The Sand Dune Lizard *Sceloporus arenicolus* and Oil and Gas Development in Southeastern New Mexico. Final Report of field studies 1995 - 1997.

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Summary

The Sand Dune Lizard *Sceloporus arenicolus* is a habitat specialist of Shinnery Oak sand dunes that occupies a small geographic range in southeast NM and adjacent TX. In this region intensive oil and gas development, herbicide spraying and other development pressures pose potential threats to the continued existence of Sand Dune Lizards. This report examines the status of *S. arenicolus* in relation to oil and gas development in southeast NM.

In 1995 we compared reptile numbers on plots of land located at different distances from individual wells. We found a 39% reduction in *S. arenicolus* on plots of land 0 to 80 m away from wells compared to plots of land more than 190 m from wells. We did not find this distance effect in any other species of reptile. This localized effect demonstrated a need to examine larger scale population and species effects that might be associated with oil field development. In 1996-97 observers walked 529 random 25 minute transects to count reptiles, the number of wells within 600 m of the transects and to measure habitat features of Shinnery Oak. The transect analysis was based on 5146 reptile sightings; 2126 *Uta stansburiana*, 1398 *S. arenicolus*, 392 *Cnemidophorus tigris* and lesser numbers of other species.

In both years we found a negative relationship between well density and abundance of *S. arenicolus*. The random transects measured the overall decline of *S. arenicolus* populations associated with reduced habitat quality and habitat loss due to oil development. However, coupled with localized *S. arenicolus* reductions around individual wells it was clear that *S. arenicolus* populations occur in remaining oil field habitat at reduced densities. There was also evidence of reduced *S. arenicolus* levels in habitat distant from wells, where wells only occurred 300 m to 600 m away from the lizards. In contrast to *S. arenicolus*, we did not find meaningful negative associations with other reptile species and well density. This demonstrated a degree of environmental sensitivity of *S. arenicolus* that was not found in sympatric reptile species.

The calculated 1996 and 1997 percent declines in *S. arenicolus* populations associated with increases in well density were very similar. To express the magnitude of these negative relations we used regression analysis and predicted a 25% decline in *S. arenicolus* populations at well densities of 13.64 w/mi^2 (this is the same as 13.64 wells per section) and a 50% decline in *S. arenicolus* populations at 29.82 w/mi^2. The maximum well densities we found occurred in the southern portions of *S. arenicolus* range. In 1996 we found 34.36 w/mi^2 with a predicted 56.21% decline in *S. arenicolus* and in 1997 we found 32.07 w/mi^2 with a predicted 53.12% decline. These areas presumably represent the maximum impact that oil fields currently exert on *S. arenicolus* populations. There were at least four high well density areas, two in the vicinity of Maljamar and two north and west of Eunice that have likely undergone at least a 50% reduction of *S. arenicolus* populations. All of these areas are large enough that it is doubtful these *S. arenicolus* populations are maintained by dispersal from source populations from surrounding low well density areas. It appears that oil field populations of *S. arenicolus* are persisting, albeit at a reduced level.

Overall, Shinnery Oak habitat that had any wells present within 600 m supported 52% (1996) to 31% (1997) fewer *S. arenicolus* than areas with no wells. There was no difference in the utilization of habitat by *S. arenicolus* comparing well present and well absent areas. There was no relation between well density and sex ratios of *S. arenicolus.* Most *S. arenicolus* were found in open sand depressions called blowouts (1996, 77.62% and 1997, 81.17%). Furthermore *S. arenicolus* were most abundant (1996, 40.90% and 1997, 43.52%) in large blowouts that had linear length of at least 24.4 m (80 ft). Destruction of blowouts and alteration of the biotic and abiotic habitat of blowouts are likely proximate sources of *S. arenicolus* declines associated with oil field development. There was no other species of reptile in southeast NM that was so exclusively associated with blowouts. There were minimal numbers of *S. arenicolus* sighted on caliche well pads, in disturbed areas around pads and on caliche roads.

Most of the remaining *S. arenicolus* were found in pipeline cuts and sand roads (1996, 15.82% and 1997, 12.59%). Transects with pipeline cuts had more *S. arenicolus* than transects without pipeline cuts. There was no difference in the number of *S. arenicolus* found in pipeline cuts between well present or well absent areas. Transects with sand roads had more *S. arenicolus* than transects without sand roads. This suggested that pipeline cuts and sand roads serve as preferred habitat where they represent artificial blowouts, new habitat and possible dispersal corridors. Based on the frequency of leaks in pipelines we found in the field, it is probable that leaks from pipelines may periodically kill off *S. arenicolus* that have settled in pipeline cuts.

We used multiple regression to make a predictive model to address the question: where do dense populations of *S. arenicolus* exist within the geographic range of the species? We identified four factors that explained 50% of the variation in *S. arenicolus* abundance: well density, percent open sand, the number of blowouts and the abundance of the Side-Blotched Lizard *Uta stansburiana.* This demonstrated that oil field development as measured by well density exerts negative influences on *S. arenicolus* populations that can be not accounted for by biotic and abiotic habitat characteristics. Instead, well density is a separate factor that should be considered in the management of the species.

Because of the small geographic range of *S. arenicolus* we recommend permanent management attention to the issue of oil and gas development. We found limited evidence that low and moderate density well development present a short term threat to *S. arenicolus* populations. Some of the oil fields were in excess of 40 years old so it is noteworthy that *S. arenicolus* still occurs in these areas. However at densities (29.82 w/mi^2) where a 50% reduction in *S. arenicolus* was predicted we recommend consideration be given to limiting the number of wells. At this level of reduction it is likely that the probability of local extinction has substantially increased. We found four high well density areas that merit attention. Some of these areas span the entire width of narrow portions of *S. arenicolus* habitat. We recommend that no developments such as oil refineries be placed in these areas which could create habitat barriers to dispersal. We know that some of the decline of *S. arenicolus* is due to habitat loss, but degradation of habitat suitability suggests that pollution control measures in high well density areas and control of pipeline leaks should be studied. Due to the inherently small range of *S. arenicolus* we do not recommend a pattern of management that creates sacrifice areas of intense development offset by conservation areas. There is a less than 8 mi^2 region SW of Maljamar and surrounded by oil fields, that should it ever be developed, priority should be given to preserving the habitat qualities of the area. This area supports one of the densest and possibly the largest population of *S. arenicolus* in the Loco Hills to Eunice region.

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Introduction

This report discusses the status of the Sand Dune Lizard *Sceloporus arenicolus* in relation to oil and gas development in southeastern New Mexico. This study was based on field work conducted in 1995-97 in Chaves, Eddy, Lea and Roosevelt Counties. These research projects were funded by the Bureau of Land Management, New Mexico Department of Game and Fish and the US Fish and Wildlife Service to acquire information applicable to the conservation biology and management of *S. arenicolus*. This lizard has been a species of concern to management agencies because of a combination of regional development within the geographic range of *S. arenicolus* and the specialized biological attributes of the species.

The Sand Dune Lizard or Dunes Sagebrush Lizard is a species occupying a very limited geographic range which includes parts of Chaves, Eddy, Lea and Roosevelt counties of southeastern New Mexico (Degenhardt, Painter and Price 1996) and 5 counties in Texas (Axtell 1988, Painter and Sias in press). *Sceloporus arenicolus* is a habitat specialist of Shinnery Oak (*Quercus havardii*) sand dunes where it is generally found in association with open sand depressions "blowouts" of the Shinnery Oak dunes. It is noteworthy that there are large areas of Shinnery Oak dunes where *S. arenicolus* does not occur. Extensive public land Shinnery Oak tracts have been altered by grazing and spraying of the herbicide Tebuthiron to eliminate Shinnery Oak. Intensive oil and gas exploration and development have taken place throughout *S. arenicolus* range in Texas and New Mexico. Energy extraction activities will continue to be a dominant aspect of this region's landscape. Additional recent works outlining the conservation status of the Sand Dune Lizard are reported for the following topics: oil wells (Sias and Snell 1996), oil fields (Sias and Snell 1997), geographic range and habitat (Sena 1985; Fitzgerald, Sias, Snell, Painter 1995a; Fitzgerald et al. 1995b, Fitzgerald et al. 1997) and herbicide spraying (Gorum, Snell, Pierce, and McBride 1995, Snell and Landwer 1992, Snell, Gorum, Doles, and Anderson 1994, Snell, Gorum, Pierce, Ward 1997).

In 1995 our research effort was directed at detecting the localized influence of individual oil wells on *S. arenicolus* around a well pad (Sias and Snell 1996). We found a mean reduction of 39% in *S. arenicolus* numbers in plots of habitat up to 80 m away from well pads compared to plots of land more than 190 m away from well pads. There was no evidence for these distance reductions in other species of reptiles. The 1995 field studies demonstrated the potential for local reductions around a well and suggested the need to examine oil development on landscape and population scales. In 1996-97 we addressed the question: how does the large scale development of oil fields influence populations of *S. arenicolus* ? We examined the variation in abundance of *S. arenicolus* in relation to well density and habitat features (Sias and Snell 1997). This report contains our final analysis of well density data collected during 1996-97, a discussion integrating the implications of localized well effects and oil field development on *S. arenicolus* population levels and our management recommendations for the species in New Mexico on public lands.

Methods

The experimental design.

Surveys were conducted during seasonal and daily periods of peak *S. arenicolus* activity. In 1996 field work was conducted with 3 observers between 15 May - 2 August and in 1997 with 4 observers between 26 May - 25 June. Surveys consisted of observers 25 m apart walking random direction transects in large patches of Shinnery Oak. Each of these transects was restricted to 25 minutes. For reasons discussed below, some transect directions were non-randomly selected. A second level of randomization existed in our experimental design. Because the observers were spread out up to 100 m and the transect length (linear distance approximately 500 m) we could not select a predictable quality of Shinnery Oak dune (SD) habitat to walk through. The use of random transects allowed us to focus on the relationship between well density and *S. arenicolus* (Sa) without having to adjust for habitat differences or the quality of the habitat. The random samples that these transects represent avoid the pitfalls of directed search techniques, where one searches for lizards, only where one expects to find them.

Pre-transect surveys confirmed the presence of *S. arenicolus* at each site where transects were to be conducted. During the transects we counted all reptiles, reptile sign and measured some habitat variables. Well counts and additional environmental variables were measured before and after each timed transect. We *a priori* planned to look at the abundance of *S. arenicolus* in relation to well counts, well density and habitat variables.

The sites.

Sites were localities of Shinnery Oak habitat throughout the NM range of *S. arenicolus* where 1-6 consecutive transects were conducted in a morning. The locations of these sites are marked on three maps included with this report, the BLM 1:100,000: Hobbs, Tatum and Elida and in Figure 8. We arbitrarily defined a south region as the area south of Hwy. 249 to Hwy. 62/180, a southeast region as the area east of Hwy. 62/180 to the TX NM border, a mid region as the area north of Hwy. 249 to Railroad Mtn. Rd. and a north region as the area north of Railroad Mtn. Rd. In 1996 we had 1 site (5 transects) in the northern region, 1 site (5 transects) in the mid region, 15 sites (56 transects) in the south region and 7 sites (27 transects) in the southeast region. In 1997 we had 7 sites (31 transects) in the south region and 7 sites (36 transects) in the southeast region. Most of the oil fields in Shinnery Oak were concentrated in the southern regions of *S. arenicolus* range.

To balance daily weather effects and seasonal influences we systematically alternated sites between high well density areas and low well density areas. Marginal habitat configurations and small patches of Shinnery Oak were not selected as survey sites.

The transects.

To avoid any localized well effects we started transects (T) in most cases 300 m from any well pad. In some areas of high well density this was not possible and we started transects 100 m from any well pad. Transects were started in the morning activity period of *S. arenicolus* after at least 5 lizards, some of which must have been *S. arenicolus* were sighted around the start area. We conducted transects until the substrate temperature (Ts) exceeded 45° C at the end of a transect. At the end of each transect we walked 50-200 m to a new location to start the next transect.

From a randomized pick of compass directions (JMP shuffle function) we chose transect directions. Another random direction was picked if one transect was going to be too close, or would cross a previous transect. We selected transect directions to avoid going onto private property, to avoid going down highways and to stay within Shinnery Oak habitat. In 1996 we did 5 random transects that ran out of Shinnery Oak (SD) habitat. These transects did not yield any useful information for a well density study since *S. arenicolus* did not use these habitats (in 100% SD habitat mean Sa/T = 6.7 vs. in less than 100% SD habitat mean Sa/T = 0.4; ANOVA on Ln(SaT+2), p = .0001). Subsequently, when necessary, we chose transect direction to keep within Shinnery Oak habitat.

In 1996 we used three observers and in 1997 we used four observers to count reptiles on the transects. In this report each category of reptile count for a transect represents the sum of the observers counts (e.g. 1996 transect one Sa counts are the sum of the 3 observer counts). Reptiles were positively identified using binoculars and in some cases caught. If it was not possible to identify a lizard, it was recorded in the No Identification (No ID) category. Non-identified lizards represent a small part of our overall samples (1996: 121 NoID/1787 total lizards = 6.7%; 1997: 201 NoID/2815 total lizards = 7.1%). Additional information regarding walking surveys and the identification of *S. arenicolus* is found in Sias and Snell (1996) and in Appendix A of this report.

At the beginning of each transect, before we started the 25 min. walk we counted all active wells (and batteries on separate pads) within a 600 m and 300 m radius of the transect start point (total well count within 600 m = WC600, total well count within 300 m = WC300). We took a GPS latitude longitude reading, air temperature 2 inches off the ground (Ta), and substrate temperature (Ts). When the transect started we recorded all reptiles by species or sign (tracks, shed skins, carcasses), sex information for *S. arenicolus* and *Uta stansburiana* and microhabitat features associated with each sighting for *S. arenicolus* (96-97), *Cnemidophorus tigris* (97), *C. sexlineatus* (97), *S. undulatus* (97), *Phrynosoma cornutum* (97) and *Holbrookia maculata* (97). We also recorded all man made objects (e.g. well pads, roads, pipelines = MO) and blowouts that we crossed. Eight and sixteen minutes into the transect we recorded habitat type, percent open sand and dune relief. At the end of the transect we redid well counts, Ts, Ta and GPS readings. Wind speed and percent cloud cover were measured at the beginning of the first transect and the end of the last transect. Grasshopper density (low, medium, high) and Shinnery condition (GF = green full, GS = green sparse, GYDY = gray dry) were estimated for the entire site.

Well distances from a start or stop transect point were estimated with the aid of optical and laser rangefinders. In 1997 all observers estimated dune relief and percent open sand for each transect they walked. Dune relief (DR) was determined by taking the mean of 5 equal spaced point estimations of dune height from the circumference of a 25 m radius circle around the observer. Percent open sand (OS%) was estimated by taking 10 spaced points from the circumference of a 25 m radius circle around the observer and recording if that point was covered by Shinnery Oak or open sand. The number of open sand points equaled the percent open sand. In 1996 dune relief and percent open sand were only estimated by the project leader in a quantitative fashion. Blowouts were categorized for counting into size classes based on their greatest linear length, small blowouts (BS) , less than 7.6 m (25 ft), medium blowouts (BM) between 7.6-24.4 m (25-80 ft), and huge blowouts (BH) greater than 24.4 m (80 ft).

A guide to the reptile abbreviations used in this report is presented below.

Abbreviation	Scientific Name	Species Common Name or Explanation
Us	*Uta stansburiana*	Side Blotched Lizard
Sa	*Sceloporus arenicolus*	Sand Dune Lizard
Ct	*Cnemidophorus tigris*	Western Whiptail
Cs	*Cnemidophorus sexlineatus*	Six Lined Race Runner
No ID		No identification of the Lizard species
Hm	*Holbrookia maculata*	Lesser Earless Lizard
Su	*Sceloporus undulatus*	Fence Lizard
Pc	*Phrynosoma cornutum*	Texas Horned Lizard
Mf	*Masticophis flagellum*	Coachwhip
To	*Terrapene ornata*	Western Box Turtle
ToT		Total Turtle tracks, all species (Box and possibly Mud turtles)
Eo	*Eumeces obsoletus*	Great Plains Skink

We also used abbreviations in the analysis as follows: the total number of *S. arenicolus* per transect (SaT) and the total number of *S. arenicolus* per transect adjusted for the number of observers (SaT.A).

Data Analysis

The 1996 data comprises 261 (3 observers x 87) individual person transects for a total of 87 site transects. The 1997 data includes 268 (4 observers x 67) individual person transects for a total of 67 site transects. Additional transects that we completed were excluded from the analysis because they included non Shinnery Oak habitat or weather problems interfered with lizard activity. We used mean values of well counts and mean values of environmental variables to relate these factors to the number of *S. arenicolus* per transect. Means were calculated by averaging site (wind, cloud cover) or transect (WC600, WC300, Ts, Ta) start and stop measurements. Dune relief and percent open sand were averaged using the eight and sixteen minute transect measurements. Well counts were converted to well densities (WD) expressed as the number of wells / (3.1415927 x radius^2 x conversion factors) to get wells/km^2 and wells/mi^2. Field well counts converted to wells/mi^2 were verified with aerial photos. The WC600 counts produced densities that matched that of the photos. The WC300 counts considerably overestimated actual well densities, therefore with one exception, the WD300 values were not used. The WC300 counts were only used in one analysis to isolate and measure the effect of distant wells on *S. arenicolus.* In general we analyzed the data by year. For analyses that used combined 1996-97 data we adjusted the number of *S. arenicolus* per transect by dividing by the number of observers that year (1996: SaT/3 and 1997: SaT/4). Unless otherwise specified well densities are reported as the number of wells per square mile, which is the same as the number of wells per section. This makes the analysis consistent with current well management accounting and mapping.

The variables cloud cover, Ts, Ta and wind speed were measured as potential covariates to allow adjustments to *S. arenicolus* counts. However the experimental design was effective in keeping these weather influences at a minimal level. We found no indication of correlations between these variables and the number of *S. arenicolus.* Habitat type measurements and conversions into percent Shinnery Oak habitat per transect were used to exclude any transects that contained non Shinnery Oak habitat from the analysis. Tables 3-6 present transect data that was used in the analyses of this report, after we excluded transects for habitat or weather reasons (1996: no. 4, 18, 32, 33, 56, 77 transects excluded, 1997: no. 13, 27 transects excluded). In Table 3 the number of huge blowouts BH (unadjusted) is the total number of blowouts walked through by each observer. However to obtain the actual number of huge blowouts, BH must be divided by two since typically a huge blowout was walked through by two observers.

Data analysis was done with Statview 4.5, Abacas Concepts, Inc., 1984 Bonita Ave., Berkeley, CA 94704; JMP 3.1, SAS Institute Inc., SAS Campus Drive, Cary, NC 27513; and DataDesk 5.0, Data Description Inc., P. O. Box 4555, Ithaca, NY 14852.

Results

The relationship of well density and Sand Dune Lizard populations.

Tables 1 and 2 show the locations of the transects in 1996 and 1997. Tables 3 and 4 show the well counts, well densities and environmental variables of the transects in 1996 and 1997. Tables 5 and 6 show the reptile counts of the transects in 1996 and 1997. In 1996 for 87 transects we recorded 2043 total reptile sightings, 1739 were lizards as follows: 784 *Uta stansburiana*, 584 *S. arenicolus* and 134 *Cnemidophorus tigris*. In 1997 for 67 transects we recorded 3103 total reptile sightings, 2815 were lizards as follows: 1342 *U. stansburiana*, 814 *S. arenicolus* and 258 *C. tigris*. We also recorded lesser numbers of other species. Given that we always started a transect where *S. arenicolus* were present, overall *S. arenicolus* was the second most abundant lizard in Shinnery Oak dunes habitat. We also found *S. arenicolus* throughout oil fields at all well densities.

