% in West Mesa between 1994 and 2001, while they declined on southern East Mesa by 45% during this same period. Overall, vehicle impacts appear to be increasing in West Mesa and the eastern Yuha and declining in southern East Mesa.

The rates at which lizards were encountered from 1979 to 2001 were highest in the Navy and Limited use areas of West Mesa (0.17 lizards/transect and 0.29 lizards/transect, respectively) and lowest in the West Mesa Area of Critical Environmental Concern (0.05), Algodones Dunes (0.04), Plaster City (0.03) and Superstition Mountains Open Areas (0.03), suggesting differences in the relative abundance of flat-tailed horned lizards among these areas. The Yuha Desert and East Mesa had intermediate sighting rates (0.11 and .08, respectively).

Chi-square analysis showed no significant ($p > .5$) association between lizard sightings and the dominant substrate type (sand, gravel, hardpan) on survey transects. Most lizard sightings between 1991 and 2001 (88%, $n = 148$) occurred between 28 and 41 degrees Celsius (82 - 106 Fahrenheit), suggesting this temperature range is ideal for detecting this species.

Introduction

The Species and Its Life History

The flat-tailed horned lizard (*Phrynosoma mcallii*) is a small phyrnosomatid (horned) lizard that occurs in extreme southeastern California, southwestern Arizona and in northern Baja California and Sonora, Mexico. The lizard has the smallest range of any horned lizard in the United States (Foreman 1997). It eats primarily ants (Pianka and Parker 1975, Turner and Medica 1982) and occurs in a broad range of habitat types from large active sand dunes to sandy or gravelly creosote flats, mudhills, dry desert washes, pssamophytic scrub and saltbush scrub (Foreman 1997, Beauchamp et. al. 1998 and BLM records, 2001). Adults typically weigh 17 to 25 grams with snout vent lengths from 70 to 80 mm (BLM records, 2001). The lizard is usually a light buff tan color with a distinct dark longitudinal stripe along the middle of the back, 2 rows of abdominal fringe scales on each side and elongated horns on the back of the head. It is active from late February to early November and lives in shallow burrows 2 to 4" deep during the winter (Foreman 1997). Peak activity in Imperial County is from mid-May to mid-September (Wright 1993). Juveniles have been seen between April and February, suggesting that breeding may occur during most of the year (Wright, personal observations, 1991 to 2002). Lizards may live at least four years (Grant 2002) and are predated by shrikes, round-tailed ground squirrels and snakes (Muth and Fisher 1992). In some areas, vehicular mortalities also occur (Muth and Fisher 1992, Wright, personal observations 1991-2002). The lizard is sympatric on the western and eastern sides of its range with the closely related, desert horned lizard, (*Phyrnosoma platyrhinos*) and perhaps with the coast horned lizard, (*Phrynosoma coronatum*) near North Palm Springs in the Coachella Valley (Cornett, pers. com. 1999).

Environmental Concerns

Much of the lizard's former range in the Imperial and Coachella Valleys has been lost to agriculture or urban development while portions of the remainder are impacted by a variety of human activities including off-highway vehicles, military activities, mining, tamarisk (*Tamarix* spp.) infestation, immigration, border patrols, highway maintenance and powerline construction (Foreman 1997). Habitat is also extensively fragmented. In the Imperial Valley by Interstate-8, agriculture and the Coachella Canal which divide the population into four major pieces: the Algodones Dunes, East Mesa, West Mesa/Anza Borrego and the Yuha. In Arizona, the lizard is separated from the California population by the Colorado River. In the Coachella Valley, the population is fragmented into two major pieces by Interstate 10. Thus the current population is divided into seven groups, more or less. Other small isolated pieces of habitat occur between the All-American Canal and Interstate-8 south of East Mesa, near the Dos Palmas Preserve at the northeastern side of the Salton Sea and at Windy Point and the eastern end of the Indio Hills in the Coachella Valley (Wright, personal observations, 2002). This habitat loss and fragmentation, coupled with impacts in the remaining habitat, have raised concerns about the lizard's future.

Policy Context

In response to such concerns, the lizard was first proposed for listing as threatened by the U.S. Fish and Wildlife Service (USFWS) in 1993 (USFWS 1993 and Foreman 1997). In 1997, the listing proposal was withdrawn based on new information about threats to the lizard and the signing of a Conservation Agreement among federal agencies (USFWS 1997). In August of 2001, a federal appeals court overturned the decision to withdraw the listing and ordered the USFWS to reconsider the lizard's status. The Service reproposed the lizard for listing in December of 2001 (USFWS 2001).

To address the lizard's status, the BLM has monitored the lizard's distribution and abundance since 1979. This report analyzes and interprets data from this monitoring from 1979 through 2001, as well as data recently collected on vehicular impacts in key areas of the lizard's habitat. The data cover areas believed to contain the highest relative abundances (based on scat counts and the lizard encounter rates) of the lizard in Imperial County: southern East Mesa, eastern Yuha and West Mesa.

Methods and Materials

The fundamental method for monitoring the lizard from 1979 to 2001 was to walk transects and record the number of lizards and scat seen along the transect. Differences existed in the method of transect selection, number of observers, number of repetitions, as well as in the length and shape of transects from year to year, however the approximate width was constant. Biologists usually surveyed for scat and lizards by walking triangular transects that were 4.02 kilometers (2.5 miles) long by about 1.27 meters (50 inches) wide. This type of transect usually took between 50 minutes and 75 minutes to complete depending on the terrain, amount of sign recorded and observer speed. Transects were usually walked by one biologist. From 1979 to 1990 transects in the Yuha were walked in a variety of shapes (Olech, no date). Beginning in 1991 all transects were standardized to 2.5 mile triangles, except where natural or man-made features (freeways, canals, mountains) prevented this shape, in which case the transect was modified to accommodate the obstruction. Data were standardized to lizards or scat seen per observer-hour or 10 hours, lizards per transect or percentage of transects with lizard scat or lizards. Navigation was with pedometer and compass from 1979 to 1997. GPS's located section corners from 1991 to 2001. Beginning in 2001 observers navigated with hand-held Garmin 3+ GPS's (Garmin Ltd. 2001).

In most cases, biologist selected transects for trend monitoring either systematically or randomly from within the sampling areas outlined in figures 7- 9. A systematic sample involved sampling Sections in an evenly spaced pattern across an area. Random sampling means Sections were selected with a random numbers table or random numbers generator. Transects in all areas in 1979 and 1984 appear to have been selected systematically based on their even spacing across the lizard's habitat. Transects in East Mesa in 1986 also appear to have been selected systematically. Transects walked in 1981 paralleled the proposed La Rosita Powerline, as a part

of the environmental assessment for that project. Although these transects were selected to evaluate the proposed powerline route, their distribution approximated a systematic sample of portions of the eastern Yuha. In other years (except 1985 in East Mesa) biologists selected transects either randomly or with a randomized systematic sample. Each year that surveys were done from 1985 to 1997, a fresh sample was drawn except that beginning in 1993 in the Yuha, the same 12 transects were done each year based on a randomized systematic sample. Transects done in 1979 in the Yuha were repeated in 1984, as were a portion of the 1981 transects.

Transects in the Yuha were walked more than once beginning in 1993, when each transect was walked 3 times. In 1994, Yuha transects were walked twice each, in 1995 only 10 of the 12 transects were walked and only one repetition was performed, in 1997 eight transects were walked once and 4 were walked twice. In 2001, all 12 Yuha transects were walked three times, while those in East Mesa and West Mesa were walked once each. Transects in East Mesa and West Mesa were walked twice in 1992. In 1979, 1986 and 1987 a few transects were repeated. The number of transect repetitions was dependent on personnel availability. Multiple transects were intended to more accurately represent the situation within a Section, as lizard surface activity and scat deposition can vary greatly during the active season (Wright 1993). After 1989 only one observer walked each transect.

Fixed transects in the Yuha beginning in 1993 reduced the sample variance by removing or at least reducing the spatial component of the variance, to achieve better interspersion of transects throughout the sampled area, and to allow more accurate tracking of temporal trends. A randomized systematic sample of East Mesa and West Mesa began in 2001, for the same reasons, with the intent that these same transects would be executed in the future. Transects surveyed in 1985 in East Mesa were included in the trend analysis although these were apparently selected to assess vehicle impacts west of Gordon's Well and southeast of the Holtville Airport and not to assess trends on East Mesa as a whole. Judging from its highly clumped distribution this sample was apparently not selected randomly. Table 1 summarizes these methods.

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Transects in the Yuha were walked more than once beginning in 1991 when each transect was walked 3 times. In 1994, Yuha transects were walked twice each. In 1995 only 8 of the 12 transects were walked and only one repetition was performed. In 1997 eight transects were walked once and 4 were walked twice. In 2001, all 12 Yuha transects were walked three times while those in East Mesa and West Mesa were walked once each. Transects in East Mesa and West Mesa were walked twice in 1992. In 1978, 1986 and 1995 transects were walked once. The number of transect repetitions was dependent on personnel and weather. Repetitions were intended to more accurately represent the situation at the time of the survey, since lizard activity and scat deposition can vary greatly during the survey season (Turner 1978). After 1990 only one observer walked each transect.

Fixed transects in the Yuha beginning in 1988 reduced the sample variance by eliminating or at least reducing the spatial component of the variance, to achieve better coverage of the sampling area throughout the sampled area, and to allow more accurate tracking of trends within the Yuha. A randomized systematic sample in East Mesa and West Mesa began in 2001 for the same reasons with the intent that these same transects would be examined in the future. Transects walked in 1985 in East Mesa were included in the trend analysis although these were in an area selected to assess vehicle impacts west of Gordon's Well and southwest of the Highway 98 and were not used to assess trends on East Mesa as a whole. Judging them as largely similar [illegible] the sample was apparently not selected randomly. Table 1 summarizes trend transects.

Table 1. Summary of Methods for Surveying Flat-tailed Horned Lizards (*Phrynosoma mcallii*) in Imperial County, CA.

Year	Areas	# of transects	Sampling method	Repetitions per transect	# of Observers
1979	All	139	Systematic	1-2	1-3
1981	Yuha(Y)	51	La Rosita	1	1
1984	Yuha	44	Systematic	1	1-2
1985	All	64	Random (Y,W), non-random (E)	1	1-3
1986	Yuha, East Mesa (E)	43	Random (Y), systematic (E)	1-2	1-2
1987	West Mesa (W), Yuha	53	Random	1-2	1-3
1988	West Mesa, Yuha	31	Random	1	1-3
1989	All	24	Random	1	1-2
1990	Yuha, West Mesa	44	Random	1	1
1991	All	53	Random	1	1
1992	East Mesa, West Mesa	38	Random	2	1
1993	Yuha	36	Randomized Systematic	3	1
1994	Yuha	25	Randomized Systematic	2	1
1995	Yuha (Y), West Mesa (W)	25	Randomized Systematic (Y), Random (W)	1	1
1997	Yuha (Y), West Mesa (W)	32	Randomized Systematic (Y), Random(W)	1-2 (Y), 1(W)	1
2001	All	118	Randomized Systematic	1-3	1

In addition to monitoring transects, project specific intensive surveys with linear transects 0.1 miles apart assessed project impacts. 2.5 mile triangular transects inventoried areas of unknown flat-tailed horned lizard status, monitored lizard emergence, assessed the impact of ant mounds

on scat production (East Mesa in 1996 and 1997) or assessed the impact of race course closures. These types of transects were not used in the trend analysis because they were not selected randomly or systematically and were not intended to reflect trends in a broader area. Figures 6 - 8 show the historical sampling areas. These are the areas from which the samples were drawn. Note that the East Mesa historic sampling area is less than the area monitored in 2001. Transects outside these areas were not analyzed in the trend data, with one exception, because they were not consistently monitored from 1979 to 2001. The one exception to this was for the two way comparison between East Mesa in 1979 and 2001, for which the entire area shown in figure 7 was compared because it was monitored in both these years.

Biologists counted the number of probable horned lizard scat (lizard scat composed entirely of ants) and flat-tailed horned lizards found on each transect. Beginning in 1993, tallying only scat greater than 5.5 mm in diameter reduced the chance of confusion with fringe-toed lizard (*Uma notata*) and whiptail (*Callisaurus draconoides*) scat (Muth and Fisher1992). This restriction reduced the amount of scat included in the scat/hr calculation by about 19% over previous years. Beginning in 1991, the air temperature 1 cm above the soil where the lizard was found was measured.

Surveys occurred during the spring and summer when lizards were active on the surface. Generally, surveys occurred between dawn and 11 AM, corresponding to the approximate activity temperature range of the species. In 1979, some summer surveys were done in the evenings from 1700 hours to sunset and some surveys were done in April during the late morning or afternoon. Observers were trained on how to locate lizards and their scat prior to beginning transects. From 1990 to 1995, surveys were delayed for five days following major wind events. Beginning in 1997, surveys were suspended for 12 days following major wind events. Prior to 1990, the length of this suspension is unknown but presumably it occurred. This suspension of surveys following major wind events allows scat fragile horned lizard scat to reaccumulate following destruction or burying by wind.

Surveys by foot to detect impacts began in 2001 on the same transects used for lizard surveys. These transects were selected in a randomized systematic fashion covering every third Section in the three areas of Imperial County believed to contain the densest lizard populations (West Mesa, eastern Yuha and southern East Mesa). Transects began within the Section 0.1 mile from the Section corner closest to an access road, possibly introducing a road or corner marker bias. The beginning of the transect on a bearing bisecting the north-south Section line and the east-west Section line. Observers usually walked a triangular transect with sides of 0.9 miles, 0.8 miles and 0.8 miles returning to their starting point. The 0.9 mile leg was the north-south leg while the 0.8 mile legs were at angles of 236, 124, 304 or 56 degrees, depending on the orientation of the transect. For Sections truncated by topographic or significant man-made features transects were modified to fit within the truncated Section. UTM coordinates recorded the exact layout of the transects on data sheets so that future researchers could repeat them.

Observers navigated with a GPS. Observers counted whatever was on the surface at the point of

their shoe every 20th step (every 10th step of the right foot). This resulted in about 270 points per transect. All data were recorded on 8.5 x 11 inch paper. A point was classified as a track if evidence of vehicular passage was at the point. If no such evidence was apparent, the point was classified by the type of vegetation present. Points under a plant's canopy were counted as a plant point even if they didn't touch the plant. Dead plant material was classified as litter, except dead creosote which was given its own category. If no vegetation or litter was present the point was classified as either sand, gravel or hardpan. Sand was considered to be particles under 1 mm in diameter, while gravel was particles of greater size, up to 50 mm, after which the substrate was classified as rock. Hardpan was consolidated material without either sand, gravel or rock on it. A point was classified by the feature exactly at the point of the toe, even if the substrate around the point was of a different type. Where practical, the number of vehicle tracks crossed was recorded. Campfires, bottles and piles of clothes seen from the transect were counted, as were the number of sets of foot tracks, pole lines, paved roads, graded roads and vehicle routes crossed. The portion of the transect that crossed geothermal, agricultural or mining activity was also recorded. Thus, two sampling methods were combined: point intercept and the number objects of interest visible from the transect or intercepted by the transect.

The percentages of vehicle impact, plant and litter cover were calculated by dividing the number of track points by the total number of points to give an approximation of the percentage of the transect directly impacted by vehicles. The percent of cover by sand (grain size < 1 mm), gravel (grain size 2mm to 50mm) or hardpan was calculated by summing the total number of points for these three categories and then dividing this total into the number of points for each substrate type. Chi-square analysis was performed to assess whether a significant association existed between lizard sightings and the most prevalent substrate on each transect.

Impact survey transects from 2001 were overlayed onto1996 route and road survey maps. These routes and roads were recorded between 1990 and 1994 with Global Positioning Systems (GPS) , foot surveys and from other route maps. The number of routes or graded roads that each transect crossed was compared between the 1990's inventory and the 2001 inventory. The 1990 to 1994 inventory did not distinguish between graded roads and routes (ungraded roads). In the early 1990's roads and routes were only completely recorded in limited areas, not in opens areas. Therefore, transects wholly or partially within open areas were not included in the comparison between the 1990's inventory and the 2001 inventory. In the 2001 inventory, all routes were counted in open areas.

<u>Superstition Mountains and Plaster City OHV Open Areas</u>

Survey data from 1979 to 2001 in the Superstition Mountains Open Area (SMOA) and Plaster City Open Area (PCOA) were pooled and compared to survey data collected during the same period from adjacent Navy and Limited Use lands. To reduce the effect of annual population fluctuations on the comparison, only years during which sampling occurred in both Open and non-Open (Navy and Limited) areas were analyzed. This resulted in the elimination of 1981's data leaving 12 years whose data were analyzed (1979, 1985, 1987 - 1993, 95, 97 and 2001).

Transects covering a mixture of Open Area and Limited or Navy Lands were eliminated from the analysis to avoid with mixed management effects. Transects on private lands were included in the analysis if they were entirely within an Open area or were surrounded by Navy or Limited Use lands. Such private lands usually assume vehicle use patterns similar to the surrounding government lands because they are generally unsigned and unfenced. Transects in two private Sections (T.14S, R.11E, Section 16 and T.15S, R. 11E, Section 16) were not included in the analysis as they lie between Open and Limited Use areas and as such have mixed management effects. Five project specific surveys of mining operations in the southeastern corner of the SMOA were eliminated as were data from a year round survey transect in the West Mesa ACEC. The mining surveys were biased toward mining impacts and the year round transect's inclusion would have created a strong bias toward one transect because this transect was repeated many times and was selected non-randomly. Data from the two pooled groups were compared with t-tests, Fisher exact test and the chi-square test to evaluate the hypothesis that sightings were associated with vehicle use class.

Lizard and scat encounter rates were calculated for various land management categories throughout the species range and listed in descending order (figure 5d). This included a comparison of the Open and Wilderness Areas of the Algodones Dunes. The Open Area of the Algodones Dunes refers to those lands open prior to the interim closures of 2001 since all the lizard data was collected prior to these closures. Private lands east of Ogilby were counted as "open" since their land use patterns are similar to the surrounding Open Area. Transects which were in partially open or partially closed areas were not included in the comparison as these transects had mixed management effects. For the remainder of the land use categories, only transects which were entirely on BLM lands and were wholly within one land use category were counted for the calculations for that category.

In 1985, the number of OHV routes in West Mesa on fifteen triangular transects was counted during June. The transects were triangular and between 2.2 and 2.7 miles in length. Nine of the transects lie wholly within the West Mesa Flat-tailed Horned Lizard Management Area. Five lie within or partially within the SMOA or PCOA, while one is on private land, just north of the PCOA. While the criteria used for transect selection is not certain, they appear to be representative given the somewhat dispersed nature of the transects' locations and their location in a variety of use categories (open, limited, Navy, ACEC). Seventeen transects of similar configuration were also walked on East Mesa in 1985. Unlike the West Mesa transects, the East Mesa transects were highly clumped in three groups. One group lay on the west side of the Navy Live Bombing Area, one between the Holtville Airport and the Hot Spring LTVA and one northeast of Gordon's Well. Most of the East Mesa transects were not repeated due to lack of personnel. The West Mesa transects were repeated in December and January of 2001 in approximately the same locations. With one exception, these transects were not the same 41 transects that were also walked in 2001 to monitor relative abundance and impacts (figure 6a).

Because the 1985 transects were not marked and were walked in 1985 with map, compass and pedometer, their exact routes cannot be repeated. The GPS coordinates of the transects were

Transects covering a mixture of Open Area and Limited or Navy Lands were eliminated from the analysis to avoid with mixed management effects. Transects on private lands were included in the analysis if they were entirely within an Open area or were surrounded by Multiple Use lands. Such private lands usually receive use patterns similar to the surrounding government lands because they are generally unsigned and unfenced. Transects in two private Sections (T.15S, R.11E, Section 16 and T.15S, R.17E, Section 14) were not included in the analysis as they lie between Open and Limited Use areas and as such have mixed management effects. Five project specific surveys of mining operations in the northeastern corner of the SMOA were eliminated as were data from a [illegible] survey in the [illegible]. The mining surveys were biased toward mining impacts and the [illegible] would have created a strong bias toward [illegible] because the [illegible] times and was selected non randomly. Data from the two [illegible] were [illegible] tests, Fisher exact test and the chi-square test to evaluate the hypotheses that [illegible] associated with vehicle use class.