Figure 1 shows *S. arenicolus* transect counts in relation to well density (w/mi^2) for 1996, 1997 and the years combined, where *S. arenicolus* counts are adjusted for the number of observers. It was evident that as well density increases variation in *S. arenicolus* counts decreases. The values of the maximum range of *S. arenicolus* per transect declined with increased well density. The variation in *S. arenicolus* counts at any given well density was a function of the random sampling. Also the transects ran through a variety of habitat configurations of different suitability for *S. arenicolus* so we expect a range of values at each well density. The 11 points that make up the "outside edge" of the 1996-7 combined years graph represent *S. arenicolus* population indices under the highest quality natural habitat conditions. For instance these 11 edge points, have mean open sand of 45.1% vs. 25.9% for all the points below this edge (Mann Whitney test, $p < .0001$). The 11 edge points have mean dune relief of 4.91 m vs. 3.57 m for all the points below this edge (Mann Whitney test, $p = .0535$). That the outside points represent an edge, was clearly demonstrated by a regression of the 11 points, which explains 95 % of the variation ($Ln(SaT.A+2) = 2.477 - .032(WD)$, $R^2 = 95.1\%$, $p < .0001$). This edge is made up equally of 1996 (5) and 1997 (6) points.

Figure 2 presents the regression of Log (Lg) and Natural Log (Ln) transformed *S. arenicolus* data on well density. In both 1996 and 1997 we found a negative relationship between well density (WD) and *S. arenicolus* abundance (1996 regression: Ln(SaT+2) = 2.107 -.016(WD), R^2 = 5.5%, p = .0281; 1997 regression: Lg(SaT+10) = 1.378 - .005(WD), R^2 = 9.8%, p = .0111; combined years, Ln(SaT.A+2) = 1.546 -.012(WD), R^2 = 6.3%, p = .0018). The slopes of these regressions express the rate of decline in *S. arenicolus* abundance as well density increases. This was the central focus of this research and a critical factor in the species management. The 1996 and 1997 rates of decline are not statistically different (ANCOVA, year p = .0001, WD p = .0125, year*WD, p = .2088). A considerable portion of the unexplained variation in *S. arenicolus* abundance in these regressions was due to the random transects running through a wide range of different quality habitat for *S. arenicolus*. We demonstrate this in a following section using multiple regression to predict *S. arenicolus* abundance. Here we took into account habitat factors as well as well density to explain *S. arenicolus* abundance.

As shown in Figure 3, the slopes of these regressions allowed us to predict the percent decline in *S. arenicolus* abundance as a function of increases in well density. To illustrate predicted declines of *S. arenicolus* we used the 1997 regression since it explains more of the variation in *S. arenicolus* and it is based on four observer transects. However we also show in Figure 3 the calculated percent reductions from the 1996 regressions. The maximum counts of wells recorded in 1997 were WC600 = 14 (WD = 32.07 w/mi^2) and in 1996 WC600 = 15 (WD = 34.36 w/mi^2). These areas represent the most intensely developed Shinnery Oak habitat in southeast NM. We found this level of development only in the south regions of *S. arenicolus* habitat. The predicted decline in *S. arenicolus* at WD = 34.36 w/mi^2 (WC600 =15) is 56.21%. The predicted decline in *S. arenicolus* at WD = 32.07 w/mi^2 (WC600 = 14) is 53.12%. Since these were the maximum ranges of well densities surveyed, we do not have field data for what happens to *S. arenicolus* populations at higher well densities. If we had found areas of higher well density we would have also surveyed these sites. We know of no areas of higher well density that occur in occupied Shinnery Oak habitat. Reductions of 50% are predicted in *S. arenicolus* populations at well densities of 29.82 w/mi^2 (WC600 = 13.02). Reductions of 25 % are predicted in *S. arenicolus* populations at well densities of 13.64 w/mi^2 (WC600 = 5.95). Extrapolating beyond the range of field data a 75% decline occurs a WD = 49.73 w/mi^2 and a 100% decline occurs at WD = 75.59 w/mi^2.

We note the regression expressions of this negative relation and predicted declines should be used with caution because the structure of the data suggests non-constant variance, a violation of regression assumptions. However using an alternative analysis we still found highly significant negative relations between well density and *S. arenicolus* abundance (Spearman correlation between well density and Sa, 1997: r = -.315, p = .0016 and 1996: r = -.302, p = .0052). The consistency between 1996 and 1997 predicted reductions shown in Figure 3, in spite of the fact that each year is based on a different geographic combination of transects and number of observers, provides replication that validates the predicted percent declines.

In order to see how far oil field effects might extend and influence *S. arenicolus*, we excluded all transects that had a WC300 >.5 (the mean of a start WC300 = 0 and an end WC300 = 1), which left in the analysis only transects with distant wells, located 300+ to 600 m away from the actual transect (1996 n = 37, 1997 n = 31). These survey areas can be thought of as a oblong donut shaped area with no wells in the donut hole. These distant well transects also showed diminished *S. arenicolus* abundance with increased well density (1996: Ln(SaT+2) = 2.502 - .185(WD), R^2 = 26.8%, p = .0010; 1997: Lg(SaT+10) = 1.393 - .017(WD), R^2 = 5.0%, p = .2257; combined years: Ln(SaT.A+2) = 1.706 -.069(WD), R^2 = 10.4%, p = .0074). Because of sample size reductions these regressions are not comparable to the overall well density relationships. It is evident that oil wells 300+ m away from lizards are associated with effects on *S. arenicolus* in some unexplained fashion.

We examined the sex ratio (SR) of *S. arenicolus*, defined as males minus females in relation to well density as shown in Figure 4. We found no trend between sex ratios and well density in *S. arenicolus* (1997: SR = .929 + .007(WD), R^2= .001, p = .8235 and 1996: SR = .086 - .032(WD), R^2= .026, p = .1391). We conclude that there was no differential reduction of male and female *S. arenicolus* associated with increased well density.

A supplemental way to view the relationship between well density and *S. arenicolus* abundance was compare areas with wells present (WC600 > 0) with areas with wells absent (WC600 = 0). More *S. arenicolus* occurred in well absent areas than in well present areas. In 1996 transects of well absence (n = 29) had mean *S. arenicolus* counts = 10.3 compared to transects of well presence (n = 58) with mean *S. arenicolus* counts = 4.9 (ANOVA on Ln(SaT+2), p = .0002). In 1997 transects of well absence (n = 12) had mean *S. arenicolus* counts = 16.6 compared to transects of well presence (n = 53) with mean *S. arenicolus* counts = 11.6 (Mann Whitney, p = .0350). Combining years and adjusting for the different number of observers per year, transects of well absence (n = 41) had mean *S. arenicolus* counts per observer = 3.7 compared to transects of well presence (n = 111) with mean *S. arenicolus* per observer = 2.2 (ANOVA on Ln(SaT.A +2), p = .0003). These differences in *S. arenicolus* abundance between well absent and present areas represent differentials in 1996 of 52%, in 1997 of 31.0% and for the combined years 39 %.

Habitat aspects of oil field development.

In Shinnery Oak habitat, the types of habitat features utilized by *S. arenicolus* do not change comparing well absent vs. well present areas. In 1996 there was no difference in proportional habitat utilization of 11 habitat features comparing well present and absent areas (Chi Square = 13.6035, df = 10, p < .1937). In 1997, comparing proportional usage of 13 habitat features, there was also no difference between well present and well absent areas (Chi Square = 14.3669, df =12 p < .2766). Although there is an overall decline in *S. arenicolus* abundance, it is not associated with any shifts in habitat utilization.

Figure 5 for 1996 and Figure 6 for 1997 show where we found *S. arenicolus* in Shinnery Oak habitat. In 1996, 77.62% of *S. arenicolus* were found in blowouts, only .54% were found in Shinnery between blowouts In 1997, 81.17% of *S. arenicolus* were found in blowouts, 1.59% were found in Shinnery in the immediate proximity of blowouts and 0% were found in Shinnery 50 m or further from blowouts. In contrast Shinnery between blowouts constituted the largest proportion of the habitat. There was a strong tendency for *S. arenicolus* to be associated with larger blowouts (total Sa sightings in 1996: BH = 40.9%, BM = 27.27%, BS = 9.45% and 1997: BH = 43.52%, BM = 34.23%, BS = 3.42%). In 1996, of the *S. arenicolus* sighted in blowouts, 52.69% occurred in large blowouts (BH) but these comprised only 14.53% of all blowouts on the transects and 12.17% of sightings occurred in small blowouts (BS) which comprised 49.94% of all blowouts (Chi Square = 128.7519, df = 2, $p < .0001$). Habitat selection was oriented around the microhabitat of large blowouts. Blowout destruction and alteration of blowout environments are likely proximate factors associated with overall declines of *S. arenicolus* in oil fields.

In both years the balance of *S. arenicolus* were found in other open sand habitats. These were primarily pipeline cuts and sand roads, where in 1996, 15.82% and 1997, 12.59% of *S. arenicolus* were found in these areas. There was no correlation between well density and the number of *S. arenicolus* found in pipeline cuts (1996: Spearman r = .099, p = .3661 and 1997: Spearman r = .077, p = .2156). Although many pipeline cuts are a result of oil field development, the pipeline cuts run throughout well present and absent areas. There was no difference in the proportion of transects containing pipeline cuts comparing transects in well present and absent areas. In 1996, 28% of the transects in well absent areas had pipeline cuts and 30% of the transects in well present areas had pipeline cuts (Chi Square = .4171, df = 1, $p < .5153$). In 1997, 19% of the transects in well absent areas had pipeline cuts and 14% of the transects in well present areas had pipeline cuts (Chi Square = .649, df = 1, p = .4205). Transects with pipeline cuts had more *S. arenicolus* than transects without pipeline cuts. In 1996 the mean number of *S. arenicolus* on transects without a pipeline cut was 6.1 vs. 7.6 on transects with pipeline cuts (Mann Whitney test, p = .0173). The data was recorded so that a 1996 transect with a pipeline cut meant that one or more observers encountered a pipeline cut. However in 1997 we recorded pipeline cuts at the individual observer level and this allowed a more precise analysis of the association between pipelines and *S. arenicolus*. In 1997 the mean number of *S. arenicolus* per observer on transects without a pipeline cut was 2.85 vs. a mean of 4.74 on transects with pipeline cuts (Mann Whitney test, p < .0001). Pipeline cuts were used equally by *S. arenicolus* in both developed and undeveloped habitat. There was no difference in the mean number of *S. arenicolus* in pipeline cuts comparing well present and absent areas (Mann Whitney test, 1996, p = .9545 and 1997, p = .4502). This is consistent with the idea that pipeline cuts represent new habitat in the form of artificial blowouts that are colonized by *S. arenicolus*. We would expect fewer *S. arenicolus* in pipeline cuts in low density well areas if they were not a preferred habitat. However this was not the case.

Transects containing sand roads had more *S. arenicolus* than transects without sand roads. In 1996 the mean number of *S. arenicolus* per transect on transects containing sand roads was 10.9 vs. 6.1 on transects with no sand roads (Mann Whitney test, p = .0612). The data was recorded so that a 1996 transect with a sand road meant that one or more observers encountered a sand road. However in 1997 we recorded sand roads at the individual observer level and this allowed a more precise analysis of the association between sand roads and *S. arenicolus*. In 1997 the mean number of *S. arenicolus* per observer on transects containing sand roads was 5.8 vs. 2.9 on transects without sand roads (Mann Whitney test, p = .0005). These patterns are consistent with sand roads simulating blowout habitat and serving as preferred habitat for *S. arenicolus*

Sand roads were not as frequent in developed (well present) areas (1996: Chi Square = 17.4376, df = 1, p < .00003; 1997: Chi Square = 9.777, df = 1, p = .0018).

Existing sand roads may fall out of use or be replaced by caliche roads concurrent with oil field development. Caliche roads are not a habitat resource for *S. arenicolus* and represent a source of mortality (1996, 0% and 1997, 0.37% of *S. arenicolus* were found on caliche roads). Caliche well pads and the disturbed areas around them receive minimal *S. arenicolus* usage (1996: 0% on caliche pads, 0.18% in pad disturbed areas and 1997: 0% on pads and 0.86% in pad disturbed areas).

Predicting the abundance of *S. arenicolus* based on habitat qualities is an important management tool. Three abiotic habitat factors: well density, percent open sand and the number of blowouts explain 1/3 of the variation in *S. arenicolus* abundance within Shinnery Oak habitat (multiple regression 1997 data: Ln[SaT+2] = 1.49 + 4.67e-3[open sand] - .070[Ln(WD600+2)] - 4.32e-3[#blowouts], R^2 = 36.4%, adjusted R^2 = 33.2%). These factors are easily estimated using aerial photos, maps and landscape inspection. If a biotic factor, the number of *Uta stansburiana* is added to this model, 50% of the variation in *S. arenicolus* is explained by these factors (multiple regression 1997 data: Lg[SaT+10] = 1.58 + 5.49e-3[open sand] - .082[Ln(WD600+2)] - 6.26e-3[Us] - 3.03[#blowouts], R^2 = 53.6%, adjusted R^2 = 50.5%). The variable dune relief was substituted for open sand with similar results. Open sand and dune relief variables were highly correlated (Pearson r = .81, p < .0001) and they explained the same variation in *S. arenicolus*. For a variety of management applications the variable open sand is more easily measured. The implication of this multiple regression perspective was that well density exerts a negative influence on population levels of *S. arenicolus* that was not accounted for by the other significant biotic and abiotic factors we measured. These multiple regression results suggest the framework for an exploratory model of *S. arenicolus* abundance as shown in Figure 7. We present this model in the discussion section of this report. Similar results were obtained using 1996 data, we report the 1997 data here since we used improved estimation techniques to measure open sand and dune relief in 1997. We report additional details of *S. arenicolus* abundance and habitat in Sias et al. (*in prep.*)

Other sympatric reptile species and well density.

To provide additional information for a model of *S. arenicolus* abundance, we contrasted the habitat specialist, *S. arenicolus*, the second most abundant lizard in the Shinnery Oak habitat with the most abundant lizard, *Uta stansburiana*, a habitat generalist (Degenhardt et al. 1996, Stebbins 1985). Both species are sit and wait foragers on insects and the potential for competition exists between these species. During the 1994-97 field seasons we have observed individual *S. arenicolus* and *U. stansburiana* scrambling for the same insect prey (interference competition). We have also observed feeding on the same species of insects and use of the same microhabitats in blowouts (exploitive competition). Abundance of *S. arenicolus* was negatively related to *U. stansburiana* abundance (1996: Spearman r = -.330, p = .0022 and 1997: r = -346, p = .0056). *Sceloporus arenicolus* populations were negatively related to well density while *U. stansburiana* populations had different relations to well density by year (1996: Us and WD600, Spearman r = .302, p = .0051 and 1997: Us and WD600, Spearman r = -.286 p = .0222). Based on the combined years *U. stansburiana* populations had no relation to well density (Spearman r = .110, p = .1764). The habitat variables of percent open sand and dune relief were positively related to *S. arenicolus* abundance (1996: Sa vs. open sand, Spearman r = .201, p = .0621 and Sa vs. dune relief, r = .299, p = .0056 and in 1997: Sa vs. open sand, Spearman r = .385, p = .0002 and Sa vs. dune relief, r = .270, p = .0305). However these same two aspects of habitat had no relation to *U. stansburiana* abundance (1996: Us vs. open sand, Spearman r = .134, p = .2146 and Us vs. dune relief, r = .011, p = .9167 and in 1997: Us vs. open sand, Spearman r = .022, p = .8602 and Us vs. dune relief, r = .028, p = .8247). *Sceloporus arenicolus* had a slight negative correlation with a catch all habitat category, the number of "man objects" (MO) which included all man constructed items we encountered on the transects (1996-7 combined data, Spearman r = -.185, p = .0278). *Uta stansburiana* had no relationship with the number of man objects (1996-7 combined data, Spearman r = .081, p = .3368). These relationships suggest there may be direct and indirect interactions between *S. arenicolus* and *U. stansburiana* mediated through well density, with population consequences for both species. The environmental sensitivity of *S. arenicolus* is in sharp contrast to *U. stansburiana.*

We found little evidence for strong negative relationships between other species of reptiles and well density in contrast to the significant negative relationship between well density and *S. arenicolus* . Abundance of *Cnemidophorus tigris* was positively associated with well density (1996: Spearman r = .296, p = .0061; 1997: r = .210, p = .0929; combined years: r = .282, p = .0005). Population levels of *C. sexlineatus* had insignificant positive associations with well density (1996: Spearman r = .211, p = .0498; 1997: r = .027, p = .8292; combined years: r = .149, p = .0676). Abundance of *Holbrookia maculata* exhibited insignificant negative trends with well density (1996: Spearman r = -.017, p = .8720; 1997: r = -.143, p = .2514; combined years: r = -.018, p = .8259). Abundance of *Sceloporus undulatus* showed no relationship with well density (1996: Spearman r = .007, p = .9464; 1997: r = .088, p = .4826; combined years: r = .011, p = .8968). Snakes exhibited a negative but insignificant association with well density (1996: Spearman r = -.196, p = .0685; 1997: r = -.022, p = .8618; combined years: r = -.143, p = .1822). Abundance of total turtles showed insignificant negative trends with well density (1996: Spearman r = -.133, p = .2181; 1997: r = -.150, p = .2307; combined years: r = -.109, p = .1822). All of these species are geographically widespread generalists in contrast to *S. arenicolus.* We conclude that these contrasts illustrated a degree of environmental sensitivity found in *S. arenicolus* but not found in other reptile species we examined.

Discussion

We show a model of factors that determine abundance of *S. arenicolus* in Figure 7. This model summarizes the analysis of 1996-97 data. Population levels of *S. arenicolus* are negatively related to well density. Habitat quality as measured by percent open sand, dune relief and the number of large blowouts are positively related to *S. arenicolus* and but have no relationship to *U. stansburiana*. Populations of *U. stansburiana* have a negative association with *S. arenicolus* which is consistent with a competitive relationship. *U. stansburiana* has variable associations with well density, depending on the year. This situation illustrates that oil field development may have both direct and indirect effects on *S. arenicolus* (indirect effects e.g. oil fields influencing *U. stansburiana* populations which, in turn interact with *S. arenicolus*). Pipelines and sand roads are an adjunct development of oil fields and provide preferred open sand and artificial blowout habitats. Pipeline cuts may serve as dispersal corridors through extensive Shinnery flat areas for *S. arenicolus* to reach blowout complexes. We relate an anecdotal example, after our random transects were completed for a day, we did a 25 min. walk (Ts = 48.5° C) through a pipeline cut across a Shinnery flat containing no blowouts. The two observers outside the cut saw zero *S. arenicolus* and the two observers inside the cut saw five *S. arenicolus* despite the high Ts. Dispersal issues are a high priority for future study because of the potential for intense oil field development to fragment *S. arenicolus* habitat.