Lizard and scat encounter rates were calculated for various land use/management categories throughout the species range and listed in descending order (Figure 5a). This included a comparison of the Open and Wilderness Areas of the Algodones Dunes. The Open Area of the Algodones Dunes refers to those lands open prior to the interim closures in 2000 since all the lizard data was collected prior to these closures. Private lands in the Algodones were counted as "open" since their land use patterns are similar to their surrounding Open Area. Transects which were in partially open or partially closed areas were not counted in the comparison as these transects had mixed management effects. For the calculation of the land use categories, only transects which were entirely on BLM lands and were wholly within one land use category were counted for the calculations for that category.

In 1985, the number of OHV routes in West Mesa on fixed triangular transects was counted during June. The transects were triangular and between 2.5 and 3 miles per triangle. Nine of the transects lie wholly within the West Mesa Flat-tailed Horned Lizard Management Area, the rest within or partially within the SMOA or PCOA, with one lying partially (?) both in the north of the PCOA. While the criteria used for transect selection is not known, they appear to be representative given the somewhat dispersed nature of the transects. Transects are also located in a variety of use categories: open, limited, Navy, ACEC. Seventeen transects of similar configuration were also walked on East Mesa in 1985. Unlike the West Mesa transects, the East Mesa transects were highly clumped in three groups. One group lay on the west side of the Navy Live Bombing Area, one between the Holtville Airport and the Test Sorting LTVA and one northeast of Gordon's Well. Most of the East Mesa transects were not repeated due to lack of personnel. The West Mesa transects were repeated in December and January of 2001 at approximately the same locations. With one exception, these transects were not the same as transects that were also walked in 2001 to monitor relative abundance and impacts (Figure 6a).

Because the 1985 transects were not marked and were walked in 1985 with map, compass and pedometer, their exact routes cannot be repeated. The GPS coordinates of the transects were calculated from 7.5' topographic maps on which the transects had been drawn in 1985. Researchers then located the transects with Garmin III+ GPS units set to the datum NAD27 Conus. Researchers walked the transects counting all routes. Researchers in 2001 were probably within about 200 meters (0.12 miles) of the routes as originally walked. Considerable error can occur with map and compass due to the inherent inaccuracy of compass bearings and pedometer. Generally, the observer finds himself within about 200 meters of his starting point using compass and pedometer. To see how this error could have impacted the comparison of route numbers between years, seven transects were walked twice. The two repetitions were off-set by 209 meters (0.13 miles) by changing the datum from NAD27 Conus to NAD83. The number of routes counted were then compared between the repetitions.

Routes were defined in 2001 as ungraded pathways or roadways formed by casual OHV (3 and 4 wheelers, motor cycles, trucks) use rather than by deliberate construction. These routes were between about 2 meters and 20 meters in width and show a depressed "roadbed" relative to the surrounding terrain. Usually routes were about 3 meters in width. "Two-tracks" (sets of tire tracks that have been driven in several times but without a definable roadbed) were not counted as routes. The route definition used in 1985 is unknown. To test the consistency of route classification, 3 researchers walked the same transect each independently counting the number of routes. The number of routes counted were then compared.

Agricultural impacts were calculated from 1:24,000 aerial photographs and field exams. In the case of East Mesa, the degree of agricultural impacts was approximated by counting the 4 Sections impacted by agriculture (T.15S, R.16E, Section 36; T.16S, R.18E, Section 16; T.16S, R.18E, Section 36 and T.16S) R.19E, Section16) and dividing this area by the total area being characterized (about 120 Sections).

Lizard sightings not on survey transects were not analyzed in relation to vehicle impacts and substrates. Sightings on transects were classified by vehicle track level, the presence of routes and substrate and their distribution was analyzed with chi-square tests to determine if they occurred independently of these features. Sightings off transect usually occurred while biologists were traveling to or from transects and so were more numerous on the way to those transects farther from roads. Additionally, sightings off transect were sometimes aided by tracking and so were also biased toward sandier areas. Sandy substrates greatly aid the location of flat-tails because tracks are left in sand but usually not on coarse terrain. For these reasons, only flat-tails seen on transect had their distribution analyzed.

The number of lizards per 10 hours were calculated by dividing the number of lizards seen by the total time observers spent walking transects in a sampling area each year. Similarly, lizards per transect were calculated by dividing the number of lizards sighted by the number of transects walked and scat per hour was calculated by dividing the amount of probable horned lizard scat (scat composed entirely of ants) by the time spent looking for it. The percentage of transects with lizards or lizard scat was calculated by dividing the number of transects on which either of these were sighted and the dividing this number by the total number of transects and multiplying

the result by 100. Observer breaks were not included in the time component of this calculation. Transects walked for project assessment or year-round monitoring were not included because they were not selected in a representative fashion, for example transects walked for sand and gravel sites or to determine the seasonal activity range of flat-tailed horned lizards. A typical sample of transects (those from southern East Mesa in 1979) were run through the program "PC Size: Consultant" to determine the sample sizes needed to determine the probability of detecting a given level of change in the lizard sighting rate (Dallal 1990). Additional Statistics were calculated with SYSTAT version 10 (SPSS Science 2001), Microsoft Excel (Microsoft Corporation 2002), Statpages (Pezullo 2001) or Vassarstats (Lowrey 1998).

In the preparation of graphs showing lizard detection trends (figures 1 - 4), data were calculated based on historic sampling areas (figures 7 -9) that cover most of what is believed to be the optimal or densest habitat for the species in Imperial County. Data from the three areas were pooled for graph 3d. East Mesa data for figure 4e compares both southern and central East Mesa, the area corresponding to that sampled in both 1979 and 2001 (figure 7).

Results

Results are shown in figures 1 - 12.

Trends in Lizard Abundance

Trends are shown separately for each area, as well as for all three areas combined. Comparisons are not shown between areas. Results are shown for four separate measures: lizards/10 hours, % of transects with lizards or scat, scat/hr and lizards per transect. No statistically significant trends ($p > .05$) were detected in the rate that lizards were sighted within East Mesa, West Mesa or the Yuha Desert from 1979 to 2001. Neither were any significant ($p < .05$) trends detected in the proportion of transects with scat or lizards (figures 1 - 4). A significant ($p < .05$ downward trend in scat per hour was detected in the Yuha Desert (figure 4c). The number of lizards sighted per transect in 1979 did not differ significantly ($p = 0.18$ to 0.54) from the number sighted in 2001 in any of the 3 areas monitored (figure 4e). No significant trend was found in the number of lizards detected per transect for the three areas combined (figures 3d, 4a) either.

Open areas in West Mesa were negatively associated with lizards and their scat (figures 5a to 5c). Historical lizard encounter rates are shown in figure 5d: rates varied from a high of 0.29 lizards per transect in the limited areas of West Mesa to 0 lizards per hour in the Algodones Dunes Wilderness (an area where the species has subsequently been detected during fringe-toed lizard surveys). The lizard encounter rate was compared to scat per hour in figure 5e; a weak correlation (r-squared = 0.166) of low statistical significance ($p = 0.24$) was found.

the results by 100. Observer breaks were not included in the time component of the calculations. Transects walked for project assessment of Cow Island vegetation were not included because they were not selected in a representative fashion, for example transects made to examine sand or gravel sites or to determine the seasonal activity range of the lizard. Several time series samples of transects (those from southern East Mesa in 1979) were run through the program "Sample Size Consultant" to determine the sample sizes needed to determine the probability of detecting a given level of change in the lizard sighting rate (Diller 1996). Additional statistics were calculated with SYSTAT version 10 (SPSS Science 2000), Microsoft Excel (Microsoft Corporation 2002), Statpages (Pezzullo 2001) or Vassarstats (Lowry 2004).

In the preparation of graphs showing lizard detection rates (figures 1-4), data were partitioned based on historic sampling areas (figures 7-9) that cover areas of what are believed to be the optimal or densest habitat for the species in Imperial County. Data from the three areas were pooled for graph 3d. East Mesa data for figure 4c compares data in different parts of the East Mesa, the area corresponding to that sampled in both 1979 and 2001 [illegible]

Results

Results are shown in figures 1 - 12.

Trends in Lizard Abundance

Trends are shown separately for each area, as well as for all three areas combined. Comparisons are not shown between areas. Results are shown for four separate measures. Based on proportions of transects with lizards or scat, lizards and scat/lb per transect, no statistically significant trends (p > .05) were detected in the rate that lizards were sighted within East Mesa, West Mesa or the Yuha Desert from 1979 to 2001. Neither were any significant trends detected in the proportion of transects with scat or lizards (figures 1 - 4). A significant decline (p [illegible]) in scat per hour was detected in the Yuha Desert (figure 4b). The number of lizards sighted per transect in 1979 did not differ significantly (p = 0.18 to 0.54) from the number sighted in 2001 for any of the 3 areas monitored (figure 4a). No significant trend was found in the number of lizards detected per transect for the three areas combined (figures 3d, 4a) either.

Open areas in West Mesa were negatively associated with lizards and their scat (figures [illegible] Historical lizard encounter rates are shown in figure 10; rates varied from a high of 1.49 lizards per transect in the limited areas of West Mesa to 0 lizards per hour in the Algodones Dunes Wilderness (an area where the species has not been detected during recent lizard surveys). The lizard encounter rate was compared to scat per hour in figure 10; a weak correlation (r-squared = 0.156) of low statistical significance (p = 0.24) was found.

Impacts

The mean amount of immigrant sign (water bottles, clothing piles and foot tracks/mile) detected was greater in the eastern Yuha (38.5) than in southern East Mesa (1.9) or West Mesa (0.9). Relatively small amounts (<1% cover) of athyll tamarisk (*Tamarix aphylla*) and salt-cedar (*Tamarix ramosissima*) were found in all three areas. Moderate impacts to southern East Mesa from agriculture, mining and geothermal activity were detected, impacting about 5% of the surface area cumulatively. No geothermal activity was detected in the eastern Yuha or West Mesa but minor impacts from mining were detected (<1% and 2% of the surface, respectively) in both areas. A very small amount of agricultural impact was detected in the Yuha Desert (<0.1%). West Mesa had significantly ($p < .05$) more vehicle tracks on the surface than East Mesa (11.4% vs 4.8%) but had approximately the same amount of track coverage as the eastern Yuha Desert (10.5%). West Mesa had significantly more routes (4.4/mile) than the Yuha (1.8/mile) ($p = .004$) and the eastern Yuha had significantly more routes than south-central East Mesa (0.7) ($p = .06$)(figure 6a). Figure 6a shows the number of routes counted per mile in 1985 and 2001. Route counts shown in figure 6a did not usually occur in the same Sections in both 1985 and 2001. Figure 6b shows a comparison of routes counted on the same transects in both 2001 and 1985. Figures 6h and 6i compare route counts on the same transects in 1985, 1994 and 2001 (below).

Routes increased by 423 % on the same 15 transects in West Mesa from 1985 to 2001 (figure 6b). Of 94 Sections surveyed in 2001, the flat-tailed horned lizard or its scat were detected on 77 of them (81.9%). Vehicle track coverage and the number of routes per mile were significantly ($p < .05$) less on transects where the flat-tail or its scat were detected than on transects where they were not detected. Conversely, vehicle track coverage and routes per mile were not significantly less on transects on which lizards were detected than on those on which they were not detected (figure 6c). Lizard sightings were not significantly associated with routes and roads (6d), with dominant substrate type of the transect (figure 6e) or with vehicle impact levels (figures 6f and 6g). The number of routes detected on the same transects increased by 23% in the Yuha and by 47% in West Mesa from 1994 to 2001. It decreased by 45% in Southern East Mesa during the same period (figure 6h). The number of routes found on the same five transects in West Mesa increased by 59% from 1985 to 1994 and by 194% from 1994 to 2001(figure 6i).

The percentages of the surface covered with vehicle tracks for each of the three areas surveyed are shown by Section in figures 7a to 9a. The number of routes crossed per mile of transect are shown by Section in figures 7b to 9b. Flat-tailed horned lizard sightings, both on and off transect, are shown overlaid on both maps. Figure 10 shows the distribution of lizard sightings in relation to the percentage of the surface covered with vehicle tracks. Logistic regression (figure 11) found that sightings and the percentage of the surface covered with tracks were not significantly associated ($p = .53$). The odds ratio was 0.98, indicating that the odds of sighting a lizard decreased very slightly with each percentage increase in vehicular impacts.

Miscellaneous

Figure 12 shows the distribution of the temperature associated with 148 flat-tailed horned lizard sightings from 1991 to 2001.

The number of routes counted by different observers on the same 2.5 mile transect were 54, 55 and 55. The number of routes counted on two repetitions of seven transects (off-set by 0.13 miles) was 178 routes using NAD83 and 204 routes using NAD27 Conus, a difference of +6.8%.

Results predicting the minimum sample size needed for a given probability of being within a certain distance of the true mean lizard sighting rate are shown in the Appendix.

The 7 observers in 1979 detected from 0 to 0.25 lizards per transect while the 4 observers in 2001 detected from 0.05 to 0.26 lizards per transect. The sighting rates (lizards per transect) for the 1979 observers were 0, 0, .11, .17, .19, .20, .25 and for the 2001 observers were: .05, .07, .23 and .26.

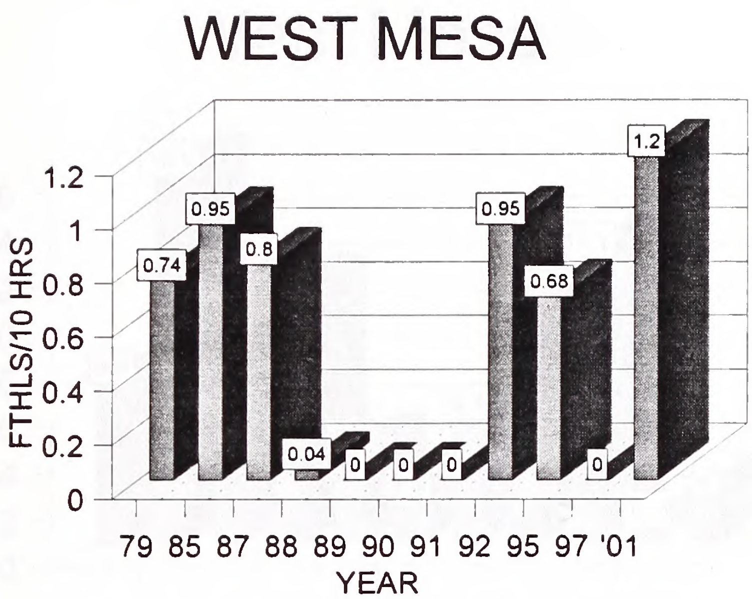


Figure 1a. Number of Flat-tailed Horned Lizards (*Phrynosoma mcallii*) detected per 10 hours of Observation in West Mesa, Imperial County, CA. 1979 - 2001.

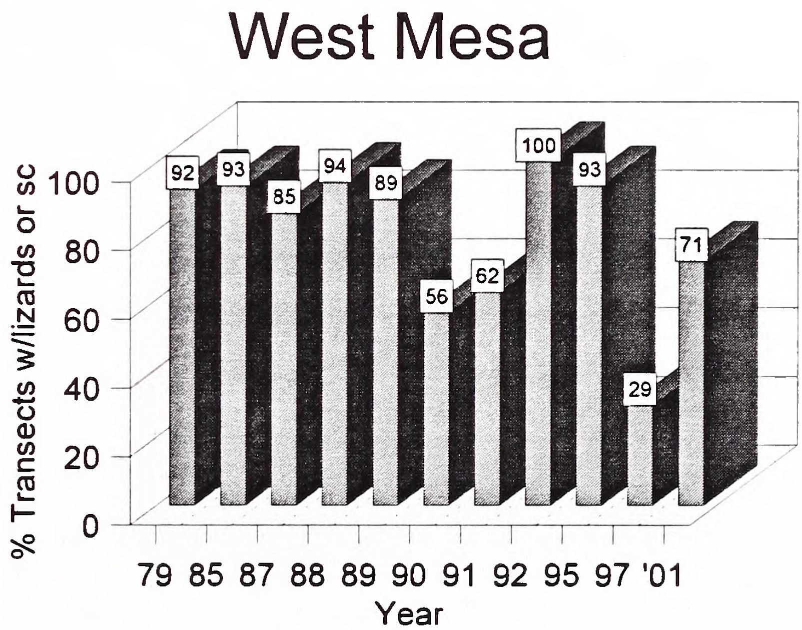


Figure 1b. Percentage of Transects with Flat-tailed Horned Lizards (*Phrynosoma mcallii*) or Their Scat. West Mesa, Imperial County, CA. 1979 - 2001.

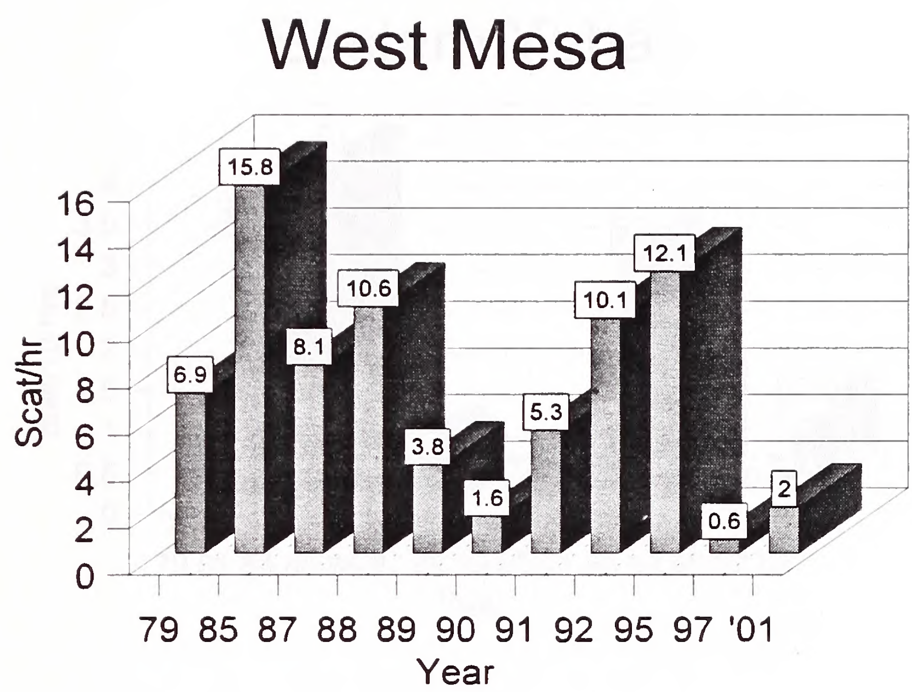


Figure 1c. Flat-tailed Horned Lizard (*Phrynosoma mcallii*) Scat detected per Hour. West Mesa, Imperial County, CA. 1979 to 2001.

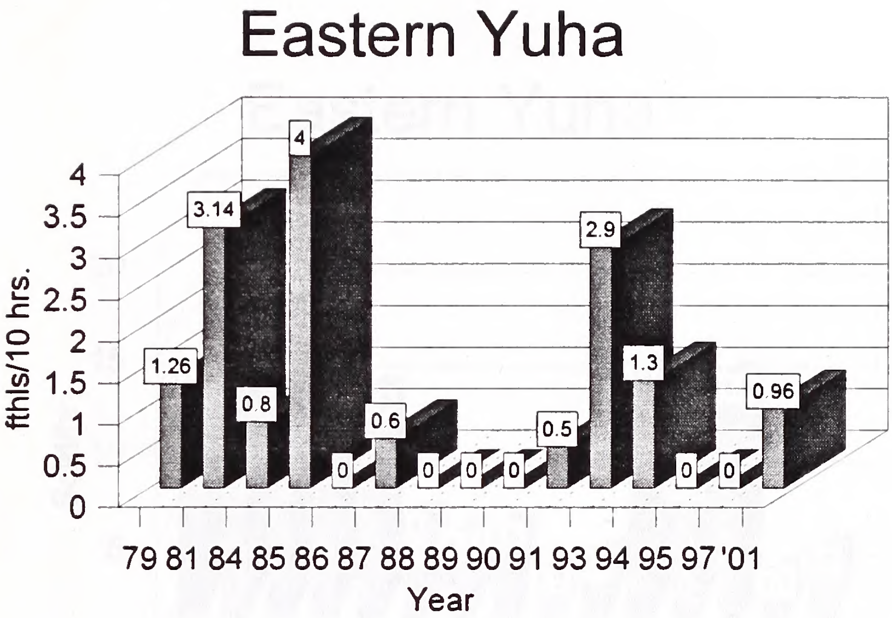


Figure 2a. Number of Flat-tailed Horned Lizards (*Phrynosoma mcallii*) Detected per 10 hours of Observation. Eastern Yuha Desert, Imperial County, CA. 1979 to 2001.

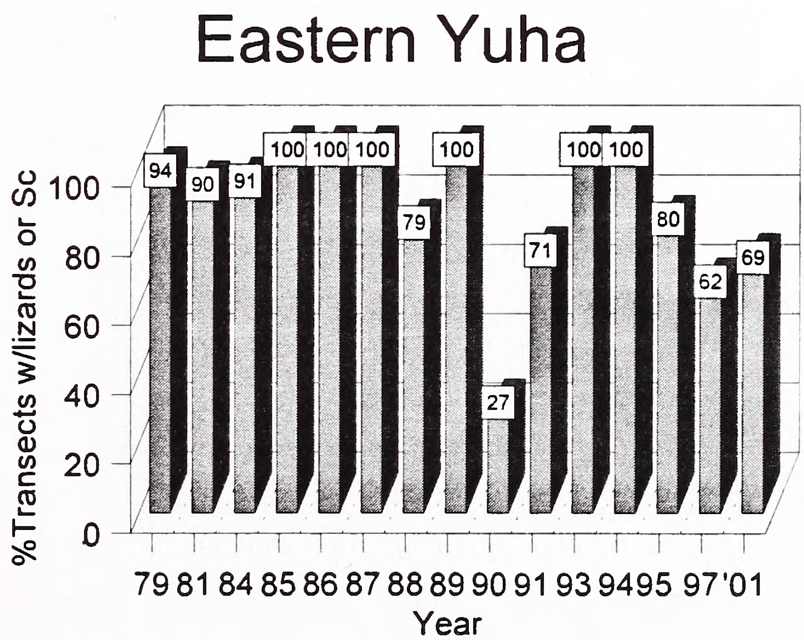


Figure 2b. Percentage of Transects with Flat-tailed Horned Lizards (*Phrynosoma mcallii*) or Their Scat. Eastern Yuha Desert, Imperial County, CA. 1979 to 2001.

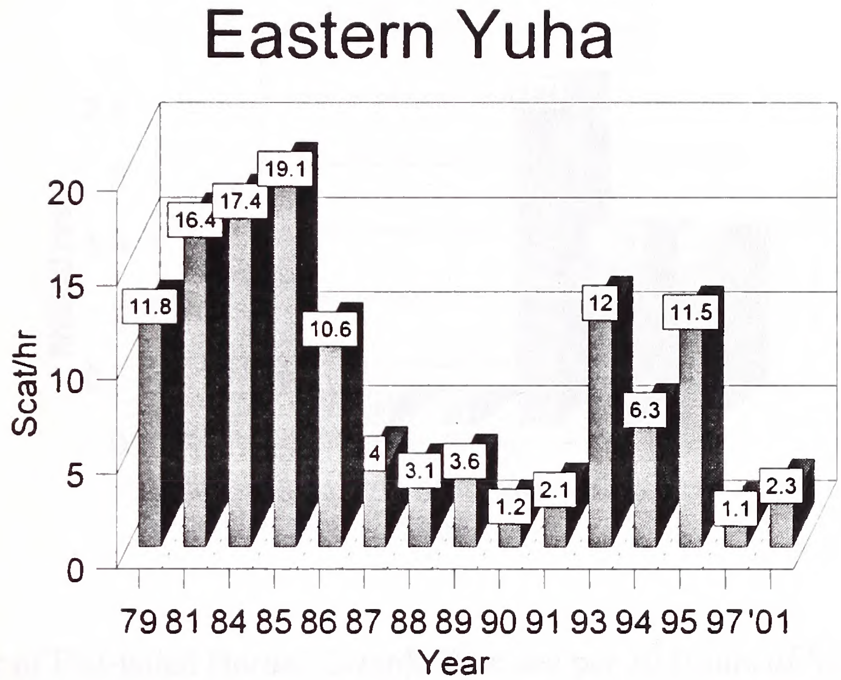


Figure 2c. Number of Flat-tailed Horned Lizard (*Phrynosoma mcallii*) Scat Detected per Hour. Eastern Yuha Desert, Imperial County, CA. 1979 to 2001.

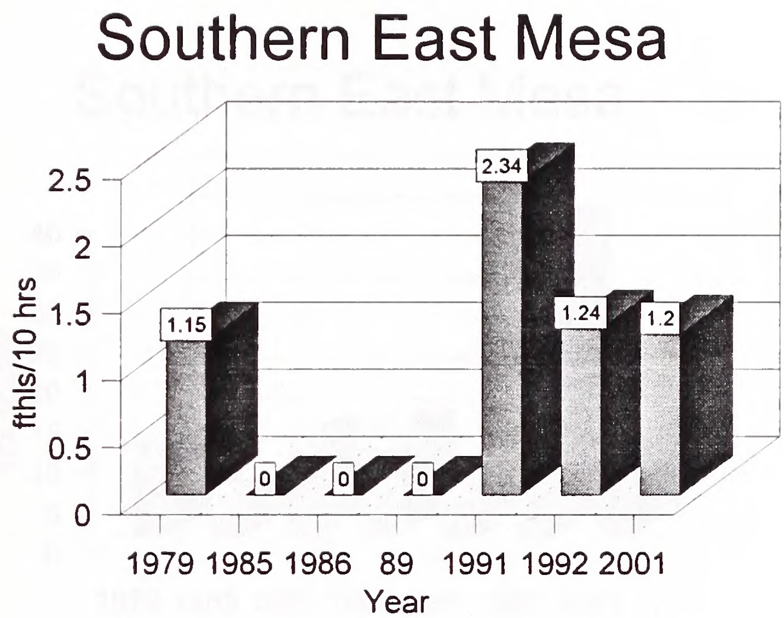


Figure 3a. Number of Flat-tailed Horned Lizards Detected per 10 Hours of Surveys. Southern East Mesa (North of Interstate 8), Imperial County, CA. 1979 to 2001.

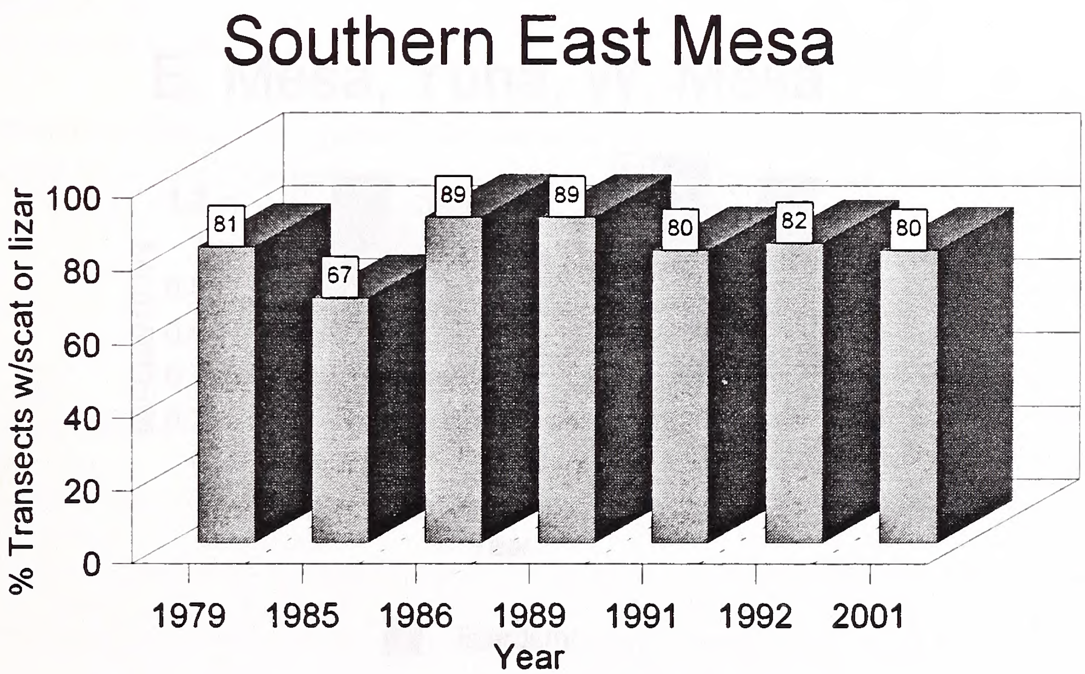


Figure 3b. Percentage of Transects with Flat-tailed Horned Lizards (*Phrynosoma mcallii*) or Their Scat. Southern East Mesa (North of Interstate 8), Imperial County, CA. 1979 to 2001.

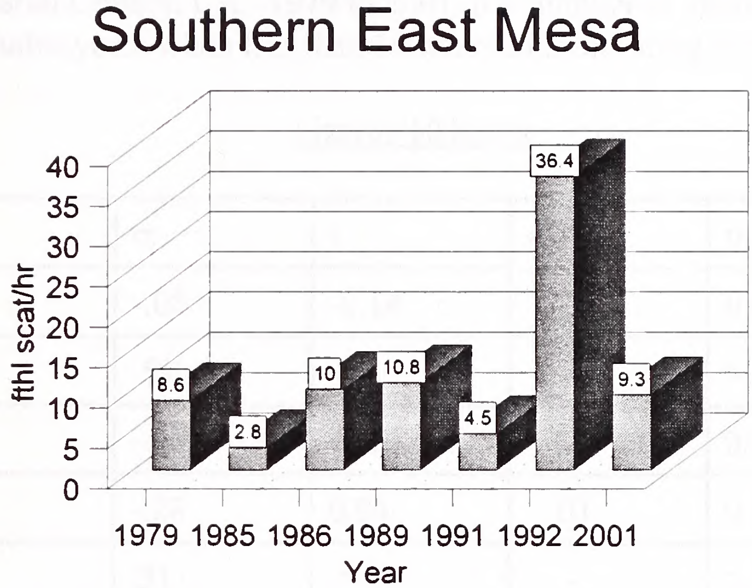


Figure 3c. Number of Flat-tailed Horned Lizard (*Phrynosoma mcallii*) Scat Detected per Hour. Southern East Mesa (North of Interstate 8), Imperial County, CA. 1979 to 2001.

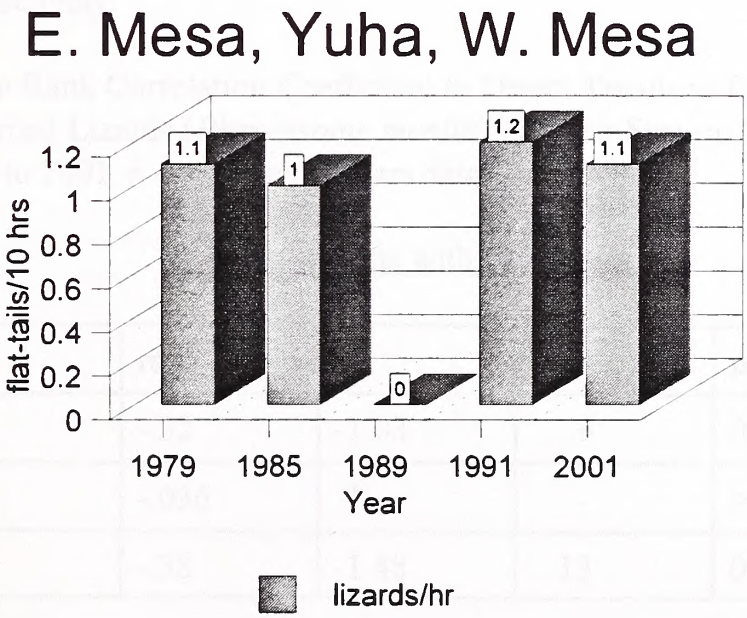


Figure 3d. Number of Flat-tailed Horned Lizards (*Phrynosoma mcallii*) Detected per 10 Hours. Southern East Mesa (North of Interstate 8), eastern Yuha and West Mesa Combined. Imperial County, CA. 1979 to 2001.

Figure 4a. Spearman Rank Correlation Coefficient to Detect Trends in Flat-tailed Horned Lizard (*Phrynosoma mcallii*) Sighting Rates (lizards/10 hours and % of transects with lizard sign) in Three Areas of Imperial County, CA. 1979 to 2001. n = number of years data collected. 2nd value for Yuha excludes years when less than 10 hours of monitoring were done.

<u>Lizards/10 hours</u>

Area	n	rs	t	df	p, 1 tail	p, 2 tail
West Mesa	11	-.05	-0.14	9	0.45	0.89
East Mesa	7	.59	-*	-	>.05	>.05
Yuha	15	-.03	-1.16	13	0.13	0.27
Yuha	12	-.28	0.94	10	0.18	0.37
All 3 Areas	5	.31	-*	-	>.05	>.05

*Note that t is not a good approximation of the sampling distribution rs when n is less than 10. For n = 7 the critical value of rs for 1 tail is +- 0.72 and +-0.79 for 2 tails, when p = .05. Therefore, the value rs for East Mesa of 0.59 is substantially less than that required for significance at the .05 level. For all 3 areas combined, the critical values for rs when p = .05 are +-0.9 and +-1, respectively.

Figure 4b Spearman Rank Correlation Coefficient to Detect Trends in Percentage of Transects with Flat-tailed Horned Lizards (*Phrynosoma mcallii*) or Their Scat in Three Areas of Imperial County, CA. 1979 to 2001. n = number of years data collected.

<u>% of transects with lizard sign</u>

Area	n	rs	t	df	p, 1 tail	p, 2 tail
West Mesa	11	-.32	-1.03	9	0.16	0.33
East Mesa	7	-.036	-*	-	>.05	>.05
Yuha	15	-.38	-1.48	13	0.08	0.16

*Note that t is not a good approximation of the sampling distribution rs when n is less than 10. For n = 7 the critical value of rs for 1 tail is +- 0.72 and +-0.79 for 2 tails when p = .05. Therefore, the value rs for East Mesa of -0.036 is substantially less than that required for significance at the .05 level.

Scat/hour

Figure 4c. Spearman Rank Correlation Coefficient to Detect Trends in Flat-tailed Horned Lizard (*Phrynosoma mcallii*) Scat Detected per Hour in Three Areas of Imperial County, CA. 1979 to 2001. n = number of years data collected.

Area	n	rs	t	df	p, 1 tail	p, 2 tail
West Mesa	11	-.43	-1.42	9	0.09	0.19
East Mesa	7	0.43	-	-	>.05	>.05
Yuha	15	-.61	-2.78	15	0.01	0.02

*Note that t is not a good approximation of the sampling distribution rs when n is less than 10. For n = 7 the critical value for 1 tail is +- 0.72 and +-0.79 for 2 tails when p = .05. Therefore, the value rs for East Mesa of 0.4286 is less than that required for significance at the .05 level.

Figure 4d. Hours Spent Monitoring Flat-tailed Horned Lizards (*Phrynosoma mcallii*) and Number of Lizards Sighted (shown in parentheses) per Year in Three areas of Imperial County, CA. 1979 to 2001. W = West Mesa, E = East Mesa (*southern only*), Y = Yuha (eastern).

Area	79	81	84	85	86	87	88	89	90	91	92	93	94	95	97	01
W	41 (3)	-	-	42 (4)	-	75 (6)	24 (1)	13 (0)	16 (0)	19 (0)	21 (2)	-	-	15 (1)	16 (0)	50 (6)
E	44 (5)	–	-	16 (0)	42 (0)	-	-	11 (0)	-	13 (3)	16 (2)	-	-	-	-	25 (3)
Y	56 (7)	26 (8)	50 (4)	5 (2)	8 (0)	17 (1)	21 (0)	7 (0)	10 (0)	22 (1)	-	34(10)	31 (4)	12 (0)	16 (0)	42 (4)

Totals for All Years Combined

Area	# lizards	# hours	lizards/hour	mean hours/year
West Mesa	23	332	0.07	30
East Mesa	13	167	0.08	24
Yuha Desert	41	357	0.11	25
Total	77	856	0.09	54

4e. Comparison of Average Number of Flat-tailed Horned Lizards (*Phrynosoma mcallii*) Detected per Transect in 1979 and 2001. West Mesa, eastern Yuha and south-central East Mesa (between I-8 and Holtville Airstrip Road). Imperial County, CA. Number of lizards sighted shown in parentheses (#). n = number of transects, s = standard deviation, p = probability, two-tailed, unpaired. Total 1: all transects. Total 2: only transects executed within the same square mile Sections both years.

Area	1979	n	s	2001	n	s	p
West Mesa	0.08 (3)	36	.28	0.15 (6)	41	.36	0.39
East Mesa*	0.07 (5)	67	.27	0.17 (7)	41	.44	0.16
Yuha	0.19 (7)	36	.45	0.11 (4)	36	.32	0.54
Total 1	**0.11 (15)**	**139**	**.33**	**0.14 (17)**	**118**	**.38**	**0.42**
Total 2	**0.06 (3)**	**50**	**.24**	**0.06 (4)**	**62**	**.25**	**0.92**

*includes additional area of central and southwestern east mesa monitored in both 1979 and 2001, not monitored in intervening years.

Figure 5a. Comparison of Mean Flat-tailed Horned Lizard (*Phrynosoma mcallii*) Sighting Rates (percent of transects with scat or lizards and mean lizards seen per transect) in Superstition Mountains and Plaster City Open Areas and adjacent Limited Use (including ACEC) and Navy Lands from 1979 to 2001. Imperial County, CA. Expected Lizard Sightings (based on number of transects) Shown in Parentheses. P values from 3 different 2-tailed statistical tests are shown.

Area	#transects	#lizards	% w/scat or lizards	mean	s
Open Areas	61	2 (6.5)	63.9	0.033	0.179
Limited/Navy	203	26 (21.5)	86.2	0.128	0.414
Totals	264	28 (28)	81.1	0.106	0.372
p (t test with unequal variance - also called separate variance t test)				**0.011**	
p (Mann-Whitney test)				**0.084**	
p (randomization test with allowance for unequal variance)				**0.016**	

Figure 5b. Contingency Table. Presence/Absence of Flat-tailed Horned Lizards (*Phrynosoma mcallii*) on Transects in Open and Limited (including ACEC)/Navy Lands in West Mesa, Imperial County, CA. 1979 to 2001. Expected Frequencies Shown in Parentheses.

	#Absent	#Present	Total
Open Areas	59 (56)	2 (6.5)	61
Limited/Navy	177 (185)	26(21.5)	203
Total	236 (241)	28 (28)	264

Pearson's Chi-square = 4.49, p = .03, 1 df.
Yates corrected Chi-square = 3.54, p = .06, 1 df.
Fisher Exact Test (2-tail), p = .03.

Figure 5c. Contingency Table. Presence/Absence of Flat-tailed Horned Lizards (*Phrynosoma mcallii*) *or* Their Scat on Transects in the Open and Limited/Navy Lands in West Mesa, Imperial County, CA. 1979 to 2001. Expected Frequencies Shown in Parentheses.

	Absent	Present	Total
Open Areas	22 (12)	39 (49)	61
Limited/Navy	28 (38)	175(165)	203
Total	50	214	264

Pearson's chi-square = 15.16, df = 1, p = 0.001
Yates corrected chi-square = 13.74, df = 1, p = 0.0002
Fisher Exact Test (2-tail), p = .0003.

Figure 5d. Flat-tailed Horned Lizards (*Phrynosoma mcallii*) Encountered per Transect, Scat per Hour and % of Transects w/Sign (lizards or scat) in Different Land Use Classes. Imperial County, CA. 1979 to 2001. ACEC = Area of Critical Environmental Concern. Algodones Dunes Open Area refers to portion of Dunes open prior to 2001 interim closures. West Mesa Limited Area not Including ACEC.