The 1996 sample appeared to have a different structure than the 1997 sample. We therefore evaluated alternative ways to express the negative relation that provided additional insight into the species biology. The 1997 relationship between well density and *S. arenicolus* abundance was best expressed as a linear relation, which generated gradual and constant reductions in *S. arenicolus* associated with increased well density. In 1996 data we could explain two to three times the variation in *S. arenicolus*, and eliminate concern about non constant variance if we used nonlinear and curvilinear functions to fit the data. A function of well presence or well absence (Ln(SaT+2) = well(P or A), R^2 = 14.9%, p = .0002) or the curvilinear function (Ln(SaT+2) = 2.361 - .207[Ln(WD600+2)], R^2 = 11.1%, p = .0017) were the two alternatives. The predicted *S. arenicolus* reductions as well density increases are shown for the Ln(y) = Ln(x) function in Figure 3. The use of the non linear Ln(y) = Ln(x) function generates very large predicted declines in *S. arenicolus* when only a few wells are put into a section (WC600 = 1 or WD = 2.29 w/mi^2, cumulative Sa reduction 18.68%, WC600 =2 or WD = 4.58 w/mi^2, cumulative Sa reduction 27.93%, WC600 = 3 or WD = 6.87 w/mi^2, cumulative Sa reduction 33.92%). Increases in well density beyond these generate proportionately smaller and smaller reductions. The consequence is that the greatest reductions in *S. arenicolus* occur when a only a few wells are put in a section and subsequent increases in the number of wells in an area have very limited effects. We do not have field information at this stage to formulate and test a biological explanation for this phenomenon. A primary reason we conducted this research for two years was to verify the nature of the association between well density and *S. arenicolus* abundance. Given only two years of data we question whether a nonlinear fit to the 1996 data has a biological or nonbiological explanation. In 1997 and using combined years data we found substantially better evidence for a linear relation between well density and *S. arenicolus* abundance. For these reasons we recommend using linear regressions of well density and *S. arenicolus* as a basis for considering the impact of oil development on *S. arenicolus* populations. This implies that oil development has gradual, progressive reductions on populations of *S. arenicolus.*

The negative relationship of *S. arenicolus* and well density appears to be an overall decline of populations around oil fields. We found no relationship of sex ratio to well density. There was no difference in habitat utilization comparing *S. arenicolus* usage of habitat features in undeveloped areas (well absent) vs. oil fields (well present). *Sceloporus arenicolus* were found throughout oil fields, but overall, *S. arenicolus* population levels were 31% - 52% lower in oil field areas compared to undeveloped areas. In the areas where we found the most wells (WC600 = 15, WD = 34.36 w/mi^2) the regressions predict 56% declines in *S. arenicolus* population levels (1997, 56.21%, 1996, 55.89%). This currently represents the maximum impact oil field development has on *S. arenicolus* populations. However at a species level there are consequences that increase the probability of metapopulation and range fragmentation.

The oil field effect is a complex phenomenon. We demonstrated long range oil field effects by measuring areas with no close wells, but only areas with wells 300 - 600 m away from lizards. There was evidence for a negative, albeit diminished effect. The individual oil well study (Sias and Snell 1995) described a caliche pad effect (habitat destruction) and a distance effect extending up to 80 meters from the pad. The combined effect of a single well was a 47% reduction of *S. arenicolus* in an area extending 253 m around the well representing 50152 m^2 (pad effect over 6750 m^2 = 100% reduction and the distance effect over 43402 m^2 = 39% reduction). When multiple wells were considered in the form of well density measurements it was evident from the significant negative regressions of *S. arenicolus* on to well density that a cumulative effect has occurred. What was noteworthy in high well density sites, was that oil field effects were not more pronounced over the large scales (mean 500 m transects) that we measured in 1996-97.

Well development reductions in *S. arenicolus* populations may be greater in high quality habitats that support the highest populations of *S. arenicolus*. This is seen in the triangular spread of points in the Figure 1 graph showing the combined year data. We showed that the points on the outer edge represent the *S. arenicolus* counts in the best habitat. A regression of these 11 points produces greater percent declines with increased well density than the combined 1996-97 regression (slope of edge points = -.032 vs. slope of the combined years regression = -.012).

There was no evidence that that other species of reptiles experience significant declines in oil fields on the same order of magnitude as *S. arenicolus. Uta stansburiana* had both positive and negative associations with well density. *Cnemidophorus tigris* had positive associations with well density. Other lizard species exhibited statistically insignificant trends. Snakes and box turtle populations probably have negative associations with oil fields. Because this was a study that focused on diurnal lizards we do not have sufficient data to demonstrate significant negative relations between well density and snakes or box turtles. However the road kill factor for both snakes and box turtles is quite evident in oil fields and is lacking in adjacent pasture land. Additionally for 1996 the number of snake sightings and tracks was 144 but we surveyed for lizards in 1997 during a period of relative snake inactivity, since we only recorded only 56 sightings. We have also found clusters of dead *Terrapene ornata* in oil fields in the Monument Valley area WNW of Eunice where we surmise that an occasional toxic gas emission killed the turtles.

The contrast between other reptile species and *S. arenicolus* when viewing well density relationships leads us to conclude that *S. arenicolus* is much more sensitive to environmental alterations than other sympatric reptiles. This is consistent with *S. arenicolus* being a habitat specialist and the other species being habitat generalists. It is also consistent with *S. arenicolus* occupying a very small geographic range spanning a narrow set of environmental conditions and the other sympatric species occupying huge geographic ranges spanning a wide set of environmental conditions.

The predicted declines shown in Figure 3 are useful for anticipating the effects of oil development in undeveloped areas, for estimating population levels and for locating favorable or threatened locations. We can predict a mean 50% reduction in *S. arenicolus* populations at well densities equal to or less than 29.82 w/mi^2 based on 1997 data (29.71 w/mi^2 with 1996 linear fit and 19.97 w/mi^2 with 1996 Ln/Ln curve fit). Although we expect substantial variation in the field from these predictions (1997, R^2 = 9.8%), this is certainly a level of population reduction where concern for the species is merited. We discuss these highly developed regions to illustrate some of the ways oil development impacts *S. arenicolus* at the species level.

We found intensely developed oil fields with well densities greater than or equal to 25 w/mi^2 (range 25.19 - 34.36) occurring in Shinnery Oak habitat in four regions indicated in Figure 8 and on the BLM maps as DEV, CON.N, EUN and MON. The DEV region is 6 mi W and 1 mi N of Maljamar. The CON.N region is SW of Maljamar and is N of Hwy. 529, S of Hwy. 82 and W of Lea Co. Rd 33. The EUN region is N of Eunice and Monument Draw on both sides of Hwy. 18 and runs into Texas. The MON region is 5 mi S and 3 mi W of Monument. These regions are so densely developed that increases in the number of wells will undoubtedly reduce *S. arenicolus* populations over large areas to a marginal state, if for no other reason than such a high percentage of habitat would be destroyed and covered with caliche. In all of these well dense regions *S. arenicolus* were still easy to find and abundant in the years we visited these sites (1994-97). In some form, these oil fields have existed for several decades. We are therefore left with the impression that, at least in the short term, these populations of lizards are tolerating oil field development, albeit at a reduced level. In the long term, extensive oil field development, residual toxic contamination, reduced habitat size and population levels increase the risk of local extinction in these areas compared to undeveloped areas.

With additional development, there exists the potential for MON region oil fields to interact with the location of Shinnery Oak habitat to fragment the *S. arenicolus* population. In this area (T20S, R36E, secs. 24, 23, 22, 21) and further west the habitat for *S. arenicolus* is less than a mile wide. It is conceivable that some type of oil related project may destroy a large enough section of this narrow band of Shinnery dunes to create a barrier to *S. arenicolus* movement and gene flow. The DEV oil fields contain substantial populations of *S. arenicolus* and the highest quality habitat remaining for *S. arenicolus* in the area. Surrounding this region, except for the south are extensive Tebuthiron treated areas were *S. arenicolus* marginally exists. Unrestricted future development in the DEV region would destroy a source population with the potential to recolonize Tebuthiron treated areas to the north and west.

The CON.N oil fields occupy the entire width of *S. arenicolus* range SW of Maljamar. The mean number of *S. arenicolus* per person (1.264) on transects (n = 23) in this high well density (mean WD = 19.4 w/mi^2) region was 43% lower the mean (2.225) on transects (n = 27) in the adjacent low well density (mean WD = 2.5 w/mi^2) CON.S region. These regions occupy the same set of Shinnery Oak dunes. The maximum number of *S. arenicolus* per person per transect in the CON.N region (2.667) was 55% lower than the maximum (6.0) in the CON.S region. Although *S. arenicolus* is still abundant in CON.N, unrestricted future development will further reduce populations locally and on a larger scale it will sever the habitat corridor between southern *S. arenicolus* and populations north of Hwy. 82.

The EUN region contains highly developed oil fields west of Hwy. 18 and low density oil development east of Hwy. 18 to the Texas border. The Shinnery Oak habitat is narrow in this region. East of Hwy. 18, the primary dune system of *S. arenicolus* habitat is less than a mile wide, with more marginal dune systems extending the habitat width to approximately 3 miles. Future disruptions in this restricted habitat can sever the TX - NM habitat corridor of *S. arenicolus* populations and increase the risk of local extinction. Just west of Hwy. 18 oil fields run across Shinnery Oak habitat fragmented by Tebuthiron treated tracts. *Sceloporus arenicolus* persists only in the Shinnery Oak oil fields.

The 1995-97 studies were correlative studies designed to detect patterns of variation in *S. arenicolus* abundance with oil development. We did not study the mechanisms of *S. arenicolus* declines associated with oil and gas wells. However we are certain of some of the factors related to population declines and we present some of the hypotheses regarding other factors. Construction of wells and roads reduces the amount of habitat. Reductions in habitat reduce the viability of populations. A primary implication of these studies is that individual well and oil field effects also reduce the density of *S. arenicolus* <u>on the remaining habitat</u>. We know that pollution and road kill are two mortality factors associated with oil development. However we do not know the magnitude of the increased mortality that occurs. We have seen all species of reptiles dead on roads. Around wells and batteries that emit gases, we saw sick and dead animals. We have also seen many *S. arenicolus* and other animals around presumably "clean" installations. We saw a 140 m diameter dead spot centered on a leak in an underground gas pipeline on the NM / TX border. We have come across gas hissing out of pipelines in the bottom of blowouts. Around some oil wells we have encountered oil spills that entangle lizards with tar and oil. At a battery emitting H_2S in the CON.N region we ran across sick Great Horned Owls and in the surrounding huge blowouts, prime habitat for *S.*

arenicolus, an absence of lizards. We do not know if *S. arenicolus* are differentially susceptible to road kill and pollution.

Several additional mechanisms have been advanced as hypotheses. Oil field development may competitively favor *Uta* at the expense of *S. arenicolus*. Wells might alter the susceptibility of *S. arenicolus* to predation, especially by birds. Pollution from oil fields may lower the fecundity of *S. arenicolus* either by direct effects on the eggs and adult longevity, or indirect effects on the productivity of *S. arenicolus* prey populations. *Sceloporus arenicolus* are strongly associated with blowouts, and to the extent they use the bottoms of these blowouts proportionately more than other species, at some point in their life cycle (foraging, hibernation, nocturnal retreats ?) they may be more susceptible to gas poisoning since H_2S is heavier than air. In 1997 we found 93.77% of *S. arenicolus* on the transects in blowouts, pipeline cuts or sand roads. *Cnemidophorus tigris* was the species with the next highest proportion with 66.67% of the sightings in these blowout type microhabitats. Oil development may alter the habitat cues that *S. arenicolus* use to select Shinnery dune locations. If so, dispersal of juveniles and hatchlings may be altered in ways that increases their mortality.

Management Recommendations

The evidence in these studies suggests that moderate density oil development does not present an imminent threat to *S. arenicolus* populations, although there are localized and spatially widespread reductions. At a higher level of well density where we predict 50% declines in *S. arenicolus* populations we suggest that serious consideration be given to measures that may reduce oil field impacts on *S. arenicolus*. Although at present regions of well density greater than 25 w/mi^2 support substantial populations of *S. arenicolus*, it is likely that these populations have a considerably lower probability of persistence and viability over time compared to populations in less developed areas. To our knowledge most, if not all of these high well density areas exist in the southern part of *S. arenicolus* range (S of Hwy. 249 to Loco Hills and east to TX border north of Eunice).

To reduce the effect of individual wells we suggest three courses of action. In many areas of Shinnery Oak, large blowouts occur in clusters separated by dense Shinnery flats. In these areas less habitat damage is caused by locating caliche pads in the Shinnery flats adjacent to blowouts. In marginal habitats this can mean the difference between the continued presence or absence of *S. arenicolus*. Pad size should be kept as small as possible to avoid additional habitat destruction. Enhanced well and battery pollution control measures should be considered in designated high well density areas where the cumulative effect of many small sources may amount to a mortality source of some magnitude.

To preserve the viability of *S. arenicolus* populations in high well density areas there must be some future limits imposed on the number of wells. This is the preferable course of action in the narrowest portions of *S. arenicolus* range because it avoids habitat and population fragmentation. The geographic range maps (Fitzgerald et al. 1997) and our field work indicate that the *S. arenicolus* range is still almost certainly continuous from the TX border west to Maljamar and north. We would not recommend any large scale developments such as refineries be placed in the narrow portions of *S. arenicolus* range. Other than roads, there was no indication that current levels of oil development have created any movement barriers or large patches of completely unusable habitat. The large size of the oil fields and the type of surrounding habitat in the regions CON.N, DEV, EUN and MON suggest that the *S. arenicolus* populations in these areas are not sink populations maintained by dispersal of *S. arenicolus* from surrounding less developed areas. Although we have limited data on dispersal, it is unlikely that lizards in these oil fields have dispersed several miles from less developed areas to inhabit these oil fields. The recapture data from Tebuthiron studies (Snell et al. 1997) indicates that adult and juvenile *S. arenicolus* have a very high site fidelity. The implication is that these densely developed oil fields still support successfully reproducing populations, albeit at a reduced level. The large blocks of Tebuthiron treated land in these narrow portions present a much more serious and immediate concern (e.g. N and S of Hwy. 62/180 as it crosses the Querecho Plains).

Because the overall range of *S. arenicolus* is so small we do not recommend patterns of oil and gas field development that create large holes of unsuitable habitat in occupied Shinnery dune habitat. Large scale reductions in this species habitat will unquestionably lower the probability of continued survival for this species. At the scale of a square mile (section) or greater we do not recommend future oil development patterns that sacrifice some areas and "preserve" other areas of Shinnery Oak. Note that at the smaller scale of individual wells (approximately a quarter / quarter section) where we refer to blowout clusters in Shinnery flats we recommend that wells should be placed in dense Shinnery and flats if possible and not in the blowouts.

Because oil field development is so pervasive throughout the southern region of *S. arenicolus* range we recommend that future development in this area be carefully monitored. We have already designated four areas of concern and remaining high well density areas should be identified from BLM leasing maps.

South of CON.N and Hwy. 529 and centered on the Eddy - Lea Co. line is our region CON.S (Eddy Co.: T17S, R31E, secs. 36, 35; T18S, R31E, secs.1, 2 and north portions of secs. 11, 12; and Lea Co: T17S, R32E, secs. 31, 32 south of Hwy. 529; T18S, R32E, secs. 6, west portion of 5, north portion of 7). This area contains Shinnery Oak habitat harboring one of the highest density and largest *S. arenicolus* populations in the Loco Hills to Eunice area. High priority should be given to conserving (as distinct from preserving) the habitat and spatial attributes of this core area, because this area is already surrounded by high well density oil fields that together span the entire width of *S. arenicolus* habitat in this region. Therefore the region CON.S occupies a strategic position for a source population. Additionally, the range of *S. arenicolus* swings south and east from CON.S and regardless of oil development, populations of *S. arenicolus* are substantially lower since the habitat quality declines (blowout dune formations diminish into extensive Shinnery flats and Tebuthiron treated areas). This core represents less than 8 mi^2 of Shinnery dunes, but it may be the largest relatively undeveloped occupied habitat area we know in the south region of *S. arenicolus* range.

Pipeline cuts in Shinnery Oak habitat may benefit *S. arenicolus* because they attract lizards and represent new blowout habitat and possible dispersal corridors. However when gas and oil pipelines are not maintained and they leak, this attraction can turn into a lethal trap. Periodic leaks may regularly kill the *S. arenicolus* occupying pipeline cuts, and when these lizards are gone, other lizards move into this apparently favorable habitat, leaving observers a false impression that pipeline cuts are good habitat. We recommend regular inspections and maintenance programs that reduce these leaks. We found water, gas and oil leaks in pipelines throughout our surveys.

Future management plans for this species should prioritize studies of dispersal, metapopulation structure and a synthesis of TX information into NM conservation efforts. Knowledge of dispersal and colonization through Shinnery Oak habitat and across other habitat types is crucial to interpreting how the species may respond to oil development patterns which fragment habitat, reduce habitat suitability and possibly create new habitat. A metapopulation study gives us a genetic record of historical dispersal which reflects on the future trends we can expect in *S. arenicolus* populations and range fluctuations. Knowledge of the TX status of the species provides perspective for NM conservation management policies.

Acknowledgments

This study was made possible by the following people. Charles Painter of the New Mexico Department of Game and Fish provided overall support for the all aspects of the study. This study would not have been possible without his efforts. Esther Nelson, Kelly Chrissinger and Brian Fedorko were the field technicians and did the data entry. Brian also completed the mapping. They endured many hours of hard work under extreme conditions. Larry LaPlant, Leslie Cone and Dan Baggao of the Roswell BLM office provided support to initiate and undertake the study. Jim Bailey of NM Game and Fish gave us valuable input into the study design and gave much thoughtful help in the final drafts. Mary Medina of NM Game and Fish helped expedite the grant paper work.

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Figure 1. The number of *S. arenicolus* per transect versus well density.

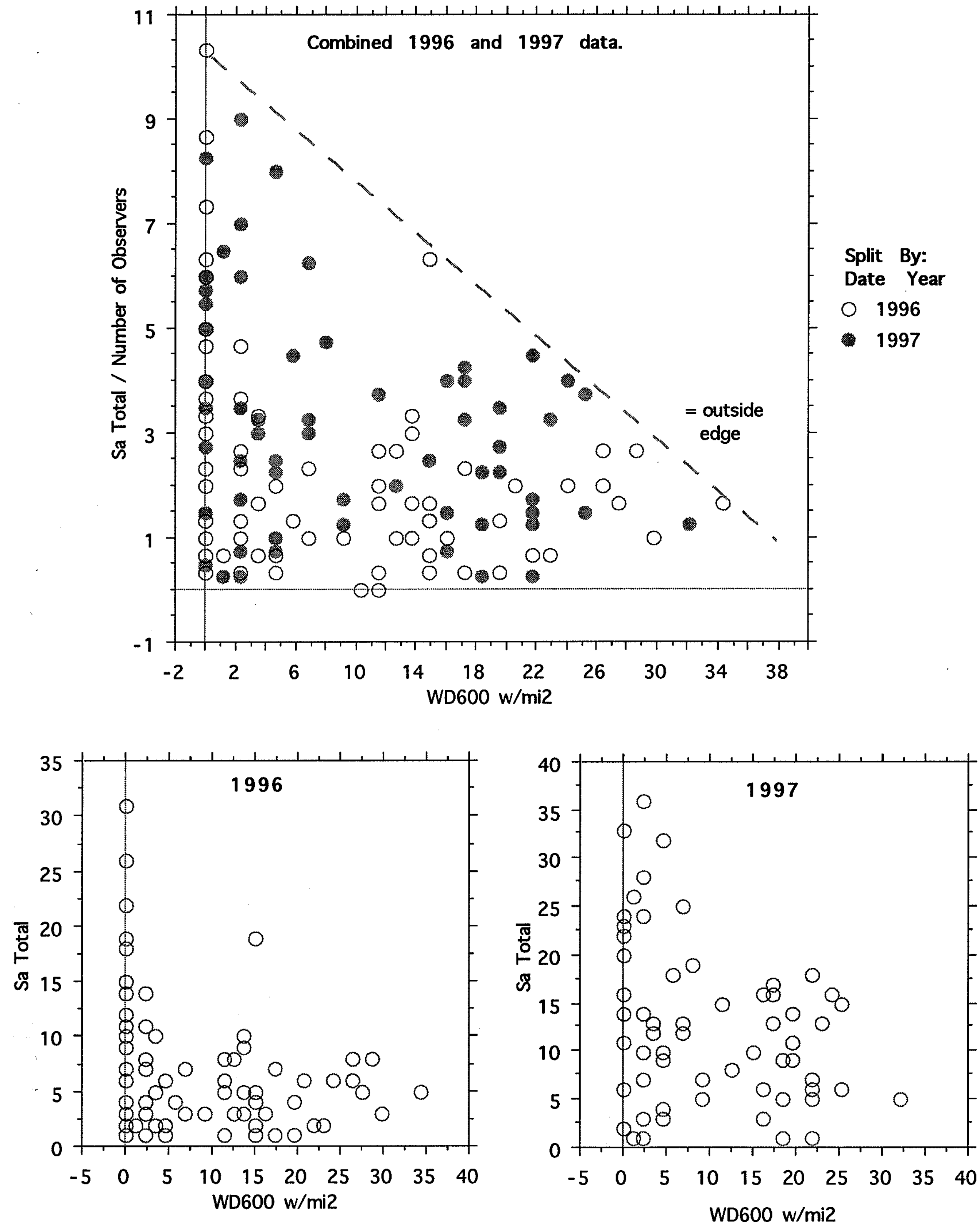
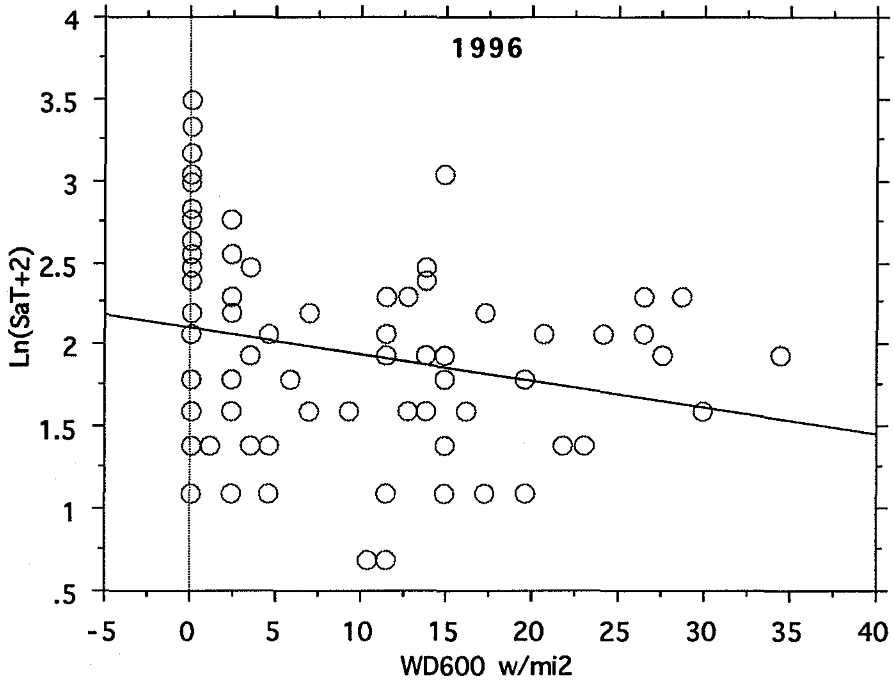
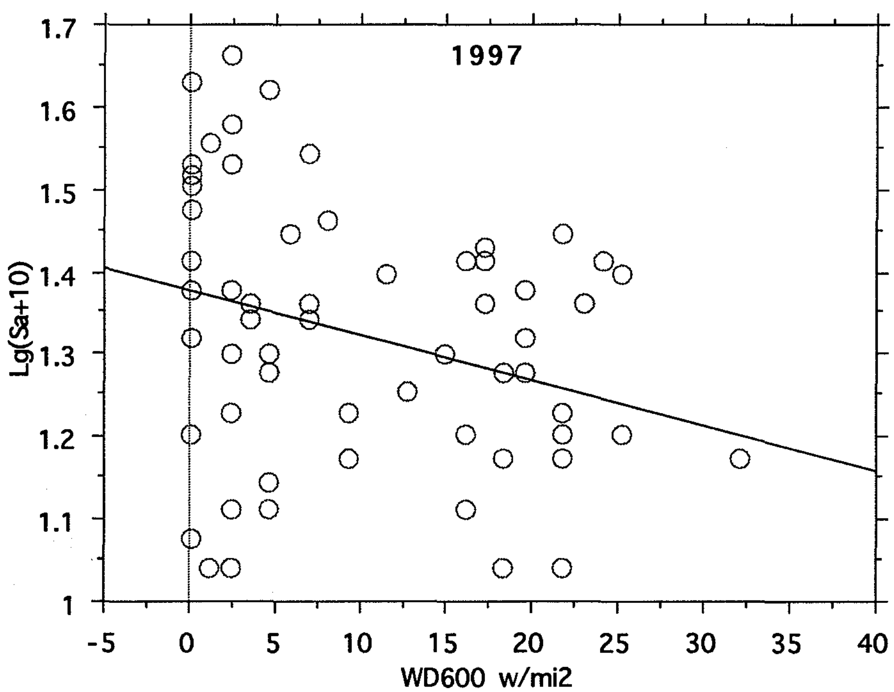


Figure 2. Regressions of transformed *S. arenicolus* transect counts on to well density for 1996 and 1997 data.



Y = 2.107 - .016 * X; R^2 = .055, p = .0281



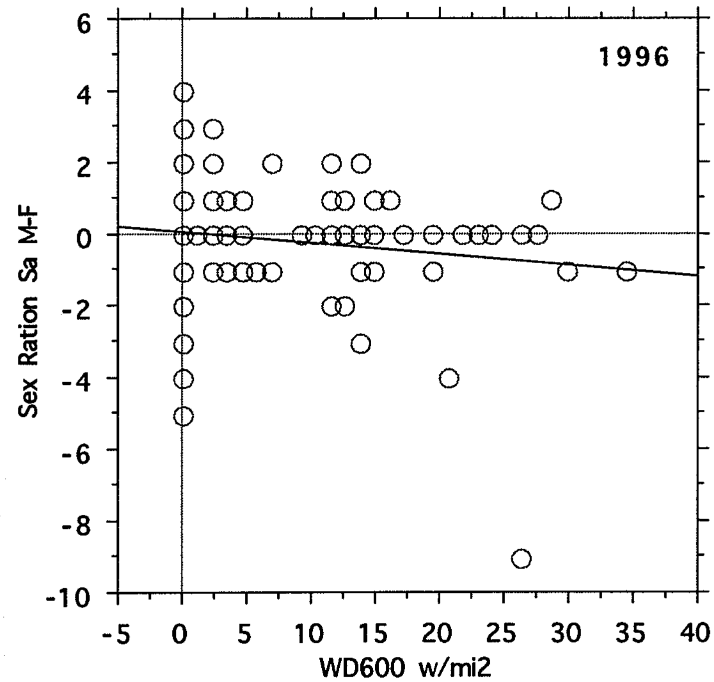
Y = 1.378 - .005 * X; R^2 = .098, p = .0111

Figure 3. Predicted reductions of *S. arenicolus* populations as a function of well density.

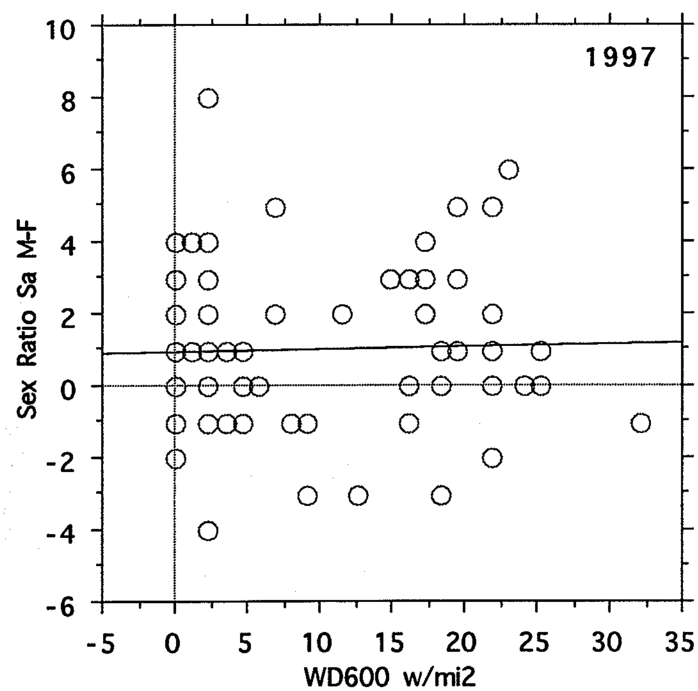
Notes	Well counts WC600	Well density wells/km^2	Well density wells/mi^2	1997 regression, percent reductions in *S. arenicolus*.	1996 regression, percent reductions in *S. arenicolus*.	1996 curve function (Ln = Ln), percent reductions in *S. arenicolus*.
	0	0.00	0.00	0.00	0.00	0.00
	1	0.88	2.29	-4.48	-4.76	-18.68
	1.63	1.44	3.72	-7.22	-7.65	● -25.00
	2	1.77	4.58	-8.84	-9.35	-27.93
	3	2.65	6.87	-13.09	-13.76	-33.92
	4	3.54	9.16	-17.22	-18.02	-38.28
	5	4.42	11.45	-21.25	-22.13	-41.68
	5.72	5.06	13.10	-24.09	● -25.00	-43.72
25% decline	5.95	5.26	13.64	● -25.00	-25.91	-44.32
	6	5.31	13.74	-25.18	-26.09	-44.44
	7	6.19	16.03	-29.00	-29.91	-46.75
	8	7.07	18.33	-32.73	-33.58	-48.73
	8.72	7.71	19.97	-35.35	-36.15	● -50.00
	9	7.96	20.62	-36.35	-37.13	-50.46
	10	8.84	22.91	-39.88	-40.55	-51.99
	11	9.73	25.20	-43.32	-43.85	-53.36
	12	10.61	27.49	-46.67	-47.02	-54.60
	13	11.47	29.71	-49.84	● -50.00	-55.69
	13	11.49	29.78	-49.94	-50.09	-55.72
50% decline	13.02	11.51	29.82	● -50.00	-50.15	-55.74
Max. count 97	14	12.38	32.07	● -53.12	-53.04	-56.75
Max. count 96	15	13.26	34.36	● -56.21	-55.89	-57.70
	16	14.15	36.65	-59.23	-58.63	-58.59
	17	15.03	38.94	-62.16	-61.27	-59.41
	18	15.92	41.23	-65.02	-63.82	-60.17
	19	16.80	43.52	-67.81	-66.28	-60.89
	20	17.68	45.81	-70.52	-68.65	-61.57
	21	18.57	48.10	-73.17	-70.94	-62.21
75% decline	21.7	19.20	49.73	● -75.00	-72.51	-62.64
	22	19.45	50.39	-75.74	-73.14	-62.81
	22.9	20.23	52.40	-77.94	● -75.00	-63.32
	23	20.34	52.69	-78.25	-75.26	-63.39
	24	21.22	54.98	-80.69	-77.31	-63.93
	25	22.10	57.27	-83.07	-79.28	-64.45
	30	26.53	68.72	-94.06	-88.13	-66.73
100% decline	33	29.18	75.59	● -99.99	-92.71	-67.89

Equations are expressed using well density, w/mi^2.
1997 Regression: Lg(SaT+10) = 1.378 - .005(WD)
1996 Regression: Ln(SaT+ 2) = 2.107 - .016(WD)
1996 Curve (Ln = Ln) function: Ln(WD + 2) = 2.361 - .207(Ln{WD + 2})

Figure 4. Sex ratios of *S. arenicolus* in relation to well density.



Y = .086 - .032 * X; R^2 = .026, p = .1391



Y = .929 + .007 * X; R^2 = .001, p = .8235

Figure 5. Habitat features associated with *S. arenicolus* sightings within Shinnery Oak habitat in 1996.

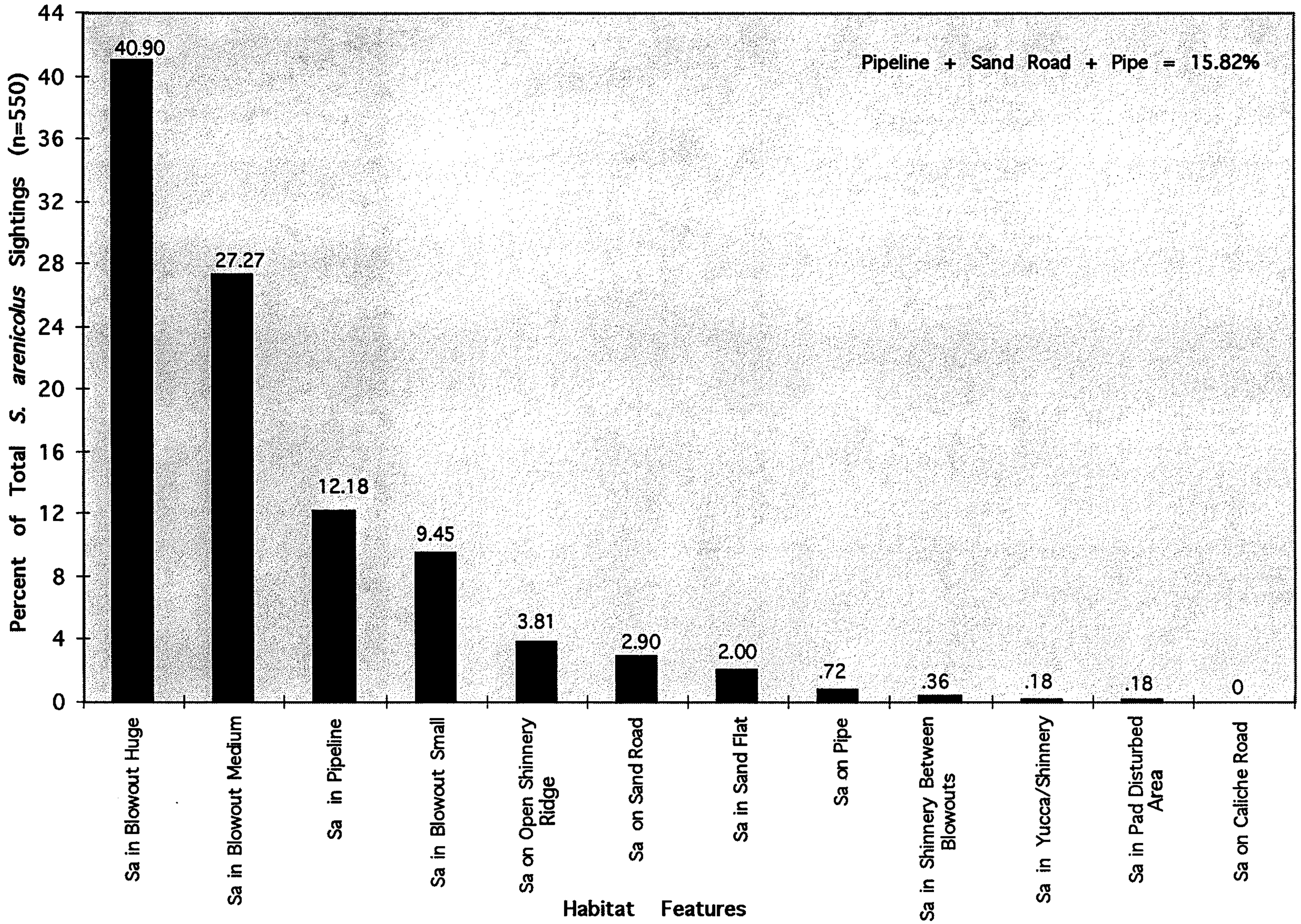


Figure 6. Habitat features associated with *S. arenicolus* sightings within Shinnery Oak habitat in 1997.

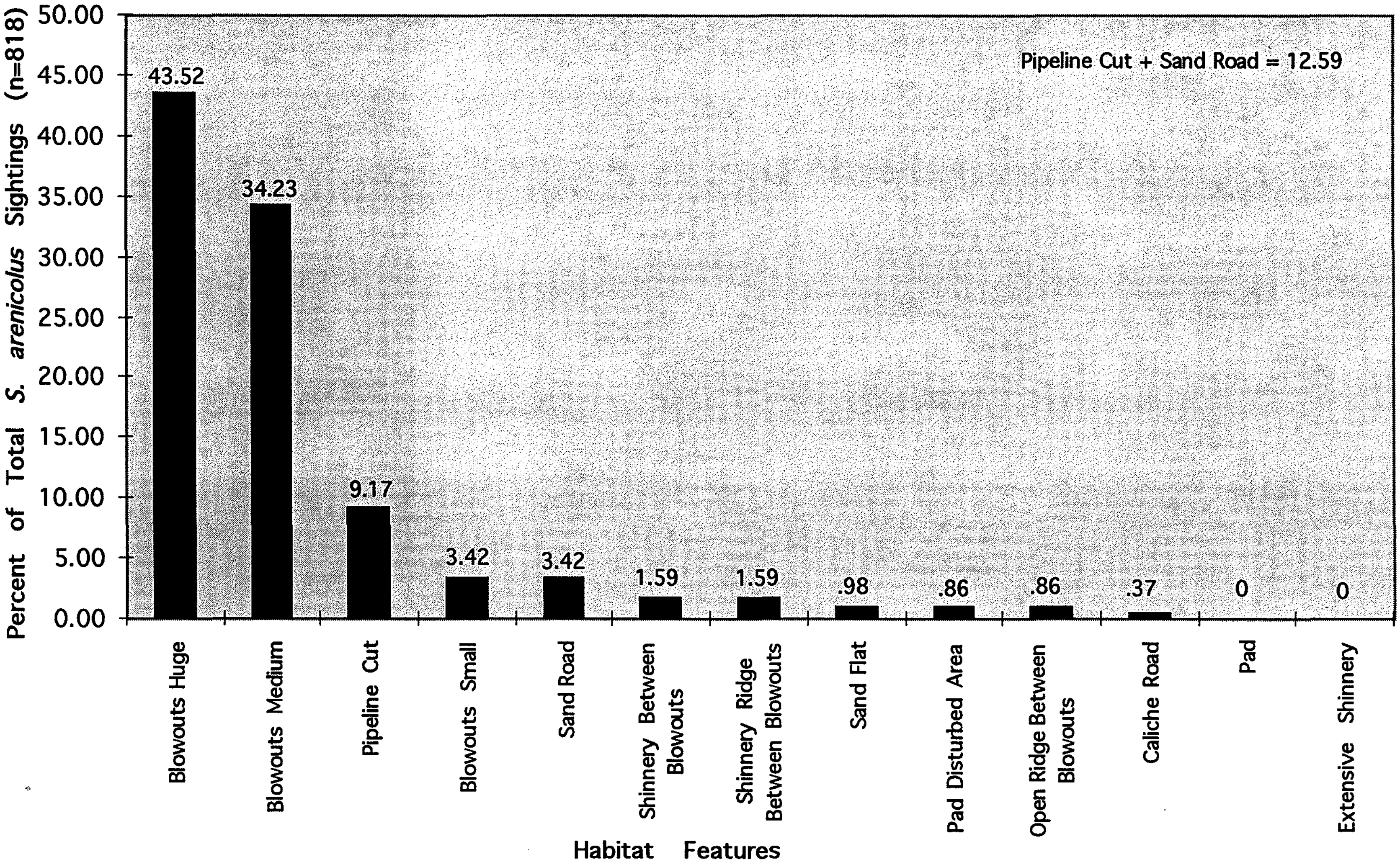


Figure 7. A model of oil/gas development and habitat influences on populations of Sand Dune lizards.