Area	#transects	lizards/transect	scat/hr	% of transects w/sign
		High		
West Mesa Limited Area	39	0.29	10.6	82
Navy Ranges West Mesa	57	0.17	6.8	72
		Medium		
Yuha ACEC	470	0.11	8.9	80
East Mesa ACEC	81	0.08	13.6	88
East Mesa Limited Areas	222	0.08	11.1	73
		Low		
West Mesa ACEC	102	0.05	14.0	91
Algodones Dunes Open Area *	68	0.04	2.0	56
Plaster City Open Area	32	0.03	2.5	72
Superstition Mountains Open Area	34	0.03	4.8	65
Algodones Dunes Wilderness	11	0.00	1.9	54

*p-value for t-test between Algodones Dunes Open Area and Wilderness, unequal variance: **0.49.**

Figure 5e. Results of Linear Regression Showing Degree of Correlation between Flat-tailed Horned Lizard (*Phrynosoma mcallii*) Scat Found per Hour (x) and Flat-tailed Horned Lizards per Transect (y) in 10 Areas (Table 5d) of Imperial County, CA. Data Shown Graphically below Regression Analysis. 1979 to 2001.

r	r2	slope	Y-intercept	stan.error	t	df	p (2-tail)
0.408	0.166	0.007	0.0312	0.0832	1.263	8	**.24**

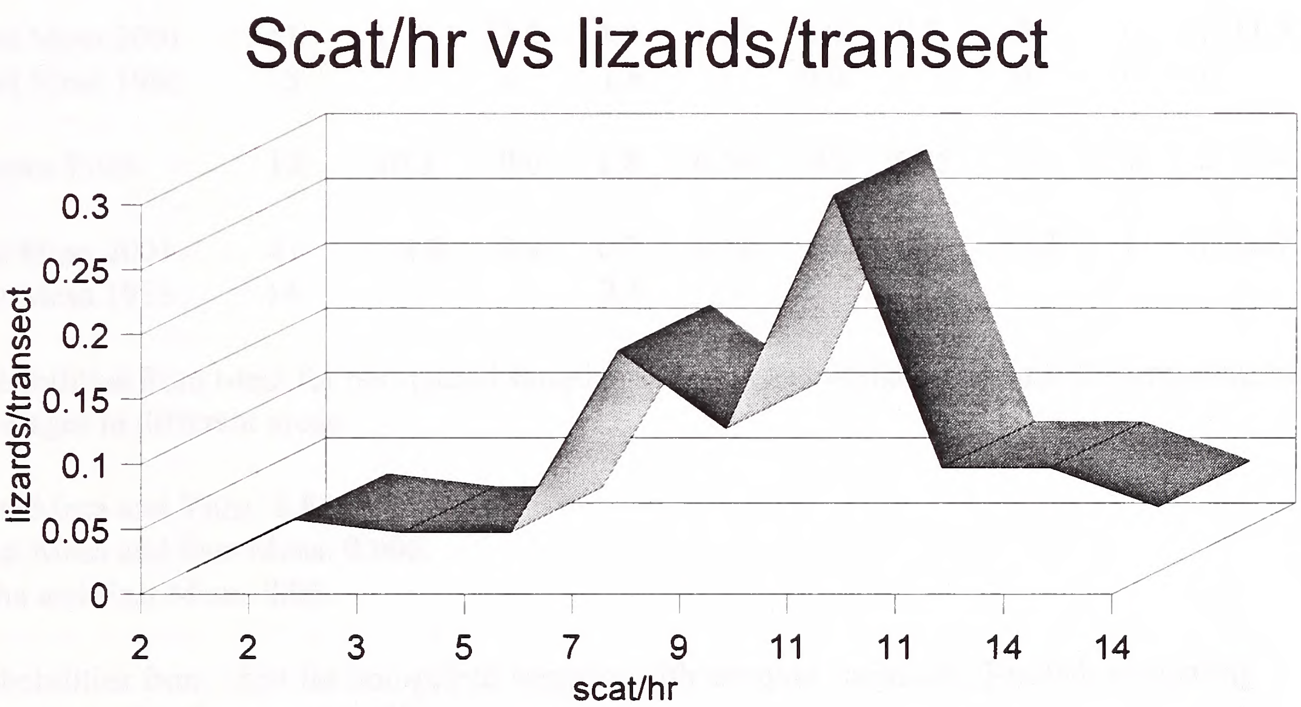


Figure 6a. Human Impacts in Flat-tailed Horned Lizard (*Phrynosoma mcallii*) Habitat in 3 Areas of Imperial County, CA. 2001 and 1985. n = number of transects, avg = average percent of transect covered with tracks, s = standard deviation, routes = routes per mile of transect, graded rds. = graded roads per mile of transect, paved roads = paved roads per mile of transect. Im = immigrant sign detected per mile of transect. Ag = % of surface with agricultural impacts, Geo = % of surface with geothermal impacts, Mine = % of surface with mining impacts, T = total % of surface directly impacted by all sources. Please note: most route counts shown in this figure occurred in different sections in 1985 than in 2001.

	n	avg.	s	routes	graded	paved	Im	Ag	Geo	Mine	T
West Mesa 2001	41	11.3	12.2	4.4	1.15	0.0	0.9	0	0	<1	**11.3**
West Mesa 1985	15	-	-	1.6	-	0.0	-	0	0	<1	-
Eastern Yuha	12	10.5	9.0	1.8	0.54	0.1	38.5	<1	0	2	**12.6**
East Mesa 2001	41	4.8	8.4	0.7	0.15	0.0	1.9	3.3	1	1	**10.1**
East Mesa 1985	14	-	-	2.1	-	-	-	-	-	-	-

Probabilities from t-test for non-paired samples with unequal variances, 2-tailed, comparing track coverages in different areas:

West Mesa and Yuha: **0.81**
West Mesa and East Mesa: **0.006.**
Yuha and East Mesa: **0.06.**

Probabilities from t-test for non-paired samples with unequal variances, 2-tailed, comparing routes per mile of transect in different areas:

West Mesa and Yuha: **0.004**
Yuha and East Mesa: **0.03**

Figure 6b. Number of Off-highway Vehicle Routes Crossing the Same Fifteen Triangular Transects (2.2 to 2.7 miles in Length). West Mesa, Imperial County, CA. 1985 and 2001. Status: O = Open Area, L = Limited, A = ACEC, MA= Flat-tailed Horned Lizard Management Area, N = Navy, P = Private. Areas of Mixed Management Are Shown with a Slash (O/N).

Legal Description	#Routes 1985	#Routes 2001	Change	%Change	Status
T.14S, R.10E, sec. 11	7	24	+17	+243	A/MA
T.14S, R.11E, sec. 10	0	14	+14	-	O/MA
T.14S, R.11E, sec. 18	6	11	+5	+83	A/MA
T.14S, R.11E, sec. 27	1	45	+44	+4400	A/MA
T.14S, R.11E, sec. 28	1	15	+15	+1500	A/MA
T.14S, R.12E, sec. 27	1	2	+1	+100	N/MA
T.14S, R.12E, sec. 32	2	22	+20	+1000	O/MA
T.14S, R.12E, sec. 33	2	23	+21	+1050	N/MA
T.15S, R.11E, sec. 04	9	17	+8	+89	A/MA
T.15S, R.11E, sec. 06	3	5	+2	+67	N/A/MA
T.15S, R.11E, sec. 08	3	5	+2	+67	N/MA
T.15S, R.11E, sec. 09	7	8	+1	+14	L/MA
T.15S, R.11E, sec. 16	1	12	+11	+1100	P
T.15S, R.11E, sec. 21	4	35	+31	+675	O
T.15S, R.11E, sec. 28	10	60	+50	+500	O
Totals	57	298	+241	+423	

routes per transect 1985: 3.8. n = 15.
routes per transect 2001: 19.8. n = 15.

routes per mile 1985: 1.6. n = 15.
routes per mile 2001: 8.2. n = 15.

% increase of routes on transects in MA 1985 to 2001: 387.
n = 9

% increase of routes on transects partially or entirely within Open Areas 1985 to 2001: 819.
n = 4

Figure 6c. Comparison of Vehicle Impacts on Transects with and without Flat-tailed Horned Lizards (*Phrynosoma mcallii*) and on Transects with Lizards or Scat and Transects with Neither. Imperial County, CA. 2001. %tracks and #routes/mile are mean values. T-test is 2-tailed.

	n	%tracks	s	#routes/mile	s
Transects w/lizards	16	6.8	9.2	2.2	3.2
Transects w/o lizards	78	8.7	11.0	2.4	3.5
Totals	94	8.3	10.7	2.37	3.5
p, t-test, unequal variance	-	**0.37**	-	**0.77**	-
Transects w/lizards or scat	77	6.9	9.0	2.0	3.37
Transects w/o liz. or scat	17	14.8	14.9	4.0	3.52
p, t-test, unequal variance	-	**0.048**	-	**0.045**	-

Figure 6d. Chi-square Analysis of Lizard Sightings in Relation to the Presence of Routes, Graded Roads or Paved Roads. Imperial County, CA. 2001. # with lizards = number of transects on which lizards were seen. # expected = number of transects expected to contain lizards.

	# of Transects	# with lizards	# expected w/liz.
Transects without routes or roads	25	6	4.3
Transects with routes or roads	69	10	11.7
Total	94	16	16.0

Pearson's Chi-square value = 1.17, **p = .28**, df = 1.
Fisher Exact Test, **p = .35** (2-tail).

Figure 6e. Chi-square Analysis of Lizard Sightings in Relation to Dominant Substrate Type of Transect on Which Lizard Was Found. # with lizards = number of transects on which lizards were seen. # expected = number of transects expected to contain lizards. Imperial County, CA. 2001.

Substrate Type	# of Transects	# with lizards	# expected
Sandy	42	9	7.1
Gravelly	44	6	7.5
Hardpan	8	1	1.4
Total	94	16	16.0

Pearson's Chi-square value = 1.05, **p = 0.59**, df = 2.

Figure 6f. Chi-square Analysis of Lizard Sightings on Transects in Relation to Percentage of Surface Covered with Vehicle Tracks. Imperial County, CA. 2001.

% covered	# of tran. w/o lizards	# tran. w/lizards	# expected w/lizards
<2.4%	27	5	5.4
2.4 to 7.8%	25	6	5.3
>7.8%	26	5	5.3
Total	78	16	16.0

Pearson's Chi-square value = 0.29, **0.9 > p > 0.50**, df = 2.

Figure 6g. Chi-square Analysis of Lizard Sightings in Relation to Percentage of Surface Covered with Vehicle Tracks. Imperial County, CA. 2001. Same Vehicle Impact categories as Shown in Figures 7a, 8a, 9a.

% covered	# tran. w/o lizards	# tran. w/lizards	# expected w/lizards
<=2.4%	29	5	5.8
2.4 to 9.4%	28	8	6.1
9.5 to 27%	16	2	3.1
27.5 to 54%	5	1	1.0
Total	78	16	16.0

Pearson's Chi-square value = 1.09, **0.9 > p > 0.50**, df = 3.

6h. Number of Vehicle Routes and Graded Roads in Limited Areas Detected on the Same Transects in 3 Areas of Imperial County, CA. 1994 and 2001.

Area	# transects	1994	2001	% change (+/-)
Eastern Yuha	12	57	70	+23
Southern East Mesa	40	119	66	-45
West Mesa	13	59	87	+47

6i. Number of Vehicle Routes Detected on Five Transects in Limited Areas of West Mesa, Imperial County, CA. 1985, 1994 and 2001.

Section	1985	1994	2001
15S, 11E, 09	7	6	8
14S, 10E, 11	7	10	24
14S, 11E, 18	6	4	11
14S, 11E, 28	1	5	15
14S, 11E, 27	1	10	45
Totals	**22**	**35**	**103**

%change 1985 to 1994: +59. %change 1994 to 2001: +194.

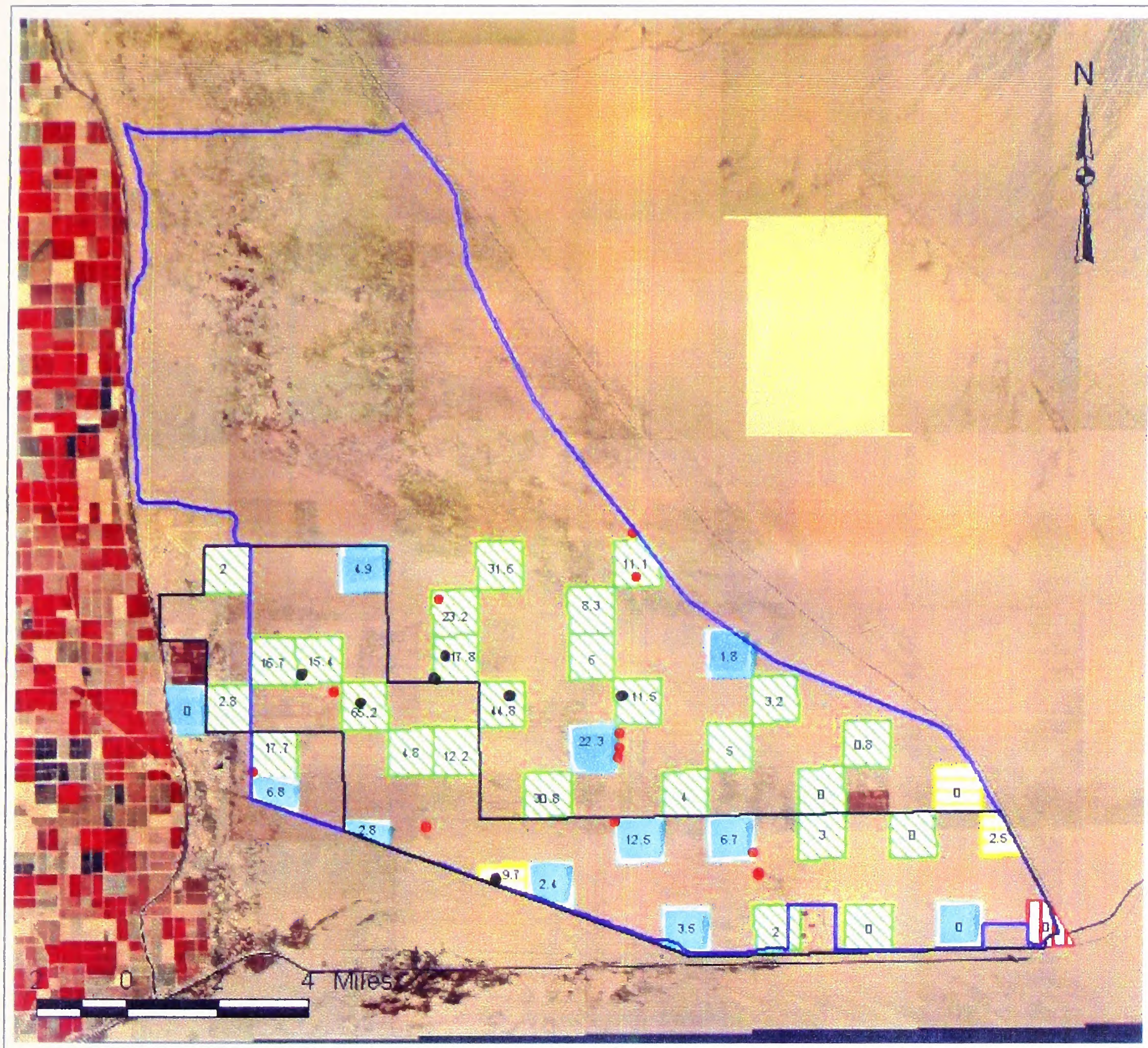
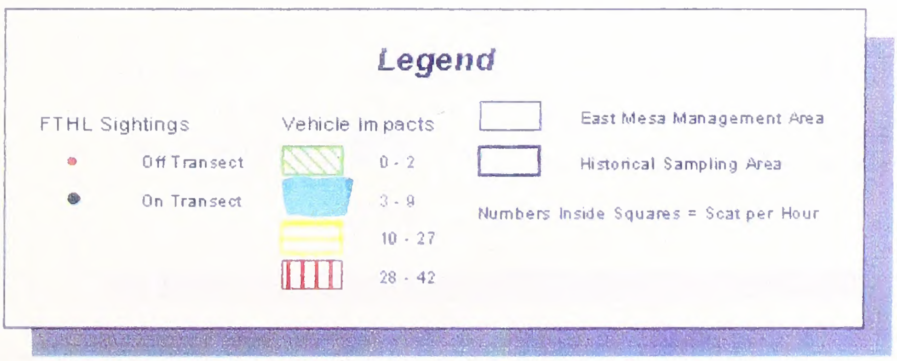


Figure 7a. Flat-tailed Horned Lizard (Phrynosoma mcallii) Sightings, Percent of Surface with Vehicle Tracks and Scat per Hour Found in the East Mesa Management Area, Imperial County, California, 2001.



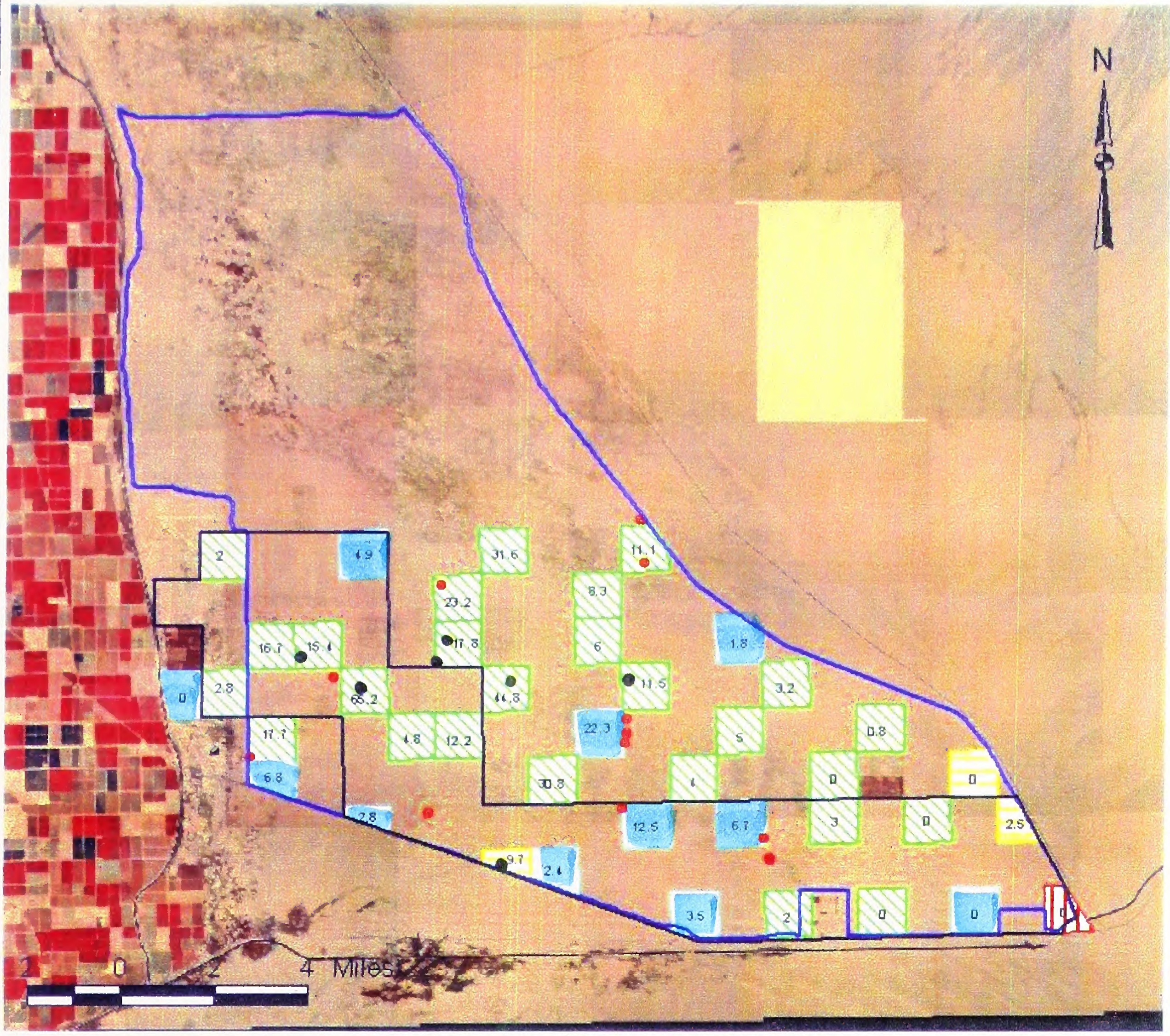
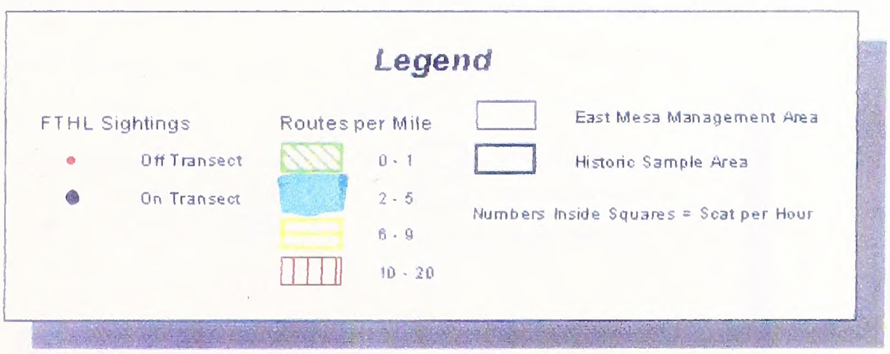


Figure 7b. Flat-tailed Horned Lizard (Phrynosoma mcallii) Sightings, Routes per Mile and Scat per Hour Found in the East Mesa Management Area, Imperial County, California, 2001.