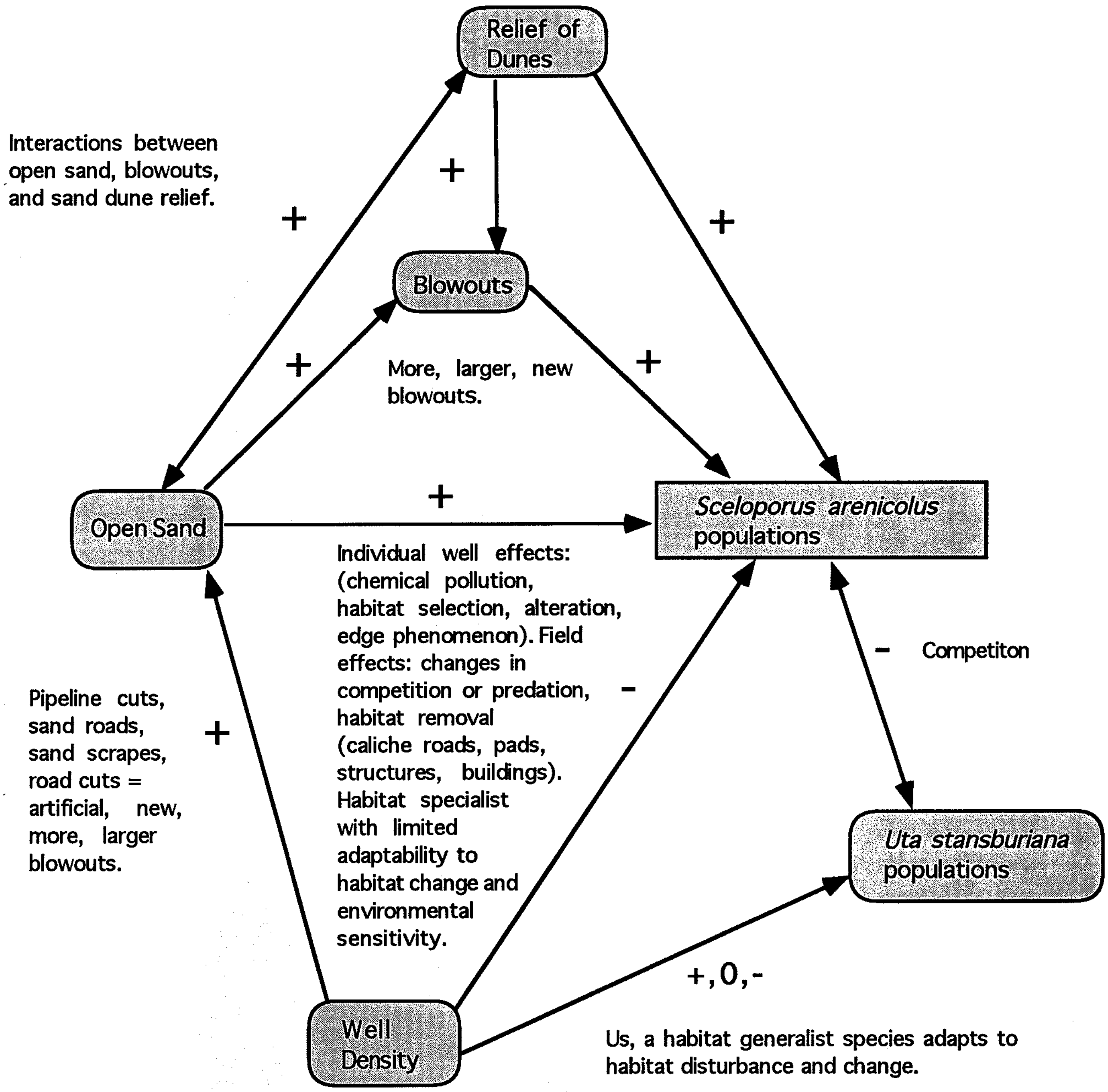
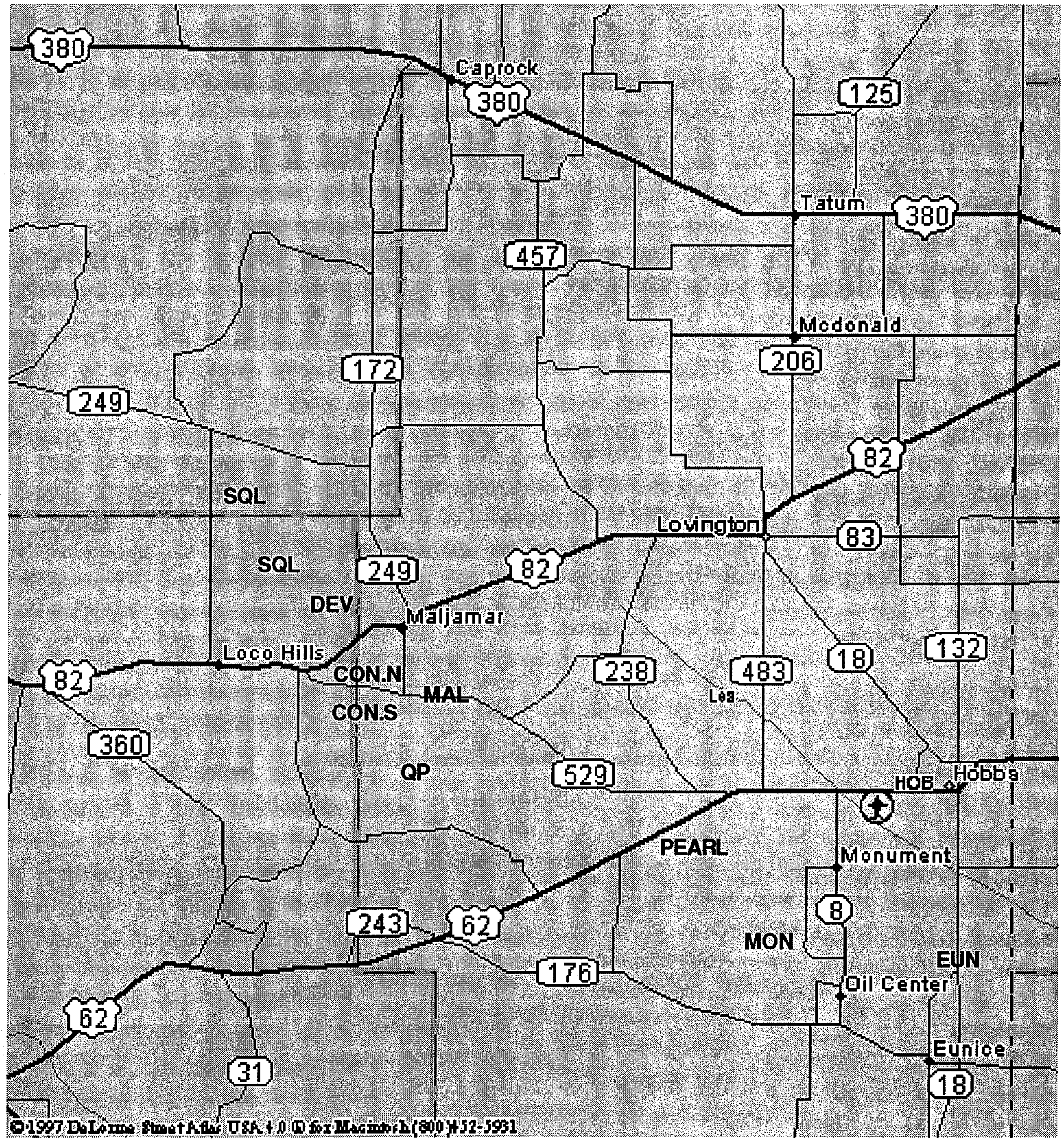


Figure 8. Selected regions that contain the sites where transects were conducted in 1996-97.



MR and NR are not on this map they are north of Hwy 380.

Table 1. Locations of transects in 1996.

Site	Total Transects by Year	Start Location Degrees Lat.	Start Location Minutes Lat.	Start Location Degrees Long.	Start Location Minutes Long.	Stop Location Degrees Lat.	Stop Location Minutes Lat.	Stop Location Degrees Long.	Stop Location Minutes Long.	Mean Location Degrees Lat.	Mean Location Minutes Lat.	Mean Location Degrees Long.	Mean Location Minutes Long.
1.0	1	32	51.51	103	51.42	32	51.58	103	51.30	32	51.545	103	51.360
1.0	2	32	51.58	103	51.30	32	51.82	103	51.40	32	51.700	103	51.350
1.0	3	32	51.82	103	51.40	32	51.93	103	51.43	32	51.875	103	51.415
1.0	4	32	51.93	103	51.43	32	51.90	103	51.48	32	51.915	103	51.455
2.0	5	32	46.87	103	49.61	32	46.84	103	49.45	32	46.855	103	49.530
2.0	6	32	46.84	103	49.45	32	46.90	103	49.42	32	46.870	103	49.435
2.0	7	32	46.90	103	49.42	32	46.73	103	49.19	32	46.815	103	49.305
2.0	8	32	46.73	103	49.19	32	46.55	103	49.31	32	46.640	103	49.250
3.0	9	32	48.54	103	49.32					32	48.540	103	49.320
3.0	10					32	48.79	103	48.62	32	48.790	103	48.620
3.0	11	34	48.79	103	48.62	32	48.54	103	48.48	33	48.665	103	48.550
3.0	12	32	48.54	103	48.48	32	48.74	103	48.29	32	48.640	103	48.385
4.0	13	32	47.42	103	47.88	32	47.24	103	48.19	32	47.330	103	48.035
4.0	14	32	47.24	103	48.19	32	47.05	103	48.41	32	47.145	103	48.300
4.0	15	32	47.05	103	48.41	32	46.99	103	48.13	32	47.020	103	48.270
4.0	16	32	46.99	103	48.13	32	46.79	103	48.29	32	46.890	103	48.210
5.0	17	32	51.94	103	51.41	32	52.05	103	51.63	32	51.995	103	51.520
5.0	18	32	52.05	103	51.63	32	52.36	103	51.29	32	52.205	103	51.460
6.0	19	32	47.01	103	47.87	32	46.91	103	48.16	32	46.960	103	48.015
6.0	20	32	46.91	103	48.16	32	46.75	103	47.91	32	46.830	103	48.035
6.0	21	32	46.75	103	47.91	32	46.67	103	47.58	32	46.710	103	47.745
6.0	22	32	46.67	103	47.58	32	46.79	103	47.24	32	46.730	103	47.410
7.0	23	32	48.25	103	47.58	32	48.37	103	47.76	32	48.310	103	47.670
7.0	24	32	48.37	103	47.76	32	48.08	103	47.78	32	48.225	103	47.770
7.0	25	32	48.08	103	47.78	32	47.95	103	47.60	32	48.015	103	47.690
7.0	26	32	47.95	103	47.60	32	48.01	103	47.29	32	47.980	103	47.445

Table 1. Locations of transects in 1996.

Site	Total Transects by Year	Start Location Degrees Lat.	Start Location Minutes Lat.	Start Location Degrees Long.	Start Location Minutes Long.	Stop Location Degrees Lat.	Stop Location Minutes Lat.	Stop Location Degrees Long.	Stop Location Minutes Long.	Mean Location Degrees Lat.	Mean Location Minutes Lat.	Mean Location Degrees Long.	Mean Location Minutes Long.
8.0	27	32	46.76	103	50.37	32	46.72	103	50.52	32	46.740	103	50.445
8.0	28	32	46.72	103	50.52	32	46.57	103	50.34	32	46.645	103	50.430
8.0	29	32	46.57	103	50.34	32	46.65	103	50.06	32	46.610	103	50.200
8.0	30	32	46.65	103	50.06	32	46.94	103	50.00	32	46.795	103	50.030
9.0	31	33	43.77	103	48.99	33	43.72	103	48.70	33	43.745	103	48.845
9.0	32	33	43.72	103	48.75	33	43.87	103	48.55	33	43.795	103	48.650
9.0	33	33	43.87	103	48.55	33	43.68	103	48.86	33	43.775	103	48.705
9.0	34	33	43.68	103	48.86	33	43.73	103	48.96	33	43.705	103	48.910
9.0	35	33	43.73	103	48.96	33	43.45	103	48.79	33	43.590	103	48.875
10.0	36	32	31.53	103	5.93	32	31.60	103	5.95	32	31.565	103	5.940
10.0	37	32	31.60	103	5.95	32	31.62	103	5.70	32	31.610	103	5.825
10.0	38	32	31.62	103	5.70	32	31.87	103	5.80	32	31.745	103	5.750
11.0	39	32	33.55	103	19.30	32	33.47	103	19.20	32	33.510	103	19.250
11.0	40	32	33.47	103	19.20	32	33.47	103	18.93	32	33.470	103	19.065
11.0	41	32	33.47	103	18.93	32	33.36	103	19.13	32	33.415	103	19.030
11.0	42	32	33.36	103	19.13	32	33.32	103	19.45	32	33.340	103	19.290
12.0	43	32	31.92	103	5.62	32	31.94	103	5.40	32	31.930	103	5.510
12.0	44	32	31.94	103	5.40	32	31.92	103	5.11	32	31.930	103	5.255
12.0	45	32	31.92	103	5.11	32	31.92	103	4.93	32	31.920	103	5.020
12.0	46	32	31.92	103	4.93	32	32.01	103	5.17	32	31.965	103	5.050
13.0	47	32	33.33	103	19.25	32	33.43	103	19.13	32	33.380	103	19.190
13.0	48	32	33.43	103	19.13	32	33.19	103	18.95	32	33.310	103	19.040
13.0	49	32	33.19	103	18.95	32	33.18	103	18.72	32	33.185	103	18.835
13.0	50	32	33.18	103	18.72	32	33.34	103	18.86	32	33.260	103	18.790
14.0	51	32	33.60	103	20.34	32	33.72	103	20.19	32	33.660	103	20.265
14.0	52	32	33.79	103	20.30	32	33.77	103	20.51	32	33.780	103	20.405

Table 1. Locations of transects in 1996.

Site	Total Transects by Year	Start Location Degrees Lat.	Start Location Minutes Lat.	Start Location Degrees Long.	Start Location Minutes Long.	Stop Location Degrees Lat.	Stop Location Minutes Lat.	Stop Location Degrees Long.	Stop Location Minutes Long.	Mean Location Degrees Lat.	Mean Location Minutes Lat.	Mean Location Degrees Long.	Mean Location Minutes Long.
14.0	53	32	33.77	103	20.51	32	33.73	103	20.79	32	33.750	103	20.650
14.0	54	32	33.50	103	20.64	32	33.55	103	20.36	32	33.525	103	20.500
15.0	55	32	48.61	103	49.76	32	48.81	103	50.10	32	48.710	103	49.930
15.0	56	32	48.81	103	50.10	32	48.70	103	50.34	32	48.755	103	50.220
15.0	57	32	48.70	103	50.34	32	48.38	103	50.11	32	48.540	103	50.225
15.0	58	32	48.38	103	50.11	32	48.50	103	49.90	32	48.440	103	50.005
15.0	59	32	48.50	103	49.90	32	48.53	103	49.69	32	48.515	103	49.795
16.0	60	32	47.01	103	48.93	32	47.10	103	48.79	32	47.055	103	48.860
16.0	61	32	47.10	103	48.79	32	47.01	103	48.58	32	47.055	103	48.685
16.0	62	32	46.95	103	48.68	32	47.01	103	48.93	32	46.980	103	48.805
16.0	63	32	47.01	103	48.93	32	47.02	103	49.16	32	47.015	103	49.045
16.0	64	32	47.02	103	49.16	32	47.20	103	48.99	32	47.110	103	49.075
17.0	65	32	47.92	103	47.25	32	47.95	103	47.43	32	47.935	103	47.340
17.0	66	32	47.95	103	47.43	32	47.99	103	47.64	32	47.970	103	47.535
17.0	67	32	47.99	103	47.64	32	48.24	103	47.47	32	48.115	103	47.555
17.0	68	32	48.24	103	47.47	32	48.30	103	47.20	32	48.270	103	47.335
18.0	69	32	58.85	103	57.84	32	59.03	103	57.73	32	58.940	103	57.785
18.0	70	32	59.03	103	57.73	32	59.27	103	57.81	32	59.150	103	57.770
18.0	71	32	59.27	103	57.81	32	59.41	103	57.46	32	59.340	103	57.635
18.0	72	32	59.41	103	57.46	32	59.29	103	57.25	32	59.350	103	57.355
19.0	73	32	33.06	103	17.86	32	33.24	103	17.97	32	33.150	103	17.915
19.0	74	32	33.24	103	17.97	32	33.19	103	18.17	32	33.215	103	18.070
19.0	75	32	33.19	103	18.17	32	33.08	103	18.34	32	33.135	103	18.255
19.0	76	32	33.08	103	18.34	32	32.90	103	18.20	32	32.990	103	18.270
20.0	77	32	47.75	103	41.76	32	47.67	103	41.47	32	47.710	103	41.615
21.0	78	32	47.72	103	42.40	32	47.89	103	42.48	32	47.805	103	42.440

Table 1. Locations of transects in 1996.

Site	Total Transects by Year	Start Location Degrees Lat.	Start Location Minutes Lat.	Start Location Degrees Long.	Start Location Minutes Long.	Stop Location Degrees Lat.	Stop Location Minutes Lat.	Stop Location Degrees Long.	Stop Location Minutes Long.	Mean Location Degrees Lat.	Mean Location Minutes Lat.	Mean Location Degrees Long.	Mean Location Minutes Long.
21.0	79	32	47.89	103	42.48	32	47.97	103	42.53	32	47.930	103	42.505
21.0	80	32	47.97	103	42.53	32	48.09	103	42.55	32	48.030	103	42.540
21.0	81	32	48.09	103	42.55	32	47.88	103	42.56	32	47.985	103	42.555
21.0	82	32	47.88	103	42.56	32	47.72	103	42.56	32	47.800	103	42.560
22.0	83	32	37.40	103	29.32	32	37.49	103	29.23	32	37.445	103	29.275
22.0	84	32	37.49	103	29.23	32	37.39	103	29.25	32	37.440	103	29.240
23.0	85	32	54.41	103	55.51	32	54.42	103	55.81	32	54.415	103	55.660
23.0	86	32	54.41	103	55.51	32	54.68	103	55.51	32	54.545	103	55.510
23.0	87	32	54.68	103	55.51	32	54.61	103	55.15	32	54.645	103	55.330
23.0	88	32	54.61	103	55.15	32	54.33	103	55.24	32	54.470	103	55.195
24.0	89	33	24.84	103	46.35	33	27.83	103	46.62	33	26.335	103	46.485
24.0	90	33	27.83	103	46.62	33	27.63	103	46.70	33	27.730	103	46.660
24.0	91	33	27.63	103	46.70	33	27.59	103	46.49	33	27.610	103	46.595
24.0	92	33	27.59	103	46.49	33	27.84	103	46.40	33	27.715	103	46.445
24.0	93	33	27.84	103	46.40	33	27.60	103	46.30	33	27.720	103	46.350

Table 2. Locations of transects in 1997.

Site	Total Transects by Year	Start Location Degrees Lat.	Start Location Minutes Lat.	Start Location Degrees Long.	Start Location Minutes Long.	Stop Location Degrees Lat.	Stop Location Minutes Lat.	Stop Location Degrees Long.	Stop Location Minutes Long.	Mean Location Degrees Lat.	Mean Location Minutes Lat.	Mean Location Degrees Long.	Mean Location Minutes Long.
1	1	32	42.610	103	48.360	32	42.380	103	48.250	32	42.495	103	48.305
1	2	32	42.380	103	48.250	32	42.570	103	47.910	32	42.475	103	48.080
1	3	32	42.570	103	47.910	32	42.410	103	47.630	32	42.490	103	47.770
1	4	32	42.410	103	47.630	32	42.200	103	47.830	32	42.305	103	47.730
2	5	32	48.510	103	48.320	32	48.370	103	48.320	32	48.440	103	48.320
2	6	32	48.370	103	48.320	32	48.300	103	47.950	32	48.335	103	48.135
3	7	32	47.020	103	47.920	32	47.160	103	48.160	32	47.090	103	48.040
3	8	32	47.160	103	48.160	32	47.120	103	48.530	32	47.140	103	48.345
3	9	32	47.120	103	48.530	32	47.170	103	48.760	32	47.145	103	48.645
3	10	32	47.170	103	48.760	32	46.920	103	48.860	32	47.045	103	48.810
3	11	32	46.920	103	48.860	32	46.750	103	48.710	32	46.835	103	48.785
3	12	32	46.750	103	48.710	32	46.760	103	48.390	32	46.755	103	48.550
4.1	13	32	48.310	103	47.730	32	48.160	103	47.670	32	48.235	103	47.700
4.2	14	32	48.359	103	47.662	32	48.138	103	47.630	32	48.249	103	47.646
4.2	15	32	48.138	103	47.630	32	48.104	103	47.869	32	48.121	103	47.750
4.2	16	32	48.104	103	47.869	32	48.230	103	48.081	32	48.167	103	47.975
4.2	17	32	48.230	103	48.081	32	48.003	103	48.343	32	48.117	103	48.212
4.2	18	32	48.003	103	48.343	32	48.087	103	48.538	32	48.045	103	48.441
5	19	32	41.501	103	44.466	32	41.620	103	44.719	32	41.561	103	44.593
5	20	32	41.620	103	44.719	32	41.799	103	44.965	32	41.710	103	44.842
5	21	32	41.799	103	44.965	32	41.691	103	44.431	32	41.745	103	44.698
5	22	32	41.691	103	44.431	32	42.063	103	44.272	32	41.877	103	44.352
5.2	PLC	32	41.490	103	44.633	32	41.480	103	44.633	32	41.485	103	44.633
6	23	32	51.549	103	51.354	32	51.699	103	51.276	32	51.624	103	51.315
6	24	32	51.699	103	51.276	32	51.861	103	51.267	32	51.780	103	51.272
6	25	32	51.861	103	51.267	32	51.842	103	51.469	32	51.852	103	51.368

Table 2. Locations of transects in 1997.

Site	Total Transects by Year	Start Location Degrees Lat.	Start Location Minutes Lat.	Start Location Degrees Long.	Start Location Minutes Long.	Stop Location Degrees Lat.	Stop Location Minutes Lat.	Stop Location Degrees Long.	Stop Location Minutes Long.	Mean Location Degrees Lat.	Mean Location Minutes Lat.	Mean Location Degrees Long.	Mean Location Minutes Long.
6	26	32	51.842	103	51.469	32	52.034	103	51.438	32	51.938	103	51.454
7	27	32	47.706	103	42.493	32	47.588	103	42.428	32	47.647	103	42.461
7	28	32	47.588	103	42.428	32	47.513	103	42.485	32	47.551	103	42.457
7	29	32	47.513	103	42.485	32	47.409	103	42.296	32	47.461	103	42.391
7	30	32	47.409	103	42.296	32	47.485	103	42.488	32	47.447	103	42.392
7	31	32	47.485	103	42.488	32	47.759	103	42.501	32	47.622	103	42.495
8	32	32	33.516	103	19.318	32	33.412	103	19.145	32	33.464	103	19.232
8	33	32	33.412	103	19.145	32	33.374	103	18.903	32	33.393	103	19.024
8	34	32	33.374	103	18.903	32	33.349	103	18.680	32	33.362	103	18.792
8	35	32	33.349	103	18.680	32	33.260	103	18.459	32	33.305	103	18.570
8	36	32	33.260	103	18.459	32	33.080	103	18.204	32	33.170	103	18.332
8	37	32	33.080	103	18.204	32	33.095	103	17.918	32	33.088	103	18.061
9	38	32	33.594	103	19.978	32	33.681	103	20.124	32	33.638	103	20.051
9	39	32	33.681	103	20.124	32	33.616	103	20.303	32	33.649	103	20.214
9	40	32	33.616	103	20.303	32	33.664	103	20.549	32	33.640	103	20.426
9	41	32	33.664	103	20.549	32	33.712	103	20.735	32	33.688	103	20.642
9	42	32	33.712	103	20.735	32	33.773	103	20.931	32	33.743	103	20.833
9	43	32	33.773	103	20.931	32	33.802	103	21.073	32	33.788	103	21.002
10	44	32	33.246	103	9.762	32	33.122	103	9.552	32	33.184	103	9.657
10	45	32	33.122	103	9.552	32	33.013	103	9.340	32	33.068	103	9.446
10	46	32	33.013	103	9.340	32	32.922	103	9.134	32	32.968	103	9.237
10	47	32	32.922	103	9.134	32	32.852	103	8.956	32	32.887	103	9.045
11	48	32	31.817	103	10.084	32	31.740	103	9.973	32	31.779	103	10.029
11	49	32	31.740	103	9.973	32	31.661	103	9.804	32	31.701	103	9.889
11	50	32	31.661	103	9.804	32	31.402	103	9.812	32	31.532	103	9.808
11	51	32	31.402	103	9.812	32	31.461	103	10.070	32	31.432	103	9.941

Table 2. Locations of transects in 1997.

Site	Total Transects by Year	Start Location Degrees Lat.	Start Location Minutes Lat.	Start Location Degrees Long.	Start Location Minutes Long.	Stop Location Degrees Lat.	Stop Location Minutes Lat.	Stop Location Degrees Long.	Stop Location Minutes Long.	Mean Location Degrees Lat.	Mean Location Minutes Lat.	Mean Location Degrees Long.	Mean Location Minutes Long.
11	52	32	31.461	103	10.070	32	31.531	103	10.329	32	31.496	103	10.200
12	53	32	34.068	103	19.189	32	33.949	103	19.310	32	34.009	103	19.250
12	54	32	33.949	103	19.310	32	33.845	103	19.393	32	33.897	103	19.352
12	55	32	33.845	103	19.393	32	33.683	103	19.421	32	33.764	103	19.407
12	56	32	33.683	103	19.421	32	33.564	103	19.506	32	33.624	103	19.464
12	57	32	33.502	103	19.375	32	33.302	103	19.306	32	33.402	103	19.341
13	58	32	33.899	103	21.896	32	33.863	103	21.741	32	33.881	103	21.819
13	59	32	33.863	103	21.741	32	33.756	103	21.589	32	33.810	103	21.665
13	60	32	33.756	103	21.589	32	33.664	103	21.394	32	33.710	103	21.492
13	61	32	33.664	103	21.394	32	33.593	103	21.199	32	33.629	103	21.297
13	62	32	33.593	103	21.199	32	33.654	103	20.956	32	33.624	103	21.078
14	63	32	31.527	103	4.495	32	31.739	103	4.569	32	31.633	103	4.532
14	64	32	31.739	103	4.569	32	32.041	103	4.627	32	31.890	103	4.598
14	65	32	32.089	103	4.554	32	32.154	103	4.600	32	32.122	103	4.577
14	66	32	32.154	103	4.600	32	32.158	103	4.789	32	32.156	103	4.695
14	67	32	32.158	103	4.789	32	31.999	103	5.029	32	32.079	103	4.909

Table 3. Well density and environmental information for 1996 transects.

Site	Total Transects By Year	Region	Specific Region	Date	WC600 Start	WC600 Stop	WC 600 Mean	WC 600 P/A	WC 600 L(=<.5)/H	WC300 Start	WC300 Stop	WC300 Mean	WC 300 P/A	WC 300 L(=<.5)/H	WD600 wells/mi2
1.0	1	SR	DEV	May 17, 1996	14	11	12.5	P	H						28.63
1.0	2	SR	DEV	May 17, 1996	11	12	11.5	P	H						26.34
1.0	3	SR	DEV	May 17, 1996	12	12	12.0	P	H						27.49
2.0	5	SR	CON.S	May 18, 1996	0	0	0.0	A	L						0.00
2.0	6	SR	CON.S	May 18, 1996	0	0	0.0	A	L						0.00
2.0	7	SR	CON.S	May 18, 1996	0	0	0.0	A	L						0.00
2.0	8	SR	CON.S	May 18, 1996	0	0	0.0	A	L						0.00
3.0	9	SR	CON.N	May 19, 1996	15	15	15.0	P	H						34.36
3.0	10	SR	CON.N	May 19, 1996	15	11	13.0	P	H						29.78
3.0	11	SR	CON.N	May 19, 1996	11	8	9.5	P	H						21.76
3.0	12	SR	CON.N	May 19, 1996	8	9	8.5	P	H						19.47
4.0	13	SR	CON.S	May 20, 1996	3	0	1.5	P	H						3.44
4.0	14	SR	CON.S	May 20, 1996	0	0	0.0	A	L						0.00
4.0	15	SR	CON.S	May 20, 1996	0	0	0.0	A	L						0.00
4.0	16	SR	CON.S	May 20, 1996	0	0	0.0	A	L						0.00
5.0	17	SR	DEV	May 21, 1996	11	9	10.0	P	H	4	5	4.5	P	H	22.91
6.0	19	SR	CON.S	May 22, 1996	2	0	1.0	P	H	1	0	0.5	P	L	2.29
6.0	20	SR	CON.S	May 22, 1996	0	2	1.0	P	H	0	0	0.0	A	L	2.29
6.0	21	SR	CON.S	May 22, 1996	2	4	3.0	P	H	0	2	1.0	P	H	6.87
6.0	22	SR	CON.S	May 22, 1996	5	5	5.0	P	H	3	3	3.0	P	H	11.45
7.0	23	SR	CON.N	May 23, 1996	10	13	11.5	P	H	4	4	4.0	P	H	26.34
7.0	24	SR	CON.N	May 23, 1996	13	8	10.5	P	H	4	6	5.0	P	H	24.05
7.0	25	SR	CON.N	May 23, 1996	8	6	7.0	P	H	6	3	4.5	P	H	16.03
7.0	26	SR	CON.N	May 23, 1996	6	7	6.5	P	H	3	4	3.5	P	H	14.89
8.0	27	SR	CON.S	May 24, 1996	1	4	2.5	P	H	0	1	0.5	P	L	5.73
8.0	28	SR	CON.S	May 24, 1996	4	5	4.5	P	H	1	2	1.5	P	H	10.31
8.0	29	SR	CON.S	May 24, 1996	5	6	5.5	P	H	2	2	2.0	P	H	12.60
8.0	30	SR	CON.S	May 24, 1996	6	2	4.0	P	H	2	1	1.5	P	H	9.16
9.0	31	NR	NR	Jun 11, 1996	0	0	0.0	A	L	0	0	0.0	A	L	0.00
9.0	34	NR	NR	Jun 11, 1996	0	0	0.0	A	L	0	0	0.0	A	L	0.00

Table 3. Well density and environmental information for 1996 transects.

Site	Total Transects By Year	WD600 wells/km2	Cloud Cover % Start	Cloud Cover % Stop	Cloud Cover % Mean	Wind m/s Start	Wind m/s Stop	Wind m/s Mean	Transect Direction degrees	Ts Start	Ts Stop	Ts Mean	Ta Start	Ta Stop	Ta Mean	Relief at 1/3 into Transect m	Relief at 2/3 into Transect m
1.0	1	11.05	20.0	10.0	15.00	0.50	6.00	3.25	70	27.0	30.0	28.5	34.2	24.4	29.3	5.49	9.15
1.0	2	10.17	20.0	10.0	15.00	0.50	6.00	3.25	335	30.0	38.0	34.0	24.4	32.1	28.3	1.53	2.14
1.0	3	10.61	20.0	10.0	15.00	0.50	6.00	3.25	345	38.0	39.5	38.8	32.1	31.8	32.0	4.58	3.66
2.0	5	0.00	60.0		60.00	2.00	1.00	1.50	90	28.0	35.5	31.8	23.6	26.8	25.2	12.20	12.20
2.0	6	0.00	60.0		60.00	2.00	1.00	1.50	65	35.5	35.5	35.5	26.8	29.4	28.1	10.68	0.92
2.0	7	0.00	60.0		60.00	2.00	1.00	1.50	200	35.5	42.0	38.8	29.4	31.6	30.5	1.53	15.25
2.0	8	0.00	60.0		60.00	2.00	1.00	1.50	210	42.0	43.2	42.6	31.6	33.4	32.5	3.66	0.61
3.0	9	13.26	85.0	75.0	80.00	1.00	6.00	3.50	355	29.5	33.3	31.4	25.9	31.0	28.5	2.44	2.44
3.0	10	11.49	85.0	75.0	80.00	1.00	6.00	3.50	275	33.3	36.0	34.7	31.0	28.0	29.5	0.61	7.63
3.0	11	8.40	85.0	75.0	80.00	1.00	6.00	3.50	150	36.0	46.0	41.0	28.0	34.2	31.1	1.83	2.75
3.0	12	7.52	85.0	75.0	80.00	1.00	6.00	3.50	35	46.0	48.0	47.0	34.2	37.1	35.7	0.92	1.83
4.0	13	1.33	90.0	65.0	77.50	1.00	3.00	2.00	240	24.5	29.0	26.8	23.7	27.4	25.6	2.44	1.53
4.0	14	0.00	90.0	65.0	77.50	1.00	3.00	2.00	245	29.0	33.5	31.3	27.4	31.1	29.3	0.92	0.61
4.0	15	0.00	90.0	65.0	77.50	1.00	3.00	2.00	95	33.5	36.1	34.8	31.1	32.2	31.7	1.53	1.83
4.0	16	0.00	90.0	65.0	77.50	1.00	3.00	2.00	230	36.1	39.0	37.6	32.2	32.4	32.3	1.83	0.61
5.0	17	8.84	0.0	0.0	0.00	15.00	2.00	8.50	305	33.5	39.6	36.6	26.6	29.2	27.9	5.19	3.36
6.0	19	0.88	0.0	0.0	0.00	1.00	3.50	2.25	255	24.6	30.2	27.4	23.6	26.6	25.1	1.83	2.75
6.0	20	0.88	0.0	0.0	0.00	1.00	3.50	2.25	130	30.2	30.2	30.2	26.6	28.6	27.6	3.66	4.58
6.0	21	2.65	0.0	0.0	0.00	1.00	3.50	2.25	105	30.2	40.2	35.2	28.6	30.8	29.7	2.75	4.27
6.0	22	4.42	0.0	0.0	0.00	1.00	3.50	2.25	70	40.2	46.0	43.1	30.8	32.8	31.8	9.15	0.92
7.0	23	10.17	0.0	0.0	0.00	0.25	14.00	7.13	320	28.0	30.4	29.2	24.8	27.9	26.4	4.88	12.20
7.0	24	9.28	0.0	0.0	0.00	0.25	14.00	7.13	195	30.4	32.0	31.2	27.9	29.2	28.6	2.14	0.92
7.0	25	6.19	0.0	0.0	0.00	0.25	14.00	7.13	165	32.0	34.9	33.5	29.2	29.4	29.3	1.53	15.25
7.0	26	5.75	0.0	0.0	0.00	0.25	14.00	7.13	70	34.9	39.5	37.2	29.4	31.0	30.2	10.68	4.58
8.0	27	2.21	0.0	15.0	7.50	0.25	3.50	1.88	220	22.0	30.2	26.1	22.8	25.9	24.4	7.63	10.68
8.0	28	3.98	0.0	15.0	7.50	0.25	3.50	1.88	130	30.2	32.2	31.2	25.9	29.0	27.5	5.49	2.14
8.0	29	4.86	0.0	15.0	7.50	0.25	3.50	1.88	70	32.2	38.3	35.3	29.0	31.6	30.3	1.53	2.75
8.0	30	3.54	0.0	15.0	7.50	0.25	3.50	1.88	5	38.3	41.5	39.9	31.6	31.9	31.8	6.10	0.61
9.0	31	0.00	5.0	0.0	2.50	1.50	2.50	2.00	130	29.5	31.5	30.5	25.9	28.4	27.2	1.53	1.83
9.0	34	0.00	5.0	0.0	2.50	1.50	2.50	2.00	275	36.0	36.7	36.4	30.6	31.0	30.8	4.58	4.58

Table 3. Well density and environmental information for 1996 transects.

Site	Total Transects By Year	Mean Relief of Transect m	Open Sand % at 1/3 into Transect	Open Sand % at 2/3 into Transect	Mean Open Sand of Transect %	Number of Blowouts	Number of Man Objects	Number of Small Blowouts BS	Number of Medium Blowouts BM	Number of Huge Blowouts BH (unadjusted)	Time of Transect Start	Time Of Transect Stop	Mean Time of Transect
1.0	1	7.32	60.00	60.00	60.00	20					7:58	8:23	8:10:00
1.0	2	1.83	10.00	10.00	10.00	20					8:50	9:15	9:02:00
1.0	3	4.12	35.00	40.00	37.50	16					9:30	9:55	9:42:00
2.0	5	12.20	55.00	80.00	67.50	13					8:16	8:41	8:28:00
2.0	6	5.80	75.00	5.00	40.00	12					8:51	9:16	9:03:00
2.0	7	8.39	5.00	50.00	27.50	18					9:24	9:49	9:36:00
2.0	8	2.14	25.00	5.00	15.00	28					9:57	10:22	10:09:00
3.0	9	2.44	50.00	20.00	35.00	30	8	14	9	7	8:40	9:05	8:52:00
3.0	10	4.12	2.00	40.00	21.00	24	4	6	11	6	9:20	9:45	9:32:00
3.0	11	2.29	30.00	15.00	22.50	30	5	7	11	11	10:00	10:25	10:12:00
3.0	12	1.37	15.00	20.00	17.50	31	10	12	12	7	10:36	11:01	10:48:00
4.0	13	1.98	10.00	10.00	10.00	23	6	10	3	10	7:54	8:19	8:06:00
4.0	14	0.76	5.00	10.00	7.50	14	1	8	5	1	8:33	8:58	8:45:00
4.0	15	1.68	5.00	15.00	10.00	20	8	14	6	1	9:13	9:38	9:25:00
4.0	16	1.22	5.00	1.00	3.00	17	0	10	4	2	9:48	10:13	10:00:00
5.0	17	4.27	40.00	50.00	45.00	36	4	4	12	17	10:04	10:29	10:16:00
6.0	19	2.29	8.00	25.00	16.50	28	1	15	9	5	7:46	8:11	7:58:00
6.0	20	4.12	25.00	15.00	20.00	13	0	6	6	2	8:24	8:49	8:36:00
6.0	21	3.51	7.00	10.00	8.50	20	12	9	8	3	9:00	9:25	9:12:00
6.0	22	5.03	65.00	2.00	33.50	15	15	4	6	5	9:38	10:03	9:50:00
7.0	23	8.54	45.00	60.00	52.50	22	11	7	7	7	7:57	8:22	8:09:00
7.0	24	1.53	3.00	5.00	4.00	27	13	13	8	6	8:32	8:57	8:44:00
7.0	25	8.39	5.00	85.00	45.00	26	6	14	4	8	9:14	9:39	9:26:00
7.0	26	7.63	45.00	40.00	42.50	33	3	10	15	8	9:52	10:17	10:04:00
8.0	27	9.15	85.00	85.00	85.00	29	1	11	9	9	7:50	8:15	8:02:00
8.0	28	3.81	30.00	15.00	22.50	27	0	11	12	4	8:38	9:03	8:50:00
8.0	29	2.14	8.00	35.00	21.50	26	1	12	6	8	9:13	9:38	9:25:00
8.0	30	3.36	5.00	2.50	3.75	26	1	13	7	6	9:52	10:17	10:04:00
9.0	31	1.68	25.00	20.00	22.50	37		18	13	6	8:07	8:32	8:19:00
9.0	34	4.58	40.00	45.00	42.50	39		18	12	9	10:07	10:32	10:19:00

Table 3. Well density and environmental information for 1996 transects.