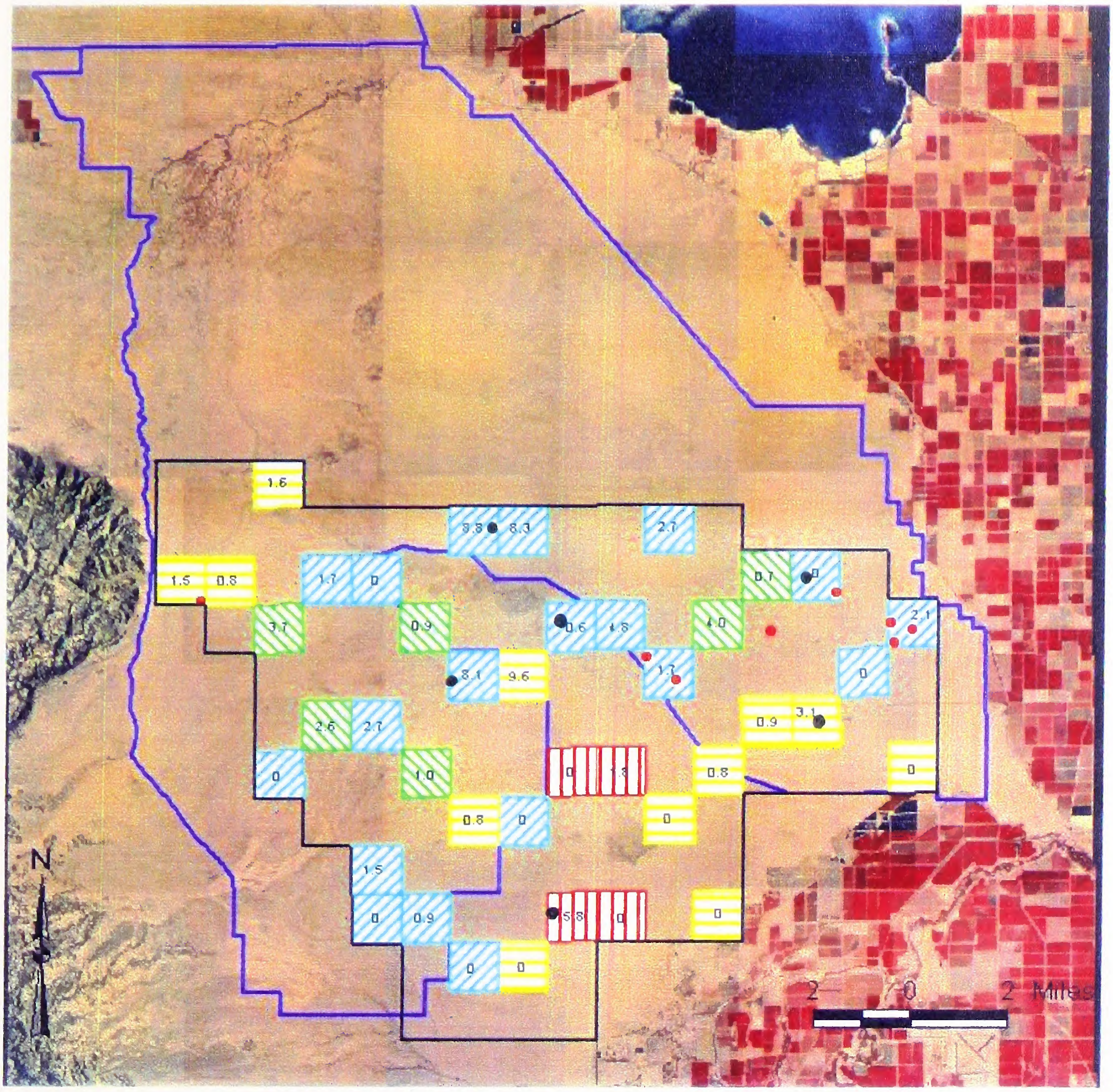
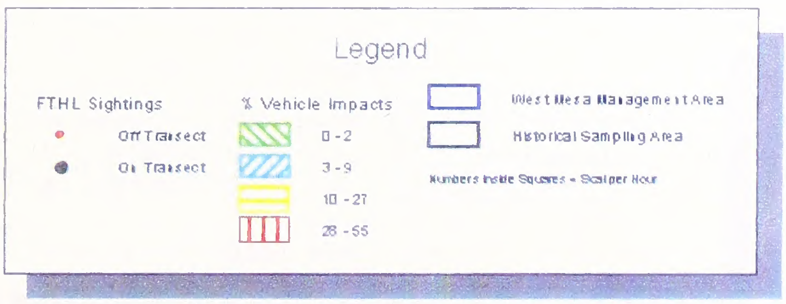


Figure 8a. Flat-tailed Horned Lizard (Phrynosoma mcallii) Sightings, Percent of Surface with Vehicle Tracks and Scat per Hour Found in the West Mesa Management Area, Imperial County, California, 2001.



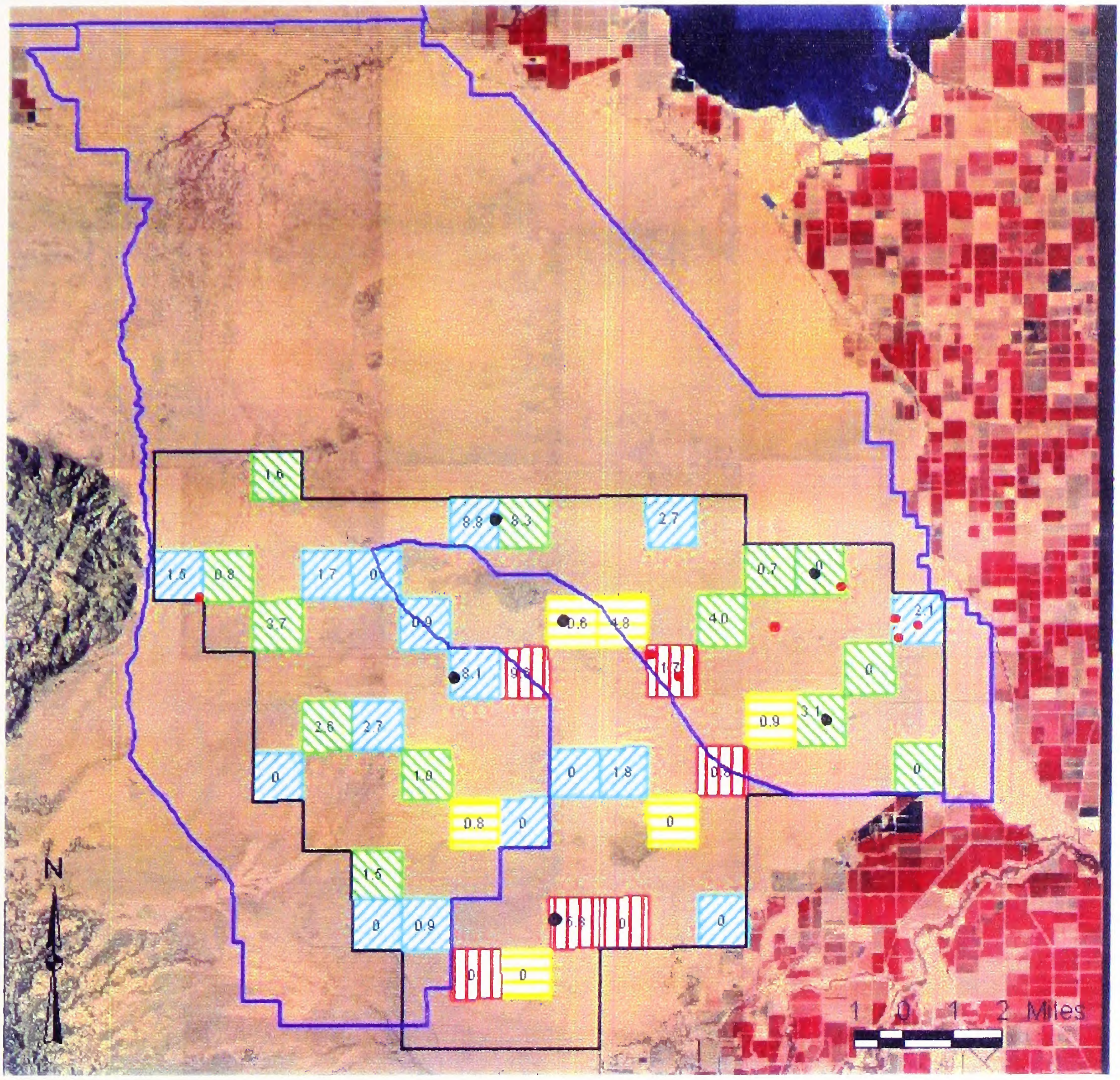
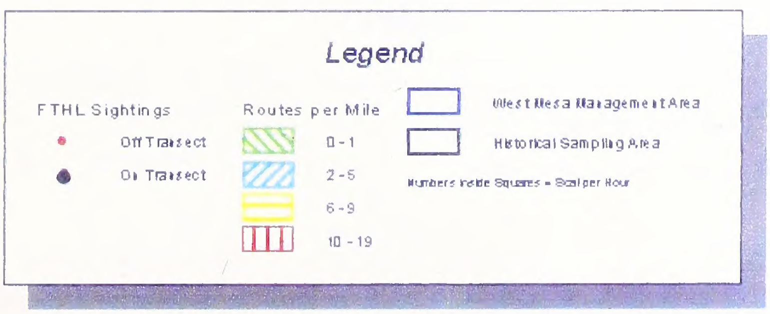


Figure 8b. Flat-tailed Horned Lizard (Phrynosoma mcallii) Sightings, Routes per Mile and Scat per Hour Found in the West Mesa Management Area, Imperial County, California, 2001.



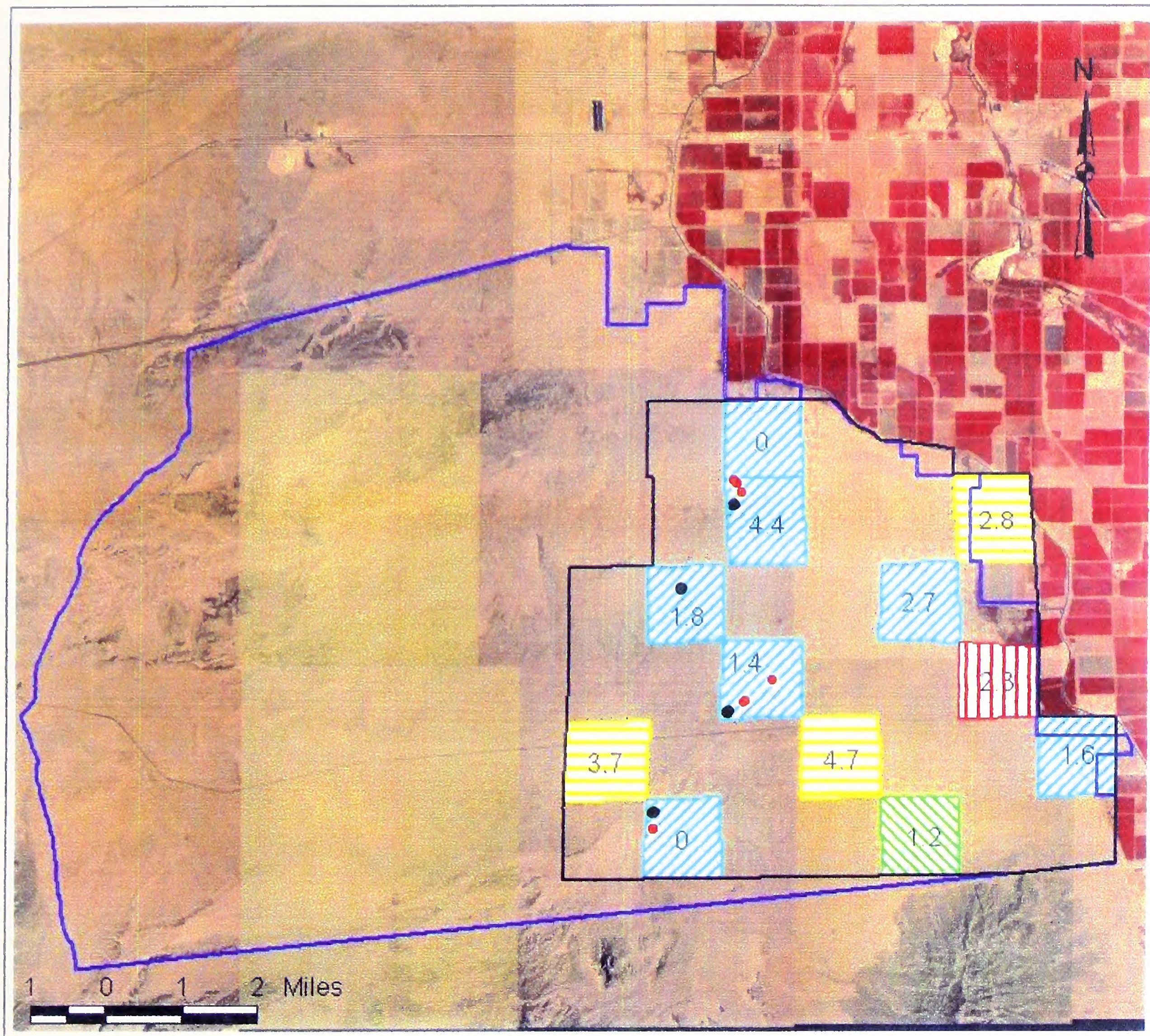
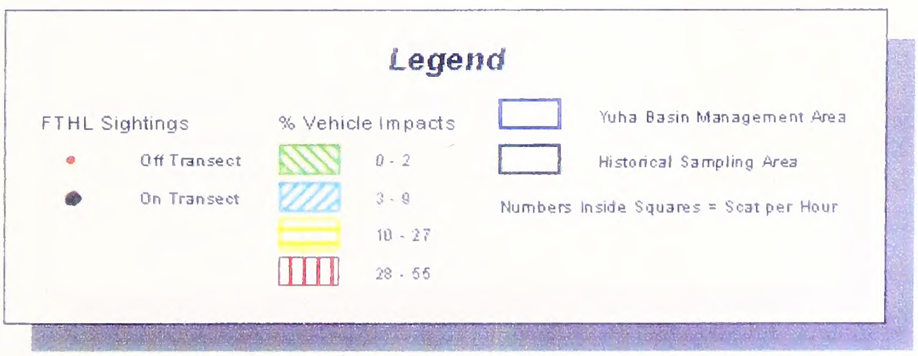


Figure 9a. Flat-tailed Horned Lizard (Phrynosoma mcallii) Sightings, Percent of Surface with Vehicle Tracks and Scat per Hour Found in the Yuha Desert Management Area, Imperial County, California, 2001.



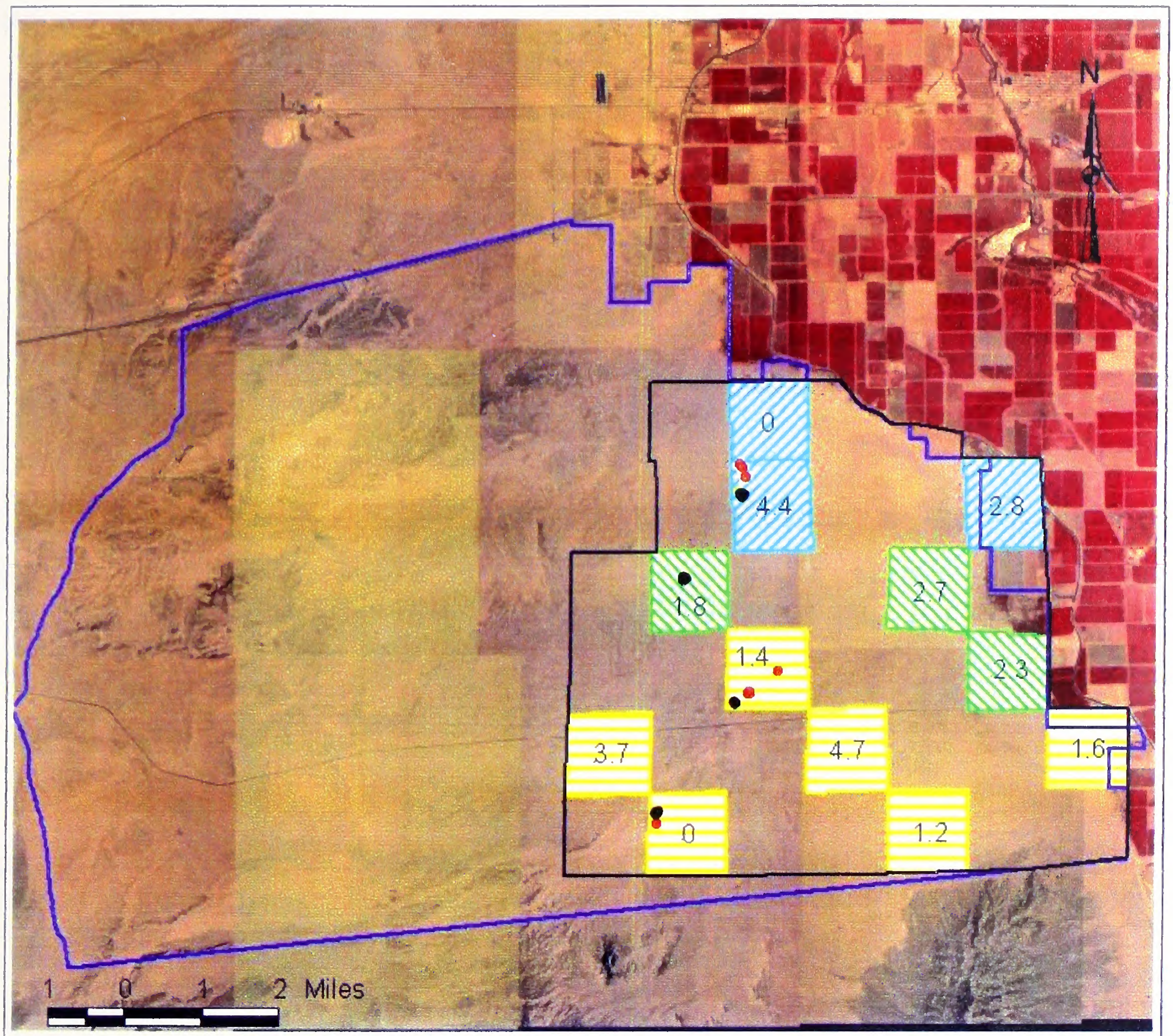


Figure 9b. Flat-tailed Horned Lizard (Phrynosoma mcallii) Sightings, Percent of Surface with Vehicle Tracks and Scat per Hour Found in the Yuha Desert M
County, California, 2001.

should say "routes per mile"

Legend

FTHL Sightings
- Off Transect
- On Transect

Routes per Mile
- 0 - 1
- 2 - 5
- 6 - 9
- 10 - 20

Historical Sam
Yuha Basin Ma
Numbers Inside Squares

Figure 10. Number of Flat-tailed Horned Lizards (*Phrynosoma mcallii*) Sighted on Transects in Relation to % of Surface Covered with Vehicle Tracks. Imperial County, CA. 2001.