Site	Total Transects By Year	Region	Specific Region	Date	WC600 Start	WC600 Stop	WC 600 Mean	WC 600 P/A	WC 600 L(=<.5)/H	WC300 Start	WC300 Stop	WC300 Mean	WC 300 P/A	WC 300 L(=<.5)/H	WD600 wells/mi2
9.0	35	NR	NR	Jun 11, 1996	0	0	0.0	A	L	0	0	0.0	A	L	0.00
10.0	36	SE	EUN	Jun 13, 1996	0	0	0.0	A	L	0	0	0.0	A	L	0.00
10.0	37	SE	EUN	Jun 13, 1996	0	0	0.0	A	L	0	0	0.0	A	L	0.00
10.0	38	SE	EUN	Jun 13, 1996	0	0	0.0	A	L	0	0	0.0	A	L	0.00
11.0	39	SE	MON	Jun 14, 1996	7	6	6.5	P	H	4	4	4.0	P	H	14.89
11.0	40	SE	MON	Jun 14, 1996	6	6	6.0	P	H	4	3	3.5	P	H	13.74
11.0	41	SE	MON	Jun 14, 1996	6	6	6.0	P	H	3	3	3.0	P	H	13.74
11.0	42	SE	MON	Jun 14, 1996	6	4	5.0	P	H	3	1	2.0	P	H	11.45
12.0	43	SE	EUN	Jun 15, 1996	1	1	1.0	P	H	0	1	0.5	P	L	2.29
12.0	44	SE	EUN	Jun 15, 1996	1	1	1.0	P	H	1	1	1.0	P	H	2.29
12.0	45	SE	EUN	Jun 15, 1996	1	1	1.0	P	H	1	0	0.5	P	L	2.29
12.0	46	SE	EUN	Jun 15, 1996	1	1	1.0	P	H	0	1	0.5	P	L	2.29
13.0	47	SE	MON	Jun 16, 1996	6	7	6.5	P	H	2	4	3.0	P	H	14.89
13.0	48	SE	MON	Jun 16, 1996	7	3	5.0	P	H	4	1	2.5	P	H	11.45
13.0	49	SE	MON	Jun 16, 1996	3	7	5.0	P	H	1	2	1.5	P	H	11.45
13.0	50	SE	MON	Jun 16, 1996	7	4	5.5	P	H	2	2	2.0	P	H	12.60
14.0	51	SE	MON	Jun 17, 1996	0	0	0.0	A	L	0	0	0.0	A	L	0.00
14.0	52	SE	MON	Jun 17, 1996	0	0	0.0	A	L	0	0	0.0	A	L	0.00
14.0	53	SE	MON	Jun 17, 1996	0	0	0.0	A	L	0	0	0.0	A	L	0.00
14.0	54	SE	MON	Jun 17, 1996	0	0	0.0	A	L	0	0	0.0	A	L	0.00
15.0	55	SR	CON.N	Jun 18, 1996	5	5	5.0	P	H	2	2	2.0	P	H	11.45
15.0	57	SR	CON.N	Jun 18, 1996	8	5	6.5	P	H	3	3	3.0	P	H	14.89
15.0	58	SR	CON.N	Jun 18, 1996	5	5	5.0	P	H	3	2	2.5	P	H	11.45
15.0	59	SR	CON.N	Jun 18, 1996	5	5	5.0	P	H	2	2	2.0	P	H	11.45
16.0	60	SR	CON.S	Jun 19, 1996	0	0	0.0	A	L	0	0	0.0	A	L	0.00
16.0	61	SR	CON.S	Jun 19, 1996	0	0	0.0	A	L	0	0	0.0	A	L	0.00
16.0	62	SR	CON.S	Jun 19, 1996	0	0	0.0	A	L	0	0	0.0	A	L	0.00
16.0	63	SR	CON.S	Jun 19, 1996	0	0	0.0	A	L	0	0	0.0	A	L	0.00
16.0	64	SR	CON.S	Jun 19, 1996	0	0	0.0	A	L	0	0	0.0	A	L	0.00
17.0	65	SR	CON.N	Jun 20, 1996	10	7	8.5	P	H	3	2	2.5	P	H	19.47

Table 3. Well density and environmental information for 1996 transects.

Site	Total Transects By Year	WD600 wells/km2	Cloud Cover % Start	Cloud Cover % Stop	Cloud Cover % Mean	Wind m/s Start	Wind m/s Stop	Wind m/s Mean	Transect Direction degrees	Ts Start	Ts Stop	Ts Mean	Ta Start	Ta Stop	Ta Mean	Relief at 1/3 into Transect m	Relief at 2/3 into Transect m
9.0	35	0.00	5.0	0.0	2.50	1.50	2.50	2.00	155	36.7	45.0	40.9	31.0	32.7	31.9	2.14	2.14
10.0	36	0.00	35.0	30.0	32.50	7.50	5.50	6.50	60	32.3	35.2	33.8	27.8	28.6	28.2	15.25	15.25
10.0	37	0.00	35.0	30.0	32.50	7.50	5.50	6.50	95	35.2	37.4	36.3	28.6	29.2	28.9	10.68	10.68
10.0	38	0.00	35.0	30.0	32.50	7.50	5.50	6.50	340	37.4	44.2	40.8	29.2	33.9	31.6	0.92	0.92
11.0	39	5.75	40.0	95.0	67.50	1.00	2.50	1.75	130	28.5	31.1	29.8	26.9	28.6	27.8	9.15	4.58
11.0	40	5.31	40.0	95.0	67.50	1.00	2.50	1.75	85	31.1	34.9	33.0	28.6	28.8	28.7	1.22	8.54
11.0	41	5.31	40.0	95.0	67.50	1.00	2.50	1.75	235	34.9	40.5	37.7	28.8	31.0	29.9	1.53	0.92
11.0	42	4.42	40.0	95.0	67.50	1.00	2.50	1.75	265	40.5	43.0	41.8	31.0	30.9	31.0	3.05	1.22
12.0	43	0.88	25.0	15.0	20.00	1.25	2.25	1.75	80	30.5	36.0	33.3	27.2	28.0	27.6	10.68	3.97
12.0	44	0.88	25.0	15.0	20.00	1.25	2.25	1.75	90	36.0	36.0	36.0	28.0	29.1	28.6	4.27	6.10
12.0	45	0.88	25.0	15.0	20.00	1.25	2.25	1.75	115	36.0	39.7	37.9	29.1	32.8	31.0	12.20	12.20
12.0	46	0.88	25.0	15.0	20.00	1.25	2.25	1.75	300	39.7	35.0	37.4	32.8	30.4	31.6	9.15	6.10
13.0	47	5.75	7.5	1.0	4.25	0.25	2.30	1.28	45	25.0	34.5	29.8	25.8	29.8	27.8	3.05	6.10
13.0	48	4.42	7.5	1.0	4.25	0.25	2.30	1.28	165	34.5	36.0	35.3	29.8	30.9	30.4	0.92	0.92
13.0	49	4.42	7.5	1.0	4.25	0.25	2.30	1.28	110	36.0	41.0	38.5	30.9	35.0	33.0	4.58	3.05
13.0	50	4.86	7.5	1.0	4.25	0.25	2.30	1.28	350	41.0	43.0	42.0	35.0	34.2	34.6	0.92	4.58
14.0	51	0.00	10.0	5.0	7.50	1.00	2.25	1.63	50	28.0	30.0	29.0	27.1	28.8	28.0	4.58	9.15
14.0	52	0.00	10.0	5.0	7.50	1.00	2.25	1.63	275	30.0	37.0	33.5	28.8	32.6	30.7	3.66	5.49
14.0	53	0.00	10.0	5.0	7.50	1.00	2.25	1.63	250	37.0	41.5	39.3	32.6	31.6	32.1	2.44	4.58
14.0	54	0.00	10.0	5.0	7.50	1.00	2.25	1.63	85	41.5	44.5	43.0	31.6	34.0	32.8	0.92	0.31
15.0	55	4.42	5.0	1.0	3.00	0.10	5.00	2.55	320	28.2	31.0	29.6	25.5	27.8	26.7	3.05	1.22
15.0	57	5.75	5.0	1.0	3.00	0.10	5.00	2.55	150	35.0	34.0	34.5	28.2	30.2	29.2	0.31	0.31
15.0	58	4.42	5.0	1.0	3.00	0.10	5.00	2.55	50	34.0	36.0	35.0	30.2	32.0	31.1	10.68	7.63
15.0	59	4.42	5.0	1.0	3.00	0.10	5.00	2.55	80	36.0	35.0	35.5	32.0	32.8	32.4	13.73	1.83
16.0	60	0.00	15.0	6.0	10.50	0.50	3.00	1.75	100	30.5	30.7	30.6	28.2	28.7	28.5	12.20	10.68
16.0	61	0.00	15.0	6.0	10.50	0.50	3.00	1.75	125	30.7	32.0	31.4	28.7	30.6	29.7	0.61	0.61
16.0	62	0.00	15.0	6.0	10.50	0.50	3.00	1.75	280	32.0	37.0	34.5	30.6	33.2	31.9	3.05	7.63
16.0	63	0.00	15.0	6.0	10.50	0.50	3.00	1.75	250	37.0	41.0	39.0	33.2	34.5	33.9	9.15	4.58
16.0	64	0.00	15.0	6.0	10.50	0.50	3.00	1.75	30	41.0	44.2	42.6	34.5	36.9	35.7	10.68	12.20
17.0	65	7.52	0.0	0.0	0.00	0.00	3.00	1.50	275	31.2	32.0	31.6	26.4	29.2	27.8	6.10	7.63

Table 3. Well density and environmental information for 1996 transects.

Site	Total Transects By Year	Mean Relief of Transect m	Open Sand % at 1/3 into Transect	Open Sand % at 2/3 into Transect	Mean Open Sand of Transect %	Number of Blowouts	Number of Man Objects	Number of Small Blowouts BS	Number of Medium Blowouts BM	Number of Huge Blowouts BH (unadjusted)	Time of Transect Start	Time Of Transect Stop	Mean Time of Transect
9.0	35	2.14	25.00	25.00	25.00	35		20	10	5	10:44	11:09	10:56:00
10.0	36	15.25	60.00	60.00	60.00	10	0	5	1	4	9:29	9:54	9:41:00
10.0	37	10.68	20.00	35.00	27.50	16	2	4	6	6	10:01	10:26	10:13:00
10.0	38	0.92	2.50	1.00	1.75	26	0	14	6	6	10:37	11:02	10:49:00
11.0	39	6.86	55.00	30.00	42.50	14	10	3	4	7	10:01	10:26	10:13:00
11.0	40	4.88	20.00	35.00	27.50	18	10	14	1	3	10:39	11:04	10:51:00
11.0	41	1.22	10.00	30.00	20.00	17	9	10	5	2	11:17	11:42	11:29:00
11.0	42	2.14	15.00	8.00	11.50	19	15	9	8	2	11:58	12:23	12:10:00
12.0	43	7.32	30.00	10.00	20.00	16	2	4	7	5	11:42	12:07	11:54:00
12.0	44	5.19	15.00	14.00	14.50	22	7	11	5	6	12:16	12:41	12:28:00
12.0	45	12.20	15.00	19.00	17.00	17	0	4	6	7	12:50	13:15	13:02:00
12.0	46	7.63	9.00	45.00	27.00	19	7	10	5	4	13:33	13:58	13:45:00
13.0	47	4.58	10.00	22.00	16.00	10	9	5	4	1	8:52	9:17	9:04:00
13.0	48	0.92	1.00	1.00	1.00	19	6	12	4	3	9:32	9:57	9:44:00
13.0	49	3.81	30.00	13.00	21.50	30	0	11	11	8	10:11	10:36	10:23:00
13.0	50	2.75	20.00	23.00	21.50	13	7	5	5	3	10:49	11:14	11:01:00
14.0	51	6.86	5.00	18.00	11.50	15	5	6	3	6	8:47	9:12	8:59:00
14.0	52	4.58	8.00	17.00	12.50	30	0	14	9	7	9:33	9:58	9:45:00
14.0	53	3.51	15.00	30.00	22.50	29	0	18	6	5	10:21	10:46	10:33:00
14.0	54	0.61	2.00	0.00	1.00	26	5	15	7	4	11:07	11:32	11:19:00
15.0	55	2.14	30.00	7.50	18.75	39	3	25	10	4	8:46	9:11	8:58:00
15.0	57	0.31	0.00	1.00	0.50	16	15	16	7	0	10:03	10:28	10:15:00
15.0	58	9.15	35.00	40.00	37.50	21	4	1	2	18	10:41	11:06	10:53:00
15.0	59	7.78	75.00	20.00	47.50	16	5	3	6	7	11:16	11:41	11:28:00
16.0	60	11.44	55.00	60.00	57.50	14	4	3	7	4	8:23	8:48	8:35:00
16.0	61	0.61	5.00	2.50	3.75	16	3	9	3	4	8:57	9:22	9:09:00
16.0	62	5.34	25.00	25.00	25.00	18	1	6	5	7	9:36	10:01	9:48:00
16.0	63	6.86	35.00	20.00	27.50	20	6	7	6	7	10:12	10:37	10:24:00
16.0	64	11.44	30.00	35.00	32.50	22	3	9	6	7	10:48	11:13	11:00:00
17.0	65	6.86	30.00	60.00	45.00	20	8	5	8	7	8:05	8:30	8:17:00

Table 3. Well density and environmental information for 1996 transects.

Site	Total Transects By Year	Region	Specific Region	Date	WC600 Start	WC600 Stop	WC 600 Mean	WC 600 P/A	WC 600 L(=<.5)/H	WC300 Start	WC300 Stop	WC300 Mean	WC 300 P/A	WC 300 L(=<.5)/H	WD600 wells/mi2
17.0	66	SR	CON.N	Jun 20, 1996	7	5	6.0	P	H	2	3	2.5	P	H	13.74
17.0	67	SR	CON.N	Jun 20, 1996	5	8	6.5	P	H	3	4	3.5	P	H	14.89
17.0	68	SR	CON.N	Jun 20, 1996	8	10	9.0	P	H	4	3	3.5	P	H	20.62
18.0	69	SR	SQL	Jun 21, 1996	1	1	1.0	P	H	1	0	0.5	P	L	2.29
18.0	70	SR	SQL	Jun 21, 1996	1	0	0.5	P	L	0	0	0.0	A	L	1.15
18.0	71	SR	SQL	Jun 21, 1996	0	0	0.0	A	L	0	0	0.0	A	L	0.00
18.0	72	SR	SQL	Jun 21, 1996	0	0	0.0	A	L	0	0	0.0	A	L	0.00
19.0	73	SE	MON	Jun 22, 1996	7	8	7.5	P	H	4	3	3.5	P	H	17.18
19.0	74	SE	MON	Jun 22, 1996	8	7	7.5	P	H	3	2	2.5	P	H	17.18
19.0	75	SE	MON	Jun 22, 1996	7	5	6.0	P	H	2	2	2.0	P	H	13.74
19.0	76	SE	MON	Jun 22, 1996	5	5	5.0	P	H	2	4	3.0	P	H	11.45
21.0	78	SR	MAL	Jun 24, 1996	4	2	3.0	P	H	2	1	1.5	P	H	6.87
21.0	79	SR	MAL	Jun 24, 1996	2	1	1.5	P	H	1	0	0.5	P	L	3.44
21.0	80	SR	MAL	Jun 24, 1996	1	1	1.0	P	H	0	0	0.0	A	L	2.29
21.0	81	SR	MAL	Jun 24, 1996	1	2	1.5	P	H	0	0	0.0	A	L	3.44
21.0	82	SR	MAL	Jun 24, 1996	2	2	2.0	P	H	0	0	0.0	A	L	4.58
22.0	83	SE	PEARL	Jun 25, 1996	7	5	6.0	P	H	2	3	2.5	P	H	13.74
22.0	84	SE	PEARL	Jun 25, 1996	5	6	5.5	P	H	3	1	2.0	P	H	12.60
23.0	85	SR	SQL	Jul 31, 1996	2	2	2.0	P	H	1	1	1.0	P	H	4.58
23.0	86	SR	SQL	Jul 31, 1996	2	2	2.0	P	H	1	0	0.5	P	L	4.58
23.0	87	SR	SQL	Jul 31, 1996	2	2	2.0	P	H	0	0	0.0	A	L	4.58
23.0	88	SR	SQL	Jul 31, 1996	2	0	1.0	P	H	0	0	0.0	A	L	2.29
24.0	89	MR	MR	Aug 1, 1996	0	0	0.0	A	L	0	0	0.0	A	L	0.00
24.0	90	MR	MR	Aug 1, 1996	0	0	0.0	A	L	0	0	0.0	A	L	0.00
24.0	91	MR	MR	Aug 1, 1996	0	0	0.0	A	L	0	0	0.0	A	L	0.00
24.0	92	MR	MR	Aug 1, 1996	0	0	0.0	A	L	0	0	0.0	A	L	0.00
24.0	93	MR	MR	Aug 1, 1996	0	0	0.0	A	L	0	0	0.0	A	L	0.00

Table 3. Well density and environmental information for 1996 transects.