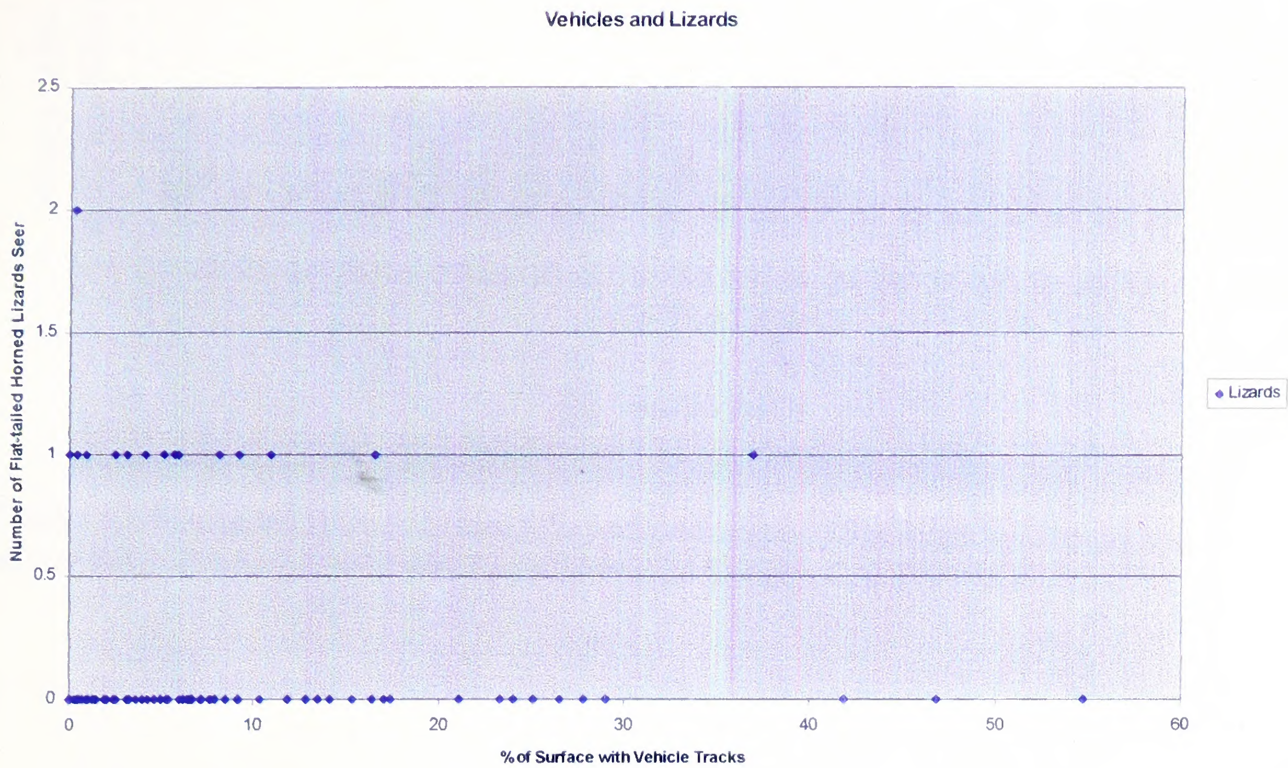


Figure 11. Results of Logistic Regression Examining the Relationship between Percentage of Surface with Vehicle Impacts and Transects on which Flat-tailed Horned Lizards (*Phrynosoma mcallii*) were Sighted. Imperial County, CA. 2001.

78 cases have Y=0 (no lizard sighted on transect); 16 cases have Y=1 (lizard sighted on transect).

Variable	Avg % Vehicle Track Coverage	Standard Deviation
1	8.3187	10.6170

Overall Model Fit
Chi Square= 0.3894; df=1; **p = 0.5326**

Coefficients and Standard Errors

Variable	Coeff.	StdErr	p	Intercept
1	-0.0178	0.0300	**0.5538**	-1.4476

Odds Ratios and 95% Confidence Intervals

Variable	O.R.	Low	High
1	0.9824	0.9263	1.0419

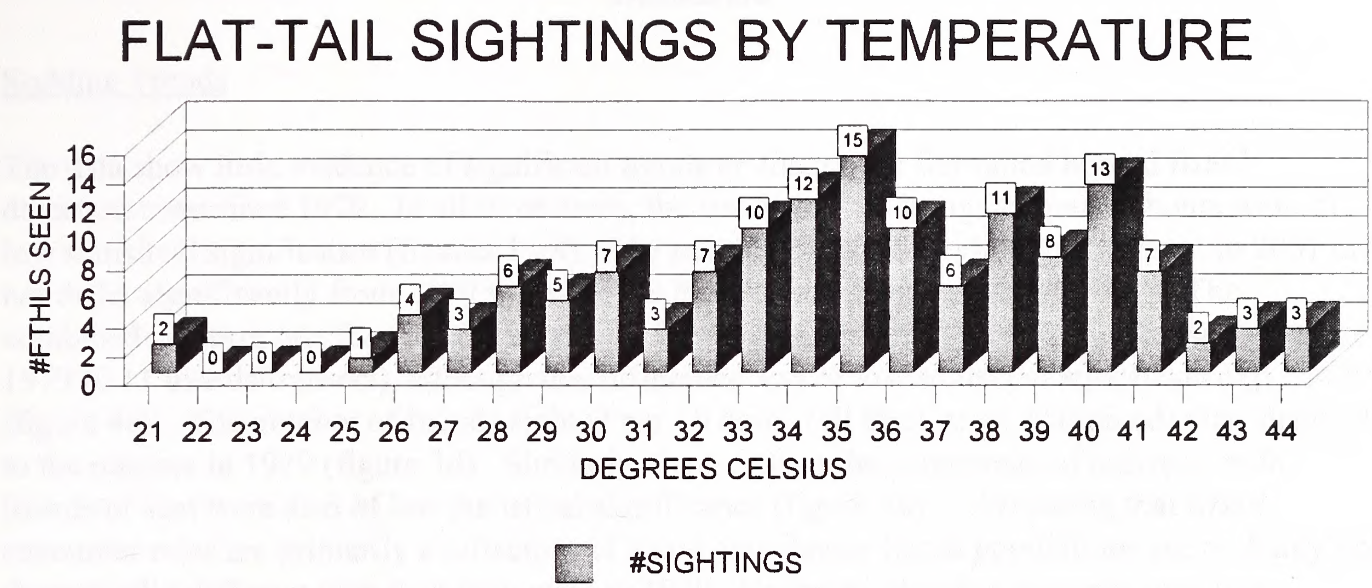


Figure 12. Flat-tailed Horned Lizard (*Phrynosoma mcallii*) Sightings by Temperature 1 cm above the Soil where Lizard was Found. Imperial County, CA. 1991 to 2001.

Discussion

Sighting Trends

The data show little evidence of significant trends or changes in flat-tailed horned lizard detection rates since 1979. In all three areas, the trends in lizards sighted per 10 hours were of low statistical significance (figures 1 - 4). The number of lizards sighted per transect in 2001 did not differ significantly from 1979 in any of the three areas monitored (figure 4e). The combined sighting rate for all three areas was 27% higher in 2001 (0.14 lizards/transect) than in 1979 (0.11 lizards/transect), although this difference was of low statistical significance ($p = .42$) (figure 4e). The number of lizards sighted per 10 hours (all three areas combined) was identical to the number in 1979 (figure 3d). Similarly, the trends in the percentage of transects with lizards or scat were also of low statistical significance (figure 4b). Assuming that lizard encounter rates are primarily a reflection of lizard abundance, lizard populations are probably not dramatically different now than they were in 1979. However, changes or trends may have occurred that the methodology was too insensitive to detect. Additionally, factors other than lizard abundance affect the rate at which lizards and their scat are sighted.

Factors Affecting Detection Rate

Most notable among these factors are observer skill and lizard surface activity. Observers vary widely in their ability to detect flat-tailed horned lizards and their scat. For example, in 2001, the 4 BLM observers varied by as much as factor of 5 in the number of lizards seen per transect (from 0.05 to 0.26). A similar difference in lizards per transect was seen in 1979 - the 7 observers ranged from 0 to 0.25 lizards seen per transect in that year. However, since transects were not randomly assigned, these differences could be due to differences in habitat quality where surveys occurred. That said, in 2001, 2 observers apparently had high acuity (> 0.20 lizards/transect) while 2 apparently had lower acuity (< 0.10 lizards/transect). In 1979, 5 observers apparently had high acuity (>0.10 lizards/transect) and 2 had low acuity (0 lizards/transect). So overall, it appears observer acuity was probably not any better in 2001 than in 1979 and therefore is unlikely to account for the slightly higher number of lizards seen per transect in 2001.

Although, observers in this monitoring program were all trained to an acceptable level of skill, underlying differences in acuity apparently remained. Such differences may be due to inherited visual acuity as much as the observer's motivation and experience sighting lizards. These differences affected the rate at which lizards or scat were sighted to an unknown degree throughout the years of monitoring. Additionally, other factors such as wind speed, rainfall, relative humidity, predator activity, ant activity, temperatures, season and surface disturbances may affect lizard surface activity. The percentage of the lizard population that is on the surface at any time can vary greatly as a result of these environmental influences. Thus the number of lizards detected per unit time is influenced not just by the population size but by surface activity and observer acuity. The amount of lizard scat detected is probably similarly affected.

Several factors other than population size impact the amount of scat detected. Both wind and rain can eradicate scat (Rorabaugh 1994), reducing detection rates in a short period of time and skewing results. Observers didn't search immediately following large weather events in the Imperial Valley but the length of the delay before resuming surveys varied from year to year. From 1990 to 1995, observers waited five days after significant wind events to search for scat but beginning in 1997, this period was extended to 12 days. The waiting period prior to 1990 is unknown but presumably observers allowed scat some time to accumulate after major wind events. Another factor is that windstorms can be highly localized in the desert summer; researchers may have been unaware that an area they were surveying had been recently impacted by wind. Therefore, scat results likely reflect weather conditions to some extent, as well as the number of lizards present and scat deposition rates. Scat deposition will be impacted by the amount of prey (ants) available, as well as by how active lizards are on the surface. Surface activity is in turn impacted by weather conditions, surface disturbances and predator activity. Even more so than the lizard detection rate, the scat detection rate is impacted by factors other than population size. However, scat are much easier to find than lizards, yielding fewer zero values and hence more robust statistical analyses than the "0/1" data typical of lizard sightings . In this respect, the scat/hour analysis is stronger than lizards/10 hours or lizards/transect (Willoughby, pers. com. 2002).

The fact that observers were looking for both scat and lizards may have reduced the rate at which both items would've been sighted if searched for separately. Lizards in particular are quite cryptic and the distraction of also looking for scat could have affected their detectability. However, this effect existed in all years and so should not have affected the comparison of detection rates between years.

Statistical Power

Finally, the high variability of the sighting rate and the low number of sightings also greatly increases the number of transects needed to make meaningful inferences about lizard detection rates. In all years except one, the number of transects was less than 55 in each area, the approximate minimum sample necessary to have an 80% probability of being with 50% of the true mean sighting rate (Appendix). Thus, the values in most years for separate areas are a rather unreliable indicator of true lizard abundance. This is especially true of years when sampling effort was very low, such as in the Yuha Desert in 1985, 1986 and 1989. For that reason, the Yuha Desert trend analysis was run with and without years with less than 10 hours of effort (figure 4a). Either way, no significant trend was detected in the lizard encounter rate but the p-value was higher when the low sampling effort years were excluded, meaning it was less likely that the observed downward trend in lizard sightings was real. However, the combined values in 4 of 5 years approach or exceed 55 transects and hence are a more reliable indicator of lizard trends (figures 3c and 4d). Readers may wish to run their own analyses eliminating years as they feel appropriate. The numbers for each year are shown above each bar in the graphs for figures 1 - 3.

Methodological Changes

From 1979 to 1990 transect shapes, sizes and the number of observers varied considerably and may have affected the results. Although, the lizard per 10 hours, lizard per hour and scat per hour figures are standardized for observer effort, the lizards per transect and percentage of transects with lizard sign figures are not. The average number of observer-minutes per transect in the Yuha varied from a high 93 minutes in 1979 to a low 24 minutes in 1990. This difference in effort per transect certainly affected the percentage of transects with lizard sign (figure 3b), as well as the comparison between lizard detection rates in 1979 and 2001 for this area. In 2001, the average observer effort per transect repetition was only 69 minutes in the Yuha. Therefore, some of the difference between the these two years is attributable to this 24 minute difference. If the 2001 index in figure 4e is adjusted upward by 35% to account for this difference in effort, the number of lizards per transect becomes 0.15, almost equal to the 1979 figure. Subsequent to 1990, all transects were walked with one observer to reduce this time problem. Transects were standardized to the 2.5 mile triangular configuration in 1991, whenever possible. Although, shape is probably less likely to impact results than time, it was deemed advisable to standardize shape in the event it could affect lizard detectability.

The amount of time variation was less in West Mesa than in the Yuha. Due to some multiple observer transects, the average number of observer minutes per transect was 107 minutes in 1987, 95 minutes in 1988 and 86 minutes in 1989. In other years, the transect time was about 1 hour (range of average: 53 to 73 minutes). Thus, detection rates for these years may be higher than they otherwise might have been if only one observer walked each transect. In East Mesa, transect times averaged between 56 and 75 observer minutes except in 1986 when the average was 84 minutes due to multiple observers. However, for both these areas the average transect times in 1979 and 2001 were closer than for the Yuha (68 and 73 minutes for West Mesa, 60 and 75 minutes for East Mesa) and thus the lizard per transect indices in figure 4e were not as seriously skewed as the Yuha. The East Mesa figure of 0.17 lizards per transect is about 25% higher than it otherwise might have been due to the slower observer average speed in this year. Adjusting this figure downward by 25% yields a result of 0.13 lizards per transect, still larger than the 1979 result, although not significantly so. Due to these fluctuations in transect time, the per hour indices are probably a more reliable indication of lizard and scat detection rates than per transect rates.

The selection of a fresh sample in some years from the same general area added a strong element of spatial variation to the data, especially given the relatively small and clumped samples in many years (figure 4d). This situation was especially acute during years in which sample sizes were small, for example 1989 in West Mesa, when most transects were clustered in the southern part of the sampling area. Such clumped and small sample sizes may lead to skewed results even if transects are selected randomly. Differences from year to year could well be a result of differences in habitat quality as much as changes in lizard numbers within the sampling area. Even when transects were walked in the same Section and were oriented from the same corner marker (as was often the case), the exact routes were not repeated due to navigational drift.

This variation was not as big a confounding factor in the Yuha sampling area because it was much smaller than the other sampling areas and because, beginning in 1993, the same transect routes were walked each year. However, in the vast expanse of West Mesa, the location in which transects occurred varied widely from one year to the next. This problem also existed to a more limited extent in southern East Mesa. Presumably, with enough years of data these spatial habitat differences would be diluted by overall trends in lizard numbers within the sampling areas. In future sampling efforts, the same transects walked in 2001 should be walked in the future to eliminate this element of spatial variation. This change is suggested based on an examination of the data from past years showing that the pure random samples collected from 1985 to 1997 often led to clumping of the sample with significant areas often left unsampled.

Orientation of Transects

Since transect starting points were oriented from the Section corners closest to access roads, the data may contain a slight road bias or corner marker bias. The biological impacts associated with roads may be greater along the transects than would have occurred if transects had simply begun on randomly selected points within the sampling areas. In retrospect, this would have been a sounder study design, however compact accurate GPS's were unavailable until the late 1990's and observers needed a way to reliably verify their location - corner markers provided such a method. However, given the long triangular shape of most transects, the impact of this orientation is probably not large because the transects end up traversing a large part of the section with varying distances from roads. In most areas, access roads are quite common, so that the biological impacts associated with them tend to be rather ubiquitous. The one area where an exception to this situation exists is in the south western portion of East Mesa, where geothermal roads run north-south and observers oriented transect start points near these roads, resulting in the first leg of the transect paralleling the road for 0.9 miles. Here a stronger bias from road effects may have occurred than in the Yuha and West Mesa where extensive route networks crisscross most sections in a rather irregular pattern. On the opposite extreme, within the interior of East Mesa, few routes occur and the road effect of picking one corner over another to orient the transect is negligible. Nonetheless, picking the corner from which to orient the transect non-randomly violates an underlying assumption of sampling theory. Furthermore, the Sectional grids themselves may impart some bias on the sample that is difficult to assess. Overall, a slight bias in the data toward more roaded or surveyed areas and their associated impacts exists.

Comparison of 1979 with 2001

For the two-way comparison in figure 4e, both years had relatively high sample sizes (139 and 118, respectively), sampled all three areas (eastern Yuha, south-central East Mesa and West Mesa) and had nearly identical average transect times (73 observer minutes and 72 observer minutes). Additionally, substantial overlap between the samples occurred, as 53% of transects done in 2001 were in the same square mile Sections as were the transects from the 1979 sample. However, all three areas (East Mesa, Yuha and West Mesa) were not sampled with equal intensity in 1979 and 2001. Twenty-nine percent of observation time was in West Mesa during

This variation was not as big a confounding factor in the Yuba sampling area because it was much smaller than the other sampling areas and because, beginning in 1993, the same transect routes were walked each year. However, in the vast expanse of West Mesa, the location of the transects occurred varied widely from one year to the next. This variation only applied to a more limited extent in southern East Mesa. Therefore, with enough years of data from each, habitat differences would be masked by overall trends in crane numbers within the sampling areas. In future sampling efforts, the same transects walked in 2001 should be walked in the future to eliminate this element of spatial variation. This change is suggested based on examination of the data from past years showing that the plot locations did vary from 1985 to 1991 often and in sampling of the survey with significant areas. See appendix.

Orientation of Transects

Since transect starting points were obtained from the fact that survey routes in previous years' data may contain a significant bias or create random bias. The ecological impacts associated with roads may be greater along the transects than would have occurred if transects had simply begun on randomly selected points within the sampling areas. In retrospect, this would have been a sounder study design, however, portable accurate GPS's were unavailable until the late 1990's and observers needed a way to reliably verify their location – contact roads provided such a method. However, given the long, linear shape of most transects, the impact of their orientation is probably not large because the transects end up far removed for a large part of the survey with varying distances from roads. In most areas, roads crossed are more ecotonal so that the biological impacts associated with them tend to be rather dispersed. The one area where an exception to this situation exists is in the south-western portion of East Mesa, where portions of roads run north-south and observers followed transects that parallel these roads, resulting in the first leg of the transect paralleling the road for 0.9 miles. Here a stronger road effects may have occurred than in the Yuba and West Mesa where transect routes generally crossroads at a rather irregular pattern. On the opposite extreme, within the interior of East Mesa, few roads occur and the road effect of picking one survey area similar to another of the transect is negligible. Nonetheless, picking the survey from a sampling point at the transect is randomly violates an underlying assumption in sampling theory. Furthermore, the sampling grids themselves may map in some bias to the sample that is difficult to assess. Overall a slight bias in the data toward more traveled or disturbed areas and their associated wildlife.

Comparison of 1979 with 2001

For the two-way comparison in figure 4c, both years had relatively high sample sizes (133 and 118, respectively), sampled all three areas (eastern Yuba, south-central East Mesa, and West Mesa) and had nearly identical average transect times (73 observer minutes and 77 observer minutes). Additionally, substantial overlap between the samples occurred, as 51% of the transects done in 2001 were in the same square mile Sections as were the transects from the 1979 sample. However, all three areas (East Mesa, Yuba and West Mesa) were not sampled with equal intensity in 1979 and 2001. Twenty-nine percent of observation time was in West Mesa during

1979 but 43% of all observation was time occurred in this area in 2001. Similarly, 31% of observation time occurred in East Mesa in 1979 but this dropped to 21% in 2001. The Yuha portion of the sample was about the same in both years at 40% in 1979 and 36% in 2001 (figure 4d). Thus, the sample in 2001 was weighted toward areas currently more heavily impacted by vehicles (Yuha and West Mesa) than was the sample in 1979. Had an equal proportion of effort been given to East Mesa in the 2001 sample, the number of lizards sighted per transect might have been higher due to the lower vehicular impacts and the higher rate that lizards were being sighted in this area (figure 4e).

With these sample sizes, the computer program PC SIZE: CONSULTANT (Dallal, 1990) predicts a 90 to 95% probability that the combined mean lizard sighting rates are within 50% of the true mean rate (Appendix). Therefore, it is highly likely that the true lizard sighting rate for 2001 was between .07 and .21 lizards per transect (.14 +- .07) while that for 1979 was probably between .055 and .165 lizards per transect (.11 +- .055). Similar 95% confidence intervals are obtained on Vassarstats, for these samples. Assuming that lizard surface activity and observer acuity were the same in both years, it appears unlikely that lizard relative abundance has declined by more than 58% since 1979 (the low end of the 2001 estimate, .07, is about 42% of the high end estimate of .165 for 1979). Since the lizard encounter rate of 0.14 in 2001 was actually greater than that of 0.11 in 1979 ($p = .42$), it is actually more likely that an increase in the lizard abundance has occurred, although the probability of such an increase is only 58% (1 - .42 x 100). The magnitude of such an increase is unlikely to have been greater than 281% (.21 is 281% greater than .055). However, if lizard surface activity or observer acuity were not about the same in both years these theoretical projections are not valid.

Spatial variation also affects the two-way comparison between 1979 and 2001, i.e. the fact that not all transects were in the same Sections each year. If only transects walked in the same square mile Sections are used for the two-way comparison between 1979 and 2001, the sighting rates are virtually identical. The rate for both years is 0.06 lizards per transect ($p = .92$). Thus, even with most of the spatial variation removed, the lizard encounter rate is unchanged from 1979. Assuming these samples were indeed representative of relative abundance (a tenuous assumption), it appears that the density of lizards was about the same in both years.

<u>Combined Trends 1979 to 2001</u>

The combined sighting rate (lizards/10 hrs) in years when all three areas were sampled was virtually unchanged at 1.1 lizard per 10 hours, except for 1989 (figure 3d) and had no significant trend ($p > .05$, figure 4a). This is probably the strongest trend analysis because in all years except 1989, the sample size is relatively large, increasing the power of the sample to detect change. However, a less pronounced population trend could easily have occurred during this period that the methodology was too insensitive to detect. For example, a trend of +-30% could have gone undetected. Furthermore, as with the two-way comparison of the combined sighting rate, the proportion of effort expended between in each area varied widely by year. This problem is particularly acute for the Yuha Desert where the portion of sampling time varied from a high

1979 but 45% of all observation time occurred in this area in 2001. Similarly, 39% of observation time occurred in East Mesa in 1979 but this dropped to 21% in 2001. The Yuha portion of the sample was about the same in both years at 40% in 1979 and 39% in 2001 (Figure 4d). Thus, the sample in 2001 was weighted towards areas extremely impacted by off-road vehicles (Yuha and West Mesa) than was the sample in 1979. With an equal proportion of sampling effort East Mesa in the 2001 sample, the number of lizards/observation/hour might have been higher due to the lower vehicular impacts and the higher rate that lizards were being sighted in this area (Figure 4c).

With these sample sizes, the computer program PC-SIZE: CONSULTANT (Dallal 1986) predicts a 90 to 99% probability that the combined mean lizard sighting rates are within 50% of the true mean rate (Appendix). Therefore, it is highly likely that the true lizard sighting rate for 2001 was between .07 and .21 lizards per transect (.14 +/- 50%) while that for 1979 was between .055 and .165 lizards per transect (.11 +/- 50%). Similar 95% confidence intervals were obtained on Vanderbilt, for these samples. Assuming that lizard surface activity and observer acuity were the same in both years it appears unlikely that lizard relative abundance has declined by more than 58% since 1979 (the low end of the 2001 estimate, .07, is about 42% of the high end estimate of .165 for 1979). Since the lizard encounter rate of .14 in 2001 was actually greater than that of 0.11 in 1979 (n = 42), it is actually more likely that an increase in the lizard abundance has occurred, although the probability of such an increase is only 50% (0.14/0.42 x 100). The magnitude of such an increase is unlikely to have been greater than 27% (.14/.11 is 1.27). However, if lizard surface activity or observer acuity were not about the same in both years these theoretical projections are not valid.

Spatial variance also affects the two-way comparison between 1979 and 2001 by the fact that not all transects were in the same Sections each year. If only transects walked in the same square mile Sections are used for the two-way comparison between 1979 and 2001, the sighting rates are virtually identical. The rate for both years is 0.09 lizards per transect (n = 42). Thus, even with most of the spatial variation removed, the lizard encounter rate is unchanged from 1979. Assuming these samples were unbiased representative of relative abundance (a major assumption), it appears that the density of lizards was about the same in both years.

Combined Trends 1979 to 2001

The combined sighting rate (lizards/10 hrs) in years when all three areas were sampled was virtually unchanged at 1.1 lizard per 10 hours, except for 1989 (figure 3d) and had no significant trend (p > .05, figure 4a). This is probably the strongest trend analysis because in all years except 1989, the sample size is relatively large, increasing the power of the sample to detect change. However, a less pronounced population trend could easily have occurred during this period that the methodology was too insensitive to detect. For example, a trend of +-30% could have gone undetected. Furthermore, as with the two-way comparison of the combined sighting rate, the proportion of effort expended between in each area varied widely by year. This problem is particularly acute for the Yuha Desert where the portion of sampling time varied from a high of 41% in 1991 to a low 8% in 1985. The East Mesa portion of the sample was more steady at 21% (2001) to 35% (1991), while the West Mesa portion also fluctuated widely from 29% (1979) to 67% (1985). This variation probably impacted the trend analysis because in some years one area was emphasized over another. In future years, the relative amount of effort expended in each area should be held constant to eliminate this spatial variability.

Rainfall

Another factor to consider when evaluating the lizard trend data is rainfall. Comparing the lizard data to rainfall totals for the City of Imperial (Imperial Irrigation District 2002) is intriguing, though dubious because the rain gauge is about 20 to 30 miles from all three sampling areas. Rainfall can be drastically different over a small distance in the desert and rainfall totals in Imperial may be very different from those where the flat-tail monitoring occurs. For example, in 1992 rainfall totals in the sampling areas were similar to those in Imperial, while in 1993 they were drastically different (Wright, 1993). That said, 1977 and 1978 were both wet years (5.21" and 4.37") with rainfall well above the long term average of 2.87". In the 12 months preceding surveys (4/78 to 3/79) 4.15" fell in Imperial. If the areas where transects were done were similarly wet, this could have impacted the lizard detection rates seen in 1979 by enhancing reproduction. By contrast the two years leading up to the 2001 surveys were not as wet. 1999 had a total rainfall of 2.01", while 2000 had 0.95", both below the long-term average of 2.87, however in the 12 months preceding surveys (6/00 to 5/01), 2.69 inches fell in Imperial, close to the long-term average at this site. The combined lizard encounter rate in 2001 (figure 4e) was actually slightly higher than in 1979. If rainfall patterns on transects were similar to those in Imperial, greater precipitation could not account for the slightly greater lizard encounter rate seen in 2001. In the 12 months prior to surveys in 1989, precipitation was only 0.89 inches in Imperial, less than a third the annual long-term average and the combined lizard encounter rate dropped to zero (figure 3d). In 1992, rainfall totals were again well above average both in Imperial (Imperial Irrigation District 2002) and the Yuha Desert (Wright 1993) (5.25 and 4.08", respectively) and the lizard encounter rate in the Yuha rose to 2.9 per 10 hours in 1993, following 6.3" in Imperial during in the preceding 12 months (June of 1992 to May of 1993). This rise occurred after a long period of low rainfall in the late 80's and early 90's - a period when the average annual rainfall was only 2.14" in Imperial (1987 to 1991), 26% below normal. It was during this period that drops in the lizard encounter rate, scat/hr and percentage of transects with lizard sign can be seen in the Yuha and West Mesa, though not in East Mesa (figures 1 - 3). Interestingly, the combined lizard encounter rate rose from 0 in 1989 to 1.2 in 1991 (figure 3d), following 3.06 inches of rain in the preceding 12 months in Imperial, although this increase is only significant at the 0.18 level. In future years, rain gauges should be put in areas monitored to determine responses of the population to rainfall patterns. Relying on distant rain gauges may lead to spurious conclusions, however preliminarily it appears flat-tail numbers respond to the general precipitation patterns in the Valley, with periods of robust rainfall preceding increases in lizard sighting rates. It is important that rain gauges be installed and monitored in all three areas to ensure that the impact of rainfall on the lizard is considered along with human impacts.

Trends in Scat

Of the eleven trend tests (figures 4a to 4d) performed on the three areas, only scat/hr in the Yuha showed a trend significant below the 0.05 probability level. This decline cannot be attributed to the fact that scat <= 5.5 mm in diameter were not counted after 1992. This exclusion eliminates about 19% of the scat that were previously counted (between 1979 and 1992). If the scat/hr from each year from 1993 forward is adjusted upwards by 19% the trend is still significant at the 0.03 level. However, scat are only weakly correlated with lizards, if at all (Wright 1993, figure 5e and Beauchamp, et. al. 1997). Note in figure 5 that while the West Mesa ACEC has the highest historical scat per hour number it also has one of the lowest lizards per hour figures, hardly suggestive of a close association between lizard abundance and scat abundance. Therefore, one cannot be sure that lizard populations have dropped substantially from this trend, especially in light of the lack of a significant trend in lizards/10 hours and the percentage of transects with lizard sign within the same area.

While differences in scat abundance could represent a difference in lizard numbers, the observed decline in the scat sighting rate could well be a result of vehicle crushing of scat, lower deposition rates, greater wind eradication, different observers or other factors. Nonetheless, scat densities should return eventually to within 19% of levels seen in the early 80's and 90's, if the lizard population remains strong. If the population in the Yuha is indeed as large as it once was, at some point optimal conditions for scat detection should occur and historical detection rates approached. The same applies to West Mesa where large drops in the relative abundance of scat were seen in the late 80's and late 90's. These levels would also be expected to eventually recover and come to within at least 19% of historic rates. Despite the week association between scat numbers and lizard numbers, a sustained and dramatic drop in the amount of scat in these areas could indicate a large reduction in the lizard population. Currently, such a pattern has not emerged.

Distributional Data

By contrast to the scat data, the distributional data (figures 1b - 4b and 7 -9) may be more reliable as they only attempt to reflect presence or absence rather than abundance. Although, the proportion of transects with lizard sign declined in all three areas from 1979 to 2001, these declines were not significant (p > .05) and the lizard is still found throughout all three areas (figures 7 - 9). Even in areas with relatively high levels of vehicular impacts the lizard or its scat are still found, e.g. the Superstition Mountains Open Area. However, lizard numbers could have declined due to vehicle mortalities and related habitat degradation in these areas, while distribution remained unchanged. Flat-tailed horned lizards are still found in two other highly impacted OHV areas within the BLM's El Centro Field Area: PCOA and the Algodones Dunes. Lizards were also recently found on the west half of Section 31 (T.16S, R.20E) in an area with greater than 60% of the surface covered with tracks in 2002 (BLM 2002) (these sightings are not shown on figure 7). Therefore, it is clear the species still occurs in areas of very high OHV disturbance.

Whether this situation is sustainable in light of increasing vehicular impacts is unknown. The lizard populations in these high impact areas may be "recharged" from nearby areas of low impact or they may be self-sustaining. If impacts spread to adjacent lower impact areas, reducing lizard numbers, such population "recharging" may cease, leading to localized extirpation. However, no such extirpations have yet been documented due to OHVs. Flat-tailed horned lizards have not been seen on the Indian Avenue Preserve since the early 1990's (Fisher, pers. com. 2002) but this area is not subject to major OHV use. However, the surrounding area is heavily impacted by wind energy, high use paved roads, water projects, railroad, housing developments, etc (Wright, personal observation 2001). At the Ocotillo Wells State Vehicular Recreation Area, the flat-tail persists despite over 30 years of intense OHV recreation (Young, pers. com. 2002). Thus, no evidence yet exists of OHV's extirpating the species.

One cause for concern is the very low percentage (29%) of transects on which the lizard or its scat were detected in 1997 in West Mesa (figure 1b), as well as the low detection rates seen in the Yuha in the last 3 survey years (80%, 62% and 69%, respectively). In 1981, the Yuha detection rate dropped to 27% (partly due to the short transect times during this year - about 30 minutes) only to recover to 100% in subsequent years. These fluctuations contrast quite sharply with those seen in the more lightly impacted East Mesa, where detection rates have hovered consistently around 80% since 1979. These percentages should be monitored closely in the future to see if detection rates return to their historic highs in the Yuha and West Mesa, particularly following rainy years. While these declines are not yet significant, continued declines in these percentages would be a cause for concern, especially given the increasing level of vehicle impacts in these areas.

Because of the many the many factors impact these data, they should be considered only as rough indicators of lizard population trends, although some biologists are skeptical even of this inference (Weigand, pers. com. 2002 and Knauf, pers. com. 2002). However, given the absence of any significant trend in lizard sighting rates, it is unlikely that the population in any of the three areas is dramatically different now than it was in 1979. This is particularly likely given the lack of a significant difference in the combined lizard sighting rate between 1979 and 2001 (figures 3d, 4a and 4e). Had the population collapsed, it is very unlikely that observers would have been able to detect lizards at a higher rate than they did in 1979. In summary, the current transect methodology should be considered a "late warning system" due to its insensitivity. Formulating policy based on its prognosis may well occur after a substantial change in lizard numbers has occurred.

Lizard Abundance in Different Areas

Lizard sighting rates varied widely across the lizard's range (figure 5d) with the Navy and Limited Areas having the highest encounter rates, while the Open Areas, Algodones Dunes Wilderness and West Mesa ACEC had the lowest encounter rates. The Yuha Desert and East Mesa had intermediate encounter rates. Overall however, the eastern Yuha actually had the highest lizard encounter rate relative to the combined totals in West Mesa and southern East

Mesa (figure 4d), 0.11 lizard per hour vs .08 for southern East Mesa and .07 for West Mesa. In this latter comparison the encounter rates may indeed be a fairly reliable relative abundance indicator because transects numbered in the hundreds. If this is the case, it may be a cause for concern, as the Yuha is the smallest of three Management Areas, is impacted extensively by immigration and is bisected by State Highway 98, a travel corridor that could eventually be widened to four lanes, a development which would likely prevent the movement of flat-tails from the southern portion of this area, fragmenting the population. In the case of the Algodones Wilderness, the reliability of the encounter rate is very low due to the low sample size (n = 11) and should be verified with a more intensive mark-recapture survey. The Open Area should be simultaneously sampled for comparison. Most of the historical surveys have been on the fringes of the Dunes, so the interior is largely uncharacterized with respect to flat-tail densities. Additional data is needed from the interior of the Dunes, particularly in light of the ongoing OHV use of the Open Area and recent discussions of how much of the Dunes should be open to OHVs. Mark-recapture data on other areas of the lizard's range is also desirable, especially in the Management Areas designated by the Flat-tailed Horned Lizard Rangewide Strategy (Foreman 1997). Differences in lizard densities need to be known to assist planning for the lizard's conservation, rather relying on the lizard encounter rates.

Impacts to Habitat

The impact surveys (figures 7 -9) demonstrate that the habitat in southern East Mesa is still relatively intact while that in the eastern Yuha and West Mesa is considerably more damaged. East Mesa, in addition to having significantly fewer vehicular impacts, also has a very lightly impacted interior. The Yuha and West Mesa have relatively high levels of impact throughout and lack protected cores. This situation is primarily due to intensive immigration activity, as well as recreational off-roading. Immigrants and drugs are smuggled into the US across the Yuha Desert and to a lesser extent across West Mesa. These areas have extensive road networks and relatively firm surfaces that allow freer movement than in East Mesa. By contrast, East Mesa has very few routes and its sandy substrate can easily trap vehicles, even with four wheel drive. For these reasons, impacts are confined primarily to the exterior of East Mesa. By contrast, figure 8 shows that OHV activity from the SMOA has spilled over into the southern edges of the West Mesa MA, where relatively high levels of tracks are seen.

In a related trend the number of routes jumped on the same transects within the West Mesa Management Area (MA) by 387% from 1985 to 2001 (figure 6b). Such route proliferation is not seen in East Mesa, where the number of routes detected per mile declined from 1985 to 2001 (figure 6a). However, only 5 of the 14 route counts from 1985 were in the same Section as the 2001 counts. The five counts that were within the same Sections showed a decrease from 17 routes to 8 routes, a drop of over 50%. Routes and graded roads declined by 45% in southern East Mesa from 1994 to 2001 (figure 6h) - these counts were on the same transects in both years. No route data are available for the Yuha from 1985 but data between 1994 and 2001 show a 23% increase in routes and graded roads from 1994 to 2001 on the same transects. The vehicle track levels along Highway 98 in the eastern Yuha are also more consistent with an Open Area rather

than a limited one. Impacts to the lizard's habitat from vehicles appear to be increasing in West Mesa and the eastern Yuha and declining in southern East Mesa.

Several factors affect the interpretation of the route surveys from 1994 and 2001. The methodologies were different, the earlier survey having been done primarily from vehicles and not by foot, as the 2001 surveys were. Therefore, the detection rate in the 2001 surveys was probably higher and some of the routes found in 2001 may have been present in 1994 and gone undetected. Therefore, some of the increase seen in the Yuha and West Mesa may be due to this higher detection rate. However, the increases seen are very unlikely to be higher than this and the decrease in East Mesa in very likely a real phenomenon resulting from changing vehicle use patterns and the very active sand movement of this area. Routes are quickly obscured by sand coverage in this area when vehicle use ceases. Despite the methodological differences, it appears that routes increased in the eastern Yuha and West Mesa during this period and declined in southern East Mesa.

Concern has been raised about the effect of such vehicle impacts on the lizard. Figure 5a shows that fewer lizards or lizard scat were detected per unit effort in Open Areas than in adjacent limited or Navy areas from 1979 to 2001. The rate at which lizards were sighted outside of Open Areas is larger than inside them and this rate shows a high level of statistical significance using the t-tests (0.011 and 0.016), however with the non-parametric Mann-Whitney test the significance level drops to 0.084. The reliability of Mann-Whitney with data such as these, with many tied zero values, reduces the power of this test to detect real differences, so its reliability is questionable (Willoughby, pers. com. 2002). Assuming lizards were equally detectable between Open and non-open areas, these results suggest lizard populations are denser outside the Open Areas of West Mesa. Figure 5b demonstrates a significant negative association between Open Areas and lizard sightings. However, since no lizard data are available on the PCOA and SMOA prior to the advent of substantial OHV use, it's difficult to be sure that the observed differences in lizard detection rates didn't exist prior to the introduction of OHVs.

Several factors other than lizard abundance may have influenced the scat detection rates seen in figures 5c and d. Vehicles can eradicate scat, reducing its abundance in an area. This reduction could biase any comparison between areas. Almost all the data comparing Open with non-Open areas in West Mesa were collected in the late spring or early summer (the most notable exception being 1979) after the main recreational OHV use season. Therefore, differences observed in scat abundance in the SMOA and PCOA are unlikely to be due to recreational OHVers. During the summer vehicle impacts are primarily limited to smugglers, Border Patrol and occasional BLM or Imperial Irrigation District (IID) vehicles. Whether these users favored the PCOA or SMOA over the Limited/Navy lands, thereby eradicating scat more frequently in one type of area or another is unknown. Also, different wind regimens can impact scat abundance in an area. Whether the PCOA and SMOA are windier than the nearby Limited/Navy lands is unknown. If such a difference exists, it also could have caused the difference in observed scat abundance. Observer acuity is unlikely to have been a factor in the scat and lizard detection rates because over 20 observers participated in these surveys in both areas thereby

diluting the influence of any one observer.

Yet another factor is the abundance of fringe-toed lizards in an area. About 1/3 of this species' scat is larger than 5.5mm diameter and it is indistinguishable from scat of the flat-tailed horned lizard (Muth and Fisher 1992). Therefore, sandier areas may have more scat due to the presence of *U. notata*. Whether the Open or Limited/Navy lands have denser U. notata populations that could cause differences in scat abundance is unknown. For these reasons, one cannot definitively link the greater detection rate for *P. mcallii* and its scat in the Limited/Navy lands to the presence of less recreational OHV use in these areas. Similarly, the detection rates seen in other areas in figure 5d may not mean that a difference in *P. mcallii* abundance exists. However, very large differences in detection rates are more suggestive of such a difference in abundance, e.g. Algodones Dunes vs. West Mesa Navy Lands.

The difference between vehicle impact levels on transects with lizards and on those without lizards was of low statistical significance but was significant between transects with the lizard or its scat and those transects with neither. In this latter case, it must be remembered that vehicles themselves may have eradicated scat, thereby lowering the scat detection rate on transects with higher track coverages. Although little recreational OHV use occurs during the summer, substantial immigrant and Border Patrol traffic does occur. This traffic may have lowered scat abundance by roughly twice the rate on transects where scat was not detected (6.9% track coverage vs. 14.8%). This loss of scat due to vehicle crushing could account for the significant difference seen in figure 6c rather than an actual difference in lizard numbers.

The numbers of routes on transects with lizards and those without lizards were virtually identical (figure 6c) and Chi-square analysis found no significant ($p > .5$) association between the vehicle impact levels and lizard sightings (figures 6e and 6f) or between routes or roads and lizard sightings (figure 6d). The results from figures 6c - 6f suggest that differences in lizard sighting rates between Open and non-open areas may be partially the result of influences other than OHVs, such as underlying habitat quality in the two management types, rainfall patterns in these areas, weather at time of survey (e.g. temperature, relative humidity, wind speed), predator activity (squirrels, shrikes), observer acuity, mining, substrate, agriculture or other human impacts, as much as the presence or absence of an Open Area.

In the case of the Open vs Limited/Navy comparisons of figures 5a and 5b, 23% of the transects in the Open Areas were in areas impacted directly or indirectly (due close proximity) by either mining, agriculture or a dry lake bed. These same types of impacts were not detected on the transects in the Limited and Navy Lands. Since these three types of impacts all result in severe surface disturbance, they probably negatively impacted lizard abundance and may account for some of the difference in lizard encounter rates between the vehicle use classes. Conversely, impacts from military activities are more common on transects within the Navy lands, while Open, Limited and Navy lands all have impacts from the Gypsum Railway and power lines. This multitude of conflicting impacts makes interpretation of differences in sighting rates between the areas difficult.

Logistic regression (figure 11) of the data in figure 10 showed that the odds of finding a lizard on a transect dropped very slightly with each percentage increase in vehicle track levels. The odds ratio, 0.9824, was very near one (the level at which the odds of an event occurring equals the odds of it not occurring). The chi-square statistic was quite small and of low significance, meaning the model of vehicle track levels predicting lizard sightings performed poorly. Therefore, based on the regression model alone, the null hypothesis that vehicle tracks are not a good predictor of lizard sightings would be accepted. This result is not surprising in light of the many other factors that impact lizards besides vehicular impacts. This regression analysis would be stronger if these other factors were controlled for and if the sample size were larger. For these reasons, the power of logistic regression to detect a trend with these data is likely very low.

Route Proliferation

The large increase in vehicle routes in West Mesa from 1985 to 2001 (figure 6b) may have adversely impacted lizard populations through increased mortality and habitat degradation. However, because no before and after population estimates are available for the transects on which routes were counted, it is not possible to determine the degree of this impact, if any. All of the transects surveyed had the lizard on them in 1985, however the lizard's presence has only been reconfirmed near 3 of the transects in the last three years. For the remainder of the transects, no recent survey data is available. Interestingly, these three transects have some of the highest levels of route proliferation (T.14S, R.11E, secs. 27 and 28, T.15S, R.11E, sec. 21) on West Mesa. For the remainder of the transects the status of the lizard is uncertain for the last 6 to 16 years, depending on the transect. Further surveys could shed light on this issue, however it is unlikely that the lizard has been extirpated from these transects because the species has been recently detected in areas with far greater vehicle impacts than on these transects (for example, near Gordon's Well, CA, T.16S, R.20E, Section 31) (Malo L., pers.com 2001 and Loeffler W., pers. c com. 2001). Furthermore, the lack of a strong association between routes and lizard sightings (figures 6c and d) and the increase in the lizard sighting rate during this period (Figure 1a) suggests that a significant negative impact is not a foregone conclusion.

In contrast to West Mesa, the number of routes detected on East Mesa declined from 1985 to 2001 and as mentioned earlier, a decline of 45% in routes and graded roads was also detected between 1994 and 2001 (figures 6a and 6h). This decline may have been due to the elimination of camping adjacent to the old Coachella Canal in the late 1980's and the elimination of racing from this area in the mid 1970's (Schoek pers. com. 2002). Nine of the 14 transects walked on East Mesa in 1985 were not in the same section as those walked in 2001 and the 1985 transects were highly clumped on the eastern and western extremities of East Mesa. By contrast, the forty-one, 2001 transects were systematically distributed throughout southern East Mesa. For these reasons, the comparison between 1985 and 2001 incorporates a strong element of spatial as well as temporal variation and the 1985 transects are not representative of East Mesa as a whole, whereas the 2001 transects are. For that reason, the some of the decline in routes detected may be the result of more peripheral sampling in 1985. Additionally, all routes were not counted on the Section of land just east of Gordon's Well in 1994 (Schoek and Bower, pers. coms. 2002), an

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The eastern Yuha Desert saw an increase in routes and graded roads of 23% from 1994 to 2001, during a time period corresponding to the advent of Operation Gatekeeper in 1994. This deployment by the U.S. Border Patrol in the San Diego area pushed thousands of illegal immigrants into the Yuha, apparently increasing route proliferation. Vehicle impacts are especially acute along Highway 98 where smugglers frequently drop off immigrants and pursuits by the Border Patrol are common. In addition, this area is popular with recreational OHV riders during the cooler part of the year. During this same period the lizard encounter rate, percentage of transects with lizard sign and scat/hr all declined (figures 2a - 2c). Whether the increase in routes is linked to the decrease in lizard detection during this period is unknown.

Factors Affecting Routes Counts

Several factors other than route proliferation may have affected the number of routes counted on the transects in 1985 and 2001. While defining routes in the field may be somewhat ambiguous, it is unlikely that the magnitude of change seen on West Mesa could be accounted for by the 2001 observers using a more inclusive definition than was used in 1985. Most routes are readily discernable by the presence of a "roadbed" or depressed area containing more or less continuous tracks from one side to the other. Only about 10% of routes counted in 2001 fell into the ambiguous category, so this ambiguity is unlikely to have accounted for the 423% change seen between the two years. Similarly, on the test transect on which routes were counted independently by 3 observers, the counts were virtually identical. Also, note that on the 7 transects off-set by 0.13 miles, route counts were close (within 7%). Therefore, differences in route classification and slight differences in transect location are unlikely to account for the change seen on West Mesa between 1985 and 2001.

A third factor that could account for some of the difference in the number of routes counted between the two years is the time of year of the surveys. Routes in sandy areas can fluctuate seasonally due to OHV levels and the wind regime. In the spring and summer, in sandy areas, the number of routes may fall as wind moves across the routes left by OHVs in the preceding winter. Routes were counted in 1985 during the late spring and early summer but were counted in the winter in 2001. Thus, some of the additional routes counted may be attributable to this seasonal effect, especially in sandy areas. This effect is unlikely to have been great however, as only 3 of the 15 fifteen transects were predominantly sandy, the remainder were composed primarily of either gravelly creosote flats or rugged uplands (mudhills). In the latter substrate types, routes remain much longer and are less affected by seasonal movement of windblown

sand. Even if the assumption is made that all of the 423% increase between 1985 and 2001 was due to such short-term seasonal effects, rather than long-term trends, the impact of such large short term route proliferation could be considerable. Despite the effect these factors may have had on the number of routes counted, the magnitude of the increase (423%) suggests strongly that routes have indeed increased dramatically in West Mesa since 1985. Although we found no negative association between routes and lizard sightings (figure 6d), such a large increase is a cause for concern.

The potential magnitude of such a decrease may have been seen on a transect south of Highway 98 in the Yuha Desert where only 9 of 69 flat-tail sightings (13%) were within 0.45 miles of the Highway. The remaining 60 were more than 0.45 miles from the Highway (figure 2 in Grant et. al. 2001), despite approximately equal observer effort on the portion of the transect near the Highway. While highways are much more heavily traveled than most OHV routes, this result is suggestive of the potential magnitude of vehicular mortality if traffic becomes heavy enough. Certainly, on major holiday weekends, well traveled OHV routes can have very heavy traffic, with numerous vehicles passing within a short time period, creating the opportunity for flat-tail mortality.

<u>Habitat Use</u>

Given the difficulty in sighting lizards, the adequacy of assessing the potential presence of the species through macro habitat (landscape level) characteristics has been considered. The data collected in 2001 don't show a substrate preference at this level. Lizards were not significantly ($p > 0.5$) associated with transects dominated by any of the three major substrates (sand, gravel, hardpan). They also suggest that the traditional model of flat-tail habitat as fine, aeolian sand at the edges of, or away from, dunes (Klauber, 1932, Norris 1949, Funk 1981 and Rorabaugh, et. al., 1987 cited in Beauchamp et al 1998) should be reassessed. The use of gravelly areas confirms the work of Beauchamp et. al (1998) who also found use of such areas, as well as mud hills. Additionally, the species has been recorded in active sand dunes deep within the Algodones Dunes (BLM 1999). Thus the habitat range of the species appears to be quite broad making habitat modeling a tenuous means of gauging the likelihood of the lizard's presence. For that reason, when evaluating project impacts in areas without previous data but within the lizard's known range, intensive surveys should be considered as a means of determining the lizard's presence, rather than relying on substrate types.

<u>Temperatures</u>

Surveys need to take into account air temperatures near the surface. Figure 12 indicates that the best range to search for the lizard during such surveys is between 28 and 41 degrees Celsius (82 to 106 degrees Fahrenheit). The number of lizards sighted per degree inside this range is 8.1, while the sighted per degree outside this range is 2.6, a three fold difference. This difference exists despite the approximately equal effort expended looking for the lizards between the low 20's and low 40's. Future surveying efforts should adhere to this range.

sand. Even if the assumption is made that all of the 42% decrease between 1985 and 2001 was due to such short-term seasonal effects, rather than long-term trends, the impact of even short term route proliferation could be considerable. Despite the effect these factors may have had on the number of routes counted, the magnitude of the increase (417%) suggests strongly that routes have indeed increased dramatically in West Mesa since 1985. Although we found no negative association between routes and lizard sightings (Figure 14), such a increase is cause for concern.

The potential magnitude of such a decrease may have been seen in a similar study of State Route 98 in the Yuha Desert where only 9 of 69 lizard sightings (13%) were within the paths of the Highway. The remaining 60 were more than 0.40 miles from the Highway (Figure 15; Lovich et al. 2001), despite approximately equal observer effort on the presence of the lizard near the Highway. While highways are much more heavily traveled than most OHV routes, this result is suggestive of the potential magnitude of vehicular mortality if traffic becomes heavy enough. Certainly, on major holiday weekends, well traveled OHV routes can have very heavy traffic, with numerous vehicles passing within a short time period, creating the opportunity for high mortality.

Habitat Use

Given the difficulty in sighting lizards, the adequacy of assessing the possible presence of the species through macro habitat (landscape level) characteristics has been considered. The data collected in 2001 don't show a substantive preference at this level. Lizards were not significantly (p > 0.5) associated with transects dominated by any of the three major sand types [illegible] [illegible]. They also suggest that the traditional models of [illegible] habitat as flat sandy areas at the edges of, or away from, dunes (Collins, 1982; Norris, 1958; Turner et al., 1987 cited in Beauchamp et al 1998) should be reassessed. This research also confirms the work of Beauchamp et. al (1998) who also found use of both areas, as well as rolling hills. Additionally, the species has been recorded in active sand dunes deep within the Algodones Dunes (BLM 1997). Thus the habitat range of the species is nearly as wide as [illegible], making habitat modeling a tenuous means of gauging the likelihood of the lizard's presence. For that reason, when evaluating project impacts in areas without previous data on [illegible] lizard's known range, intensive surveys should be considered as a means of determining the lizard's presence, rather than relying on substrate types.

Temperatures

Surveys need to take into account air temperatures near the surface. Figure 12 indicates that the best range to search for the lizard during such surveys is between 28 and 41 degrees Celsius (82 to 106 degrees Fahrenheit). The number of lizards sighted per degree inside this range is [illegible], while the sighted per degree outside this range is 1.6, a three-fold difference. This difference exists despite the approximately equal effort expended looking for the lizards between the low 20's and low 40's. Future surveying efforts should adhere to this range.

Conclusions and Recommendations

1) Lizard detection rates in 2001 were not significantly different from those in 1979 ($p > .05$) and no significant trend ($p > .05$) was detected in the rate that lizards were detected between these years. Assuming lizard detection rates are an indicator of relative abundance, the lizard population in 2001 was probably not dramatically different from that in 1979. However, the insensitive methodology may have prevented the detection of a real population change.

2) West Mesa and the Eastern Yuha are more impacted by vehicles than southern East Mesa.

3) Assuming lizard sighting rates are correlated with lizard density, the Limited Use and Navy lands of West Mesa are apparently the densest lizard areas.

4) No consistent association between vehicle impacts and lizards was found. This inconsistency may be due to the confounding effects of weather, habitat quality and other human impacts or to the small sample size and insensitive methodology.

5) Monitoring in the future should include mark-recapture studies to generate an actual population figure for the three Management Areas and other areas, if feasible.

6) If relative abundance monitoring is done in the future using the traditional triangular transect methodology, it should have at least 55 transect repetitions per area. The same transects should be done each year to reduce spatial variation. Surveys should be done when the temperature 1 cm above the surface is between 28 and 41 degrees Celsius to maximize lizard sighting probability. Surveyors should be randomly assigned to transects to reduce the impact of observer acuity on the results.

7) Increased patrols, route rehabilitation, signs and education are needed to reduce vehicle impacts in the MAs.

8) Athyll tamarisk and salt-cedar should be reduced in the MA's before they become a serious problem.

9) Impact transects should be repeated every 3 to 5 years to assess changes in vehicular impacts.

10) Habitat suitability assessments based on a single substrate type are an unreliable means of determining the likelihood of the lizard's presence in these areas.

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Appendix

Sample size calculations for East Mesa flat-tailed horned lizard data, using the program PC SIZE: CONSULTANT by Jerry Dallal. Pilot data used were from a sample of 39 transects, 5 of which detected 1 lizard and 34 of which detected 0 lizards. The sample mean of this data set is 0.1282 and the sample standard deviation is 0.3387. The data plugged into the program consists of the desired confidence interval, the probability of obtaining this confidence interval (this applies the corrections of [Kupper, 1989 #1661]; I entered the same probability as the confidence interval I wanted), the sample standard deviation, and the desired length of the confidence interval. The latter is the *total* length. I calculated this length by multiplying the sample mean by the desired percentage–e.g., 10%, and multiplying this result by 2. So, for example, for a 10% confidence interval (within ± 10%) I multiplied the mean of 0.1282 by 0.10 = 0.0128 x 2 = 0.0256 to get the total confidence interval length. Following are the results (the language is that provided with the program when it is asked for a report). Be aware that PC Size's report rounds off the values input, but the calculations are based on the actual values entered.

95% confidence interval within 10% of mean:

A confidence interval for a single population mean will be constructed. Sample size calculations are based on an estimated standard deviation of .339 . A sample size of 2809 gives a probability of .950 of obtaining a 95.0-% confidence interval whose length is no greater than .026 .

90% confidence interval within 10% of mean:

A confidence interval for a single population mean will be constructed. Sample size calculations are based on an estimated standard deviation of .339 . A sample size of 1973 gives a probability of .903 of obtaining a 90.0-% confidence interval whose length is no greater than .026 .

80% confidence interval within 10% of mean:

A confidence interval for a single population mean will be constructed. Sample size calculations are based on an estimated standard deviation of .339 . A sample size of 1190 gives a probability of .803 of obtaining a 80.0-% confidence interval whose length is no greater than .026 .

95% confidence interval within 20% of mean:

A confidence interval for a single population mean will be constructed. Sample size calculations are based on an estimated standard deviation of .339 . A sample size of 732 gives a probability of .952 of obtaining a 95.0-% confidence interval whose length is no greater than .051 .

Appendix

Sample size calculations for flat-tailed horned lizard data using the program in [illegible] CONSULTANT by Jerry Dallal. The data used were from a sample of [illegible] which [illegible] 1 lizard and 36 in which detected 0 lizards. The sample mean is [illegible] and the standard deviation is 0.5387. The data plugged into the program consist of the desired confidence interval, the probability of obtaining this confidence interval [illegible] 1989 #1651]; I selected the same probability as the confidence level), [illegible] the sample standard deviation, and the desired length of the confidence interval. The latter is the total length. I calculated this length by multiplying the sample mean by the desired percentage and then multiplying by 2. So, for example, for a 10% confidence interval [illegible], I multiplied the mean [illegible] 0.10 = 0.0128 x 2 = 0.0256 to get the total confidence interval length. [illegible] language is that provided with the program when it is asked for a summary. [illegible] rounds off the values input, but the calculations are based on the actual values input.

95% confidence interval within 10% of mean:

A confidence interval for a single population mean will be constructed. Sample size calculations are based on an estimated standard deviation of .539. A sample size of 2809 gives a probability of .950 of obtaining a 95.00% confidence interval whose length is no greater than .026.

90% confidence interval within 10% of mean:

A confidence interval for a single population mean will be constructed. Sample size calculations are based on an estimated standard deviation of .539. A sample size of 1973 gives a probability of .901 of obtaining a 90.00% confidence interval whose length is no greater than .026.

80% confidence interval within 10% of mean:

A confidence interval for a single population mean will be constructed. Sample size calculations are based on an estimated standard deviation of .539. A sample size of 1190 gives a probability of .801 of obtaining a 80.00% confidence interval whose length is no greater than .026.

95% confidence interval within 20% of mean:

A confidence interval for a single population mean will be constructed. Sample size calculations are based on an estimated standard deviation of .539. A sample size of 732 gives a probability of .952 of obtaining a 95.00% confidence interval whose length is no greater than .051.

90% confidence interval within 20% of mean:

A confidence interval for a single population mean will be constructed. Sample size calculations are based on an estimated standard deviation of .339 . A sample size of 512 gives a probability of .900 of obtaining a 90.0-% confidence interval whose length is no greater than .051 .

80% confidence interval within 20% of mean:

A confidence interval for a single population mean will be constructed. Sample size calculations are based on an estimated standard deviation of .339 . A sample size of 309 gives a probability of .810 of obtaining a 80.0-% confidence interval whose length is no greater than .051 .

95% confidence interval within 30% of mean:

A confidence interval for a single population mean will be constructed. Sample size calculations are based on an estimated standard deviation of .339 . A sample size of 341 gives a probability of .954 of obtaining a 95.0-% confidence interval whose length is no greater than .077 .

90% confidence interval within 30% of mean:

A confidence interval for a single population mean will be constructed. Sample size calculations are based on an estimated standard deviation of .339 . A sample size of 238 gives a probability of .904 of obtaining a 90.0-% confidence interval whose length is no greater than .077 .

80% confidence interval within 30% of mean:

A confidence interval for a single population mean will be constructed. Sample size calculations are based on an estimated standard deviation of .339 . A sample size of 142 gives a probability of .805 of obtaining a 80.0-% confidence interval whose length is no greater than .077 .

Appendix (continued)

95% confidence interval within 50% of mean:

A confidence interval for a single population mean will be constructed. Sample size calculations are based on an estimated standard deviation of .339 . A sample size of 133 gives a probability of .952 of obtaining a 95.0-% confidence interval whose length is no greater than .128. 55

90% confidence interval within 50% of mean:

A confidence interval for a single population mean will be constructed. Sample size calculations are based on an estimated standard deviation of .339 . A sample size of 93 gives a probability of .910 of obtaining a 90.0-% confidence interval whose length is no greater than .128 .

80% confidence interval within 50% of mean:

A confidence interval for a single population mean will be constructed. Sample size calculations are based on an estimated standard deviation of .339 . A sample size of 55 gives a probability of .812 of obtaining a 80.0-% confidence interval whose length is no greater than .128 .