Site	Total Transects By Year	WD600 wells/km2	Cloud Cover % Start	Cloud Cover % Stop	Cloud Cover % Mean	Wind m/s Start	Wind m/s Stop	Wind m/s Mean	Transect Direction degrees	Ts Start	Ts Stop	Ts Mean	Ta Start	Ta Stop	Ta Mean	Relief at 1/3 into Transect m	Relief at 2/3 into Transect m
17.0	66	5.31	0.0	0.0	0.00	0.00	3.00	1.50	280	32.0	31.5	31.8	29.2	30.9	30.1	1.53	9.15
17.0	67	5.75	0.0	0.0	0.00	0.00	3.00	1.50	40	31.5	41.0	36.3	30.9	33.8	32.4	4.58	7.63
17.0	68	7.96	0.0	0.0	0.00	0.00	3.00	1.50	90	41.0	45.0	43.0	33.8	36.0	34.9	3.05	7.63
18.0	69	0.88	0.0	0.0	0.00	7.50	7.00	7.25	5	30.4	34.0	32.2	29.8	31.4	30.6	7.63	0.92
18.0	70	0.44	0.0	0.0	0.00	7.50	7.00	7.25	345	34.0	42.6	38.3	31.4	34.9	33.2	0.31	1.83
18.0	71	0.00	0.0	0.0	0.00	7.50	7.00	7.25	70	42.6	41.0	41.8	34.9	35.4	35.2	0.92	1.22
18.0	72	0.00	0.0	0.0	0.00	7.50	7.00	7.25	100	41.0			35.4	0.0	17.7	1.53	0.92
19.0	73	6.63	12.0	0.0	6.00	4.50	6.00	5.25	305	31.4	34.4	32.9	28.6	30.3	29.5	4.58	2.44
19.0	74	6.63	12.0	0.0	6.00	4.50	6.00	5.25	265	34.4	42.5	38.5	30.3	32.0	31.2	0.92	3.66
19.0	75	5.31	12.0	0.0	6.00	4.50	6.00	5.25	230	42.5	44.8	43.7	32.0	34.0	33.0	4.58	9.15
19.0	76	4.42	12.0	0.0	6.00	4.50	6.00	5.25	140	44.8	46.2	45.5	34.0	34.9	34.5	2.14	1.53
21.0	78	2.65	2.5	1.0	1.75	2.40	0.00	1.20	345	25.0	30.0	27.5	24.6	28.6	26.6	4.27	7.63
21.0	79	1.33	2.5	1.0	1.75	2.40	0.00	1.20	315	30.0	32.2	31.1	28.6	30.0	29.3	4.58	3.66
21.0	80	0.88	2.5	1.0	1.75	2.40	0.00	1.20	350	32.2	35.4	33.8	30.0	30.0	30.0	9.15	4.58
21.0	81	1.33	2.5	1.0	1.75	2.40	0.00	1.20	115	35.4	41.2	38.3	30.0	33.4	31.7	1.22	3.66
21.0	82	1.77	2.5	1.0	1.75	2.40	0.00	1.20	160	41.2	49.8	45.5	33.4	35.8	34.6	2.44	1.53
22.0	83	5.31	70.0	80.0	75.00	3.50	3.50	3.50	40	39.0	43.8	41.4	32.4	33.8	33.1	2.14	4.58
22.0	84	4.86	70.0	80.0	75.00	3.50	3.50	3.50	215	43.8	46.2	45.0	33.8	34.8	34.3	2.75	6.10
23.0	85	1.77	0.0	0.0	0.00	2.00	1.00	1.50	250	29.0	33.8	31.4	26.8	28.6	27.7	6.10	3.05
23.0	86	1.77	0.0	0.0	0.00	2.00	1.00	1.50	0	33.8	34.4	34.1	28.6	29.2	28.9	7.63	3.05
23.0	87	1.77	0.0	0.0	0.00	2.00	1.00	1.50	115	34.4	41.2	37.8	29.2	31.1	30.2	2.44	2.44
23.0	88	0.88	0.0	0.0	0.00	2.00	1.00	1.50	200	41.2	48.2	44.7	31.1	34.0	32.6	4.58	4.58
24.0	89	0.00	15.0	35.0	25.00	0.25	3.25	1.75	275	25.6	28.4	27.0	24.8	27.0	25.9	12.20	1.53
24.0	90	0.00	15.0	35.0	25.00	0.25	3.25	1.75	175	28.4	28.4	28.4	27.0	26.8	26.9	5.19	3.66
24.0	91	0.00	15.0	35.0	25.00	0.25	3.25	1.75	100	28.4	31.4	29.9	26.8	29.2	28.0	12.20	7.63
24.0	92	0.00	15.0	35.0	25.00	0.25	3.25	1.75	25	31.4	30.0	30.7	29.2	31.0	30.1	9.15	2.75
24.0	93	0.00	15.0	35.0	25.00	0.25	3.25	1.75	160	30.0	31.8	30.9	31.0	30.1	30.6	0.92	2.14

Table 3. Well density and environmental information for 1996 transects.

Site	Total Transects By Year	Mean Relief of Transect m	Open Sand % at 1/3 into Transect	Open Sand % at 2/3 into Transect	Mean Open Sand of Transect %	Number of Blowouts	Number of Man Objects	Number of Small Blowouts BS	Number of Medium Blowouts BM	Number of Huge Blowouts BH (unadjusted)	Time of Transect Start	Time 0f Transect Stop	Mean Time of Transect
17.0	66	5.34	8.00	30.00	19.00	35	1	19	10	6	8:37	9:02	8:49:00
17.0	67	6.10	15.00	45.00	30.00	27	9	13	8	6	9:14	9:39	9:26:00
17.0	68	5.34	80.00	35.00	57.50	18	26	7	4	7	9:59	10:24	10:11:00
18.0	69	4.27	35.00	5.00	20.00	21	0	6	4	11	8:13	8:38	8:25:00
18.0	70	1.07	0.00	12.00	6.00	24	0	16	6	2	8:48	9:13	9:00:00
18.0	71	1.07	1.00	3.00	2.00	37	1	28	8	1	9:22	9:47	9:34:00
18.0	72	1.22	30.00	2.50	16.25	36	3	14	17	4	9:55	10:20	10:07:00
19.0	73	3.51	25.00	35.00	30.00	14	9	7	5	2	8:27	8:52	8:39:00
19.0	74	2.29	2.00	30.00	16.00	22	2	13	8	1	9:00	9:25	9:12:00
19.0	75	6.86	50.00	40.00	45.00	15	5	6	5	4	9:33	9:58	9:45:00
19.0	76	1.83	18.00	8.00	13.00	28	4	15	11	2	10:10	10:35	10:22:00
21.0	78	5.95	50.00	45.00	47.50	17	10	3	8	6	8:30	8:55	8:42:00
21.0	79	4.12	38.00	30.00	34.00	18	2	5	2	11	9:04	9:29	9:16:00
21.0	80	6.86	50.00	70.00	60.00	11	7	4	4	3	9:38	10:03	9:50:00
21.0	81	2.44	15.00	60.00	37.50	35	3	19	7	9	10:20	10:45	10:32:00
21.0	82	1.98	35.00	10.00	22.50	28	10	9	15	4	10:54	11:19	11:06:00
22.0	83	3.36	20.00	15.00	17.50	31	3	9	14	8	12:15	12:40	12:27:00
22.0	84	4.42	25.00	45.00	35.00	28	2	6	10	12	12:52	13:17	13:04:00
23.0	85	4.58	50.00	15.00	32.50	25	3	9	9	7	8:20	8:45	8:32:00
23.0	86	5.34	35.00	20.00	27.50	19	0	3	6	10	9:01	9:26	9:13:00
23.0	87	2.44	10.00	20.00	15.00	33	8	9	12	12	9:36	10:01	9:48:00
23.0	88	4.58	7.50	15.00	11.25	13	7	2	1	10	10:16	10:41	10:28:00
24.0	89	6.86	75.00	10.00	42.50	25	0	11	9	5	8:57	9:22	9:09:00
24.0	90	4.42	7.00	3.00	5.00	30	0	18	8	4	9:28	9:53	9:40:00
24.0	91	9.91	45.00	80.00	62.50	22	0	5	3	14	10:02	10:27	10:14:00
24.0	92	5.95	90.00	80.00	85.00	12	0	6	2	4	10:34	10:59	10:46:00
24.0	93	1.53	5.00	9.00	7.00	36	0	17	16	3	11:07	11:32	11:19:00

Table 4. Well density and environmental conditions of the 1997 transects.

Site	Total Transects By Year	Region	Specific Region	Date	WC600 Start	WC600 Stop	WC 600 Mean	WC 600 P/A	WC 600 L(=<.5)/H	WC300 Start	WC300 Stop	WC300 Mean	WC300 P/A	WC 300 L(=<.5)/H
1.0	1	SR	CP	May 27, 1997	0	0	0.0	A	L	0	0	0.0	A	L
1.0	2	SR	CP	May 27, 1997	0	2	1.0	P	H	0	0	0.0	A	L
1.0	3	SR	CP	May 27, 1997	2	2	2.0	P	H	0	1	0.5	P	L
1.0	4	SR	CP	May 27, 1997	2	2	2.0	P	H	1	0	0.5	P	L
2.0	5	SR	CON.N	May 28, 1997	11	8	9.5	P	H	4	4	4.0	P	H
2.0	6	SR	CON.N	May 28, 1997	8	8	8.0	P	H	4	4	4.0	P	H
3.0	7	SR	CON.S	May 29, 1997	2	0	1.0	P	H	1	0	0.5	P	L
3.0	8	SR	CON.S	May 29, 1997	0	0	0.0	A	L	0	0	0.0	A	L
3.0	9	SR	CON.S	May 29, 1997	0	0	0.0	A	L	0	0	0.0	A	L
3.0	10	SR	CON.S	May 29, 1997	0	0	0.0	A	L	0	0	0.0	A	L
3.0	11	SR	CON.S	May 29, 1997	0	0	0.0	A	L	0	0	0.0	A	L
3.0	12	SR	CON.S	May 29, 1997	0	0	0.0	A	L	0	0	0.0	A	L
4.2	14	SR	CON.N	Jun 1, 1997	11	8	9.5	P	H	5	4	4.5	P	H
4.2	15	SR	CON.N	Jun 1, 1997	8	9	8.5	P	H	4	6	5.0	P	H
4.2	16	SR	CON.N	Jun 1, 1997	9	10	9.5	P	H	6	6	6.0	P	H
4.2	17	SR	CON.N	Jun 1, 1997	10	9	9.5	P	H	6	5	5.5	P	H
4.2	18	SR	CON.N	Jun 1, 1997	9	5	7.0	P	H	5	3	4.0	P	H
5.0	19	SR	CP	Jun 2, 1997	3	1	2.0	P	H	2	1	1.5	P	H
5.0	20	SR	CP	Jun 2, 1997	1	1	1.0	P	H	1	0	0.5	A	L
5.0	21	SR	CP	Jun 2, 1997	1	0	0.5	P	L	0	0	0.0	A	L
5.0	22	SR	CP	Jun 2, 1997	0	0	0.0	A	L	0	0	0.0	A	L
6.0	23	SR	DEV	Jun 3, 1997	7	7	7.0	P	H	4	4	4.0	P	H
6.0	24	SR	DEV	Jun 3, 1997	7	8	7.5	P	H	4	4	4.0	P	H
6.0	25	SR	DEV	Jun 3, 1997	8	8	8.0	P	H	4	5	4.5	P	H
6.0	26	SR	DEV	Jun 3, 1997	8	8	8.0	P	H	5	4	4.5	P	H
7.0	28	SR	MAL	Jun 4, 1997	2	1	1.5	P	H	0	0	0.0	A	L
7.0	29	SR	MAL	Jun 4, 1997	1	1	1.0	P	H	0	0	0.0	A	L
7.0	30	SR	MAL	Jun 4, 1997	1	1	1.0	P	H	0	0	0.0	A	L

Table 4. Well density and environmental conditions of the 1997 transects.

Site	Total Transects By Year	WD600 wells/mi2	WD600 wells/km2	Cloud Cover % Start	Cloud Cover % Stop	Cloud Cover % Mean	Wind m/s Start	Wind m/s Stop	Wind m/s Mean	Transect Direction degrees	Ts Start	Ts Stop	Ts Mean	Ta Start	Ta Stop	Ta Mean
1.0	1	0.00	0.00	7.5	5.0	6.25	10.00	2.00	6.00	130	33.7	40.0	36.9	23.8	27.3	25.6
1.0	2	2.29	0.88	7.5	5.0	6.25	10.00	2.00	6.00	40	40.0	44.1	42.1	27.3	28.8	28.1
1.0	3	4.58	1.77	7.5	5.0	6.25	10.00	2.00	6.00	135	44.1	47.0	45.6	28.8	27.7	28.3
1.0	4	4.58	1.77	7.5	5.0	6.25	10.00	2.00	6.00	265	47.0	50.0	48.5	27.7	29.5	28.6
2.0	5	21.76	8.40	20.0	25.0	22.50	5.50	2.50	4.00	210	36.0	42.0	39.0	24.2	25.0	24.6
2.0	6	18.33	7.07	20.0	25.0	22.50	5.50	2.50	4.00	115	42.0	46.5	44.3	25.0	28.8	26.9
3.0	7	2.29	0.88	5.0	80.0	42.50	3.50	2.90	3.20	265	27.5	31.5	29.5	19.0	21.0	20.0
3.0	8	0.00	0.00	5.0	80.0	42.50	3.50	2.90	3.20	280	31.5	34.5	33.0	21.0	23.0	22.0
3.0	9	0.00	0.00	5.0	80.0	42.50	3.50	2.90	3.20	285	34.5	39.2	36.9	23.0	22.8	22.9
3.0	10	0.00	0.00	5.0	80.0	42.50	3.50	2.90	3.20	200	39.2	41.0	40.1	22.8	27.4	25.1
3.0	11	0.00	0.00	5.0	80.0	42.50	3.50	2.90	3.20	130	41.0	46.5	43.8	27.4	32.0	29.7
3.0	12	0.00	0.00	5.0	80.0	42.50	3.50	2.90	3.20	97	46.5	50.0	48.3	32.0	34.0	33.0
4.2	14	21.76	8.40	2.5	2.5	2.50	3.00	6.50	4.80	170	33.3	34.0	33.7	23.0	22.0	22.5
4.2	15	19.47	7.52	2.5	2.5	2.50	3.00	6.50	4.80	265	34.0	37.5	35.8	22.0	26.5	24.3
4.2	16	21.76	8.40	2.5	2.5	2.50	3.00	6.50	4.80	300	37.5	43.2	40.4	26.5	28.2	27.4
4.2	17	21.76	8.40	2.5	2.5	2.50	3.00	6.50	4.80	220	43.2	43.2	43.2	28.2	29.8	29.0
4.2	18	16.03	6.19	2.5	2.5	2.50	3.00	6.50	4.80	285	43.2	46.0	44.6	29.8	31.5	30.7
5.0	19	4.58	1.77	0.0	0.0	0.00	0.50	4.50	2.50	300	25.0	32.2	28.6	21.0	23.0	22.0
5.0	20	2.29	0.88	0.0	0.0	0.00	0.50	4.50	2.50	330	32.2	36.3	34.3	23.0	27.5	25.3
5.0	21	1.15	0.44	0.0	0.0	0.00	0.50	4.50	2.50	60	36.3	37.8	37.1	27.5	29.0	28.3
5.0	22	0.00	0.00	0.0	0.0	0.00	0.50	4.50	2.50	70	37.8	45.9	41.9	29.0	33.0	31.0
6.0	23	16.03	6.19	0.0	0.0	0.00	2.00	3.50	2.80	30	27.0	33.5	30.3	22.6	25.0	23.8
6.0	24	17.18	6.63	0.0	0.0	0.00	2.00	3.50	2.80	350	33.5	35.3	34.4	25.0	26.8	25.9
6.0	25	18.33	7.07	0.0	0.0	0.00	2.00	3.50	2.80	245	35.3	39.5	37.4	26.8	27.0	26.9
6.0	26	18.33	7.07	0.0	0.0	0.00	2.00	3.50	2.80	5	39.5	49.0	44.3	27.0	31.0	29.0
7.0	28	3.44	1.33	40.0	35.0	37.50	3.00	2.00	2.50	140	30.7	32.8	31.8	23.6	25.6	24.6
7.0	29	2.29	0.88	40.0	35.0	37.50	3.00	2.00	2.50	130	32.8	35.2	34.0	25.6	24.9	25.3
7.0	30	2.29	0.88	40.0	35.0	37.50	3.00	2.00	2.50	315	35.2	39.1	37.2	24.9	27.7	26.3

Table 4. Well density and environmental conditions of the 1997 transects.

Site	Total Transects By Year	Relief at 1/3 into Transect m	Relief at 2/3 into Transect m	Mean Relief of Transect m	Open Sand % at 1/3 into Transect	Open Sand % at 2/3 into Transect	Mean Open Sand of Transect %	Number of Blowouts	Number of Man Objects	Time Start	Time Stop	Mean Time of Transect
1.0	1	2.97	3.43	3.20	31.25	40.00	35.63	54	0	10:00	10:25	10:12:30
1.0	2	3.05	1.98	2.52	31.25	21.25	26.25	57	1	10:46	11:11	10:58:30
1.0	3	2.67	1.07	1.87	47.50	10.63	29.06	41	11	11:22	11:47	11:34:30
1.0	4	2.44	1.22	1.83	31.25	12.50	21.88	54	3	12:05	12:30	12:17:30
2.0	5	2.67	1.68	2.17	30.00	17.50	23.75	34	12	10:59	11:24	11:11:30
2.0	6	0.53	0.84	0.69	11.88	12.50	12.19	26	58	11:39	12:04	11:51:30
3.0	7	2.06	2.14	2.10	19.38	18.75	19.06	23	1	8:39	9:05	8:52:00
3.0	8	0.99	0.99	0.99	13.75	5.63	9.69	37	5	9:13	9:38	9:25:30
3.0	9	2.97	1.45	2.21	18.75	13.75	16.25	29	0	9:46	10:23	10:04:30
3.0	10	2.67	1.91	2.29	20.00	35.00	27.50	21	15	10:34	11:02	10:48:00
3.0	11	0.69	0.99	0.84	4.38	10.00	7.19	30	0	11:11	11:36	11:23:30
3.0	12	1.60	1.60	1.60	37.50	20.00	28.75	29	10	11:50	12:15	12:02:30
4.2	14	1.14	1.75	1.45	51.25	27.50	39.38	32	25	8:53	9:18	9:05:30
4.2	15	2.36	2.14	2.25	23.75	20.00	21.88	40	7	9:32	9:57	9:44:30
4.2	16	1.75	2.29	2.02	15.00	31.25	23.13	40	11	10:06	10:31	10:18:30
4.2	17	1.22	1.37	1.30	11.25	15.00	13.13	33	24	10:42	11:07	10:54:30
4.2	18	1.83	2.14	1.98	22.50	17.50	20.00	41	14	11:21	11:46	11:33:30
5.0	19	1.07	3.74	2.40	14.38	43.75	29.06	42	2	8:17	8:42	8:29:30
5.0	20	2.36	1.45	1.91	17.50	15.63	16.56	53	1	8:51	9:16	9:03:30
5.0	21	1.22	1.75	1.49	18.75	15.00	16.88	53	0	9:27	9:52	9:39:30
5.0	22	0.84	0.99	0.92	3.75	9.38	6.56	48	0	10:02	10:27	10:14:30
6.0	23	3.89	3.05	3.48	47.50	41.25	44.38	27	1	8:29	8:54	8:41:30
6.0	24	4.42	3.36	3.90	61.25	37.50	49.38	19	2	9:04	9:29	9:16:30
6.0	25	2.59	4.19	3.39	30.00	48.75	44.06	27	12	9:43	10:08	9:55:30
6.0	26	2.06	2.82	2.44	23.75	47.50	35.63	22	21	10:18	10:43	10:30:30
7.0	28	3.81	4.58	4.21	47.50	48.75	48.13	26	0	9:30	9:55	9:42:30
7.0	29	1.83	4.58	3.20	27.50	42.50	35.00	38	0	10:09	10:34	10:21:30
7.0	30	2.90	4.12	3.51	27.50	47.50	37.50	35	1	10:50	11:15	11:02:30

Table 4. Well density and environmental conditions of the 1997 transects.

Site	Total Transects By Year	Region	Specific Region	Date	WC600 Start	WC600 Stop	WC 600 Mean	WC 600 P/A	WC 600 L(=<.5)/H	WC300 Start	WC300 Stop	WC300 Mean	WC300 P/A	WC 300 L(=<.5)/H
7.0	31	SR	MAL	Jun 4, 1997	1	2	1.5	P	H	0	1	0.5	P	L
8.0	32	SE	MON	Jun 17, 1997	10	9	9.5	P	H	8	6	7.0	P	H
8.0	33	SE	MON	Jun 17, 1997	9	6	7.5	P	H	6	3	4.5	P	H
8.0	34	SE	MON	Jun 17, 1997	6	7	6.5	P	H	3	4	3.5	P	H
8.0	35	SE	MON	Jun 17, 1997	7	8	7.5	P	H	4	5	4.5	P	H
8.0	36	SE	MON	Jun 17, 1997	8	6	7.0	P	H	5	5	5.0	P	H
8.0	37	SE	MON	Jun 17, 1997	6	5	5.5	P	H	5	4	4.5	P	H
9.0	38	SE	MON	Jun 18, 1997	4	2	3.0	P	H	1	0	0.5	P	L
9.0	39	SE	MON	Jun 18, 1997	2	0	1.0	P	H	0	0	0.0	A	L
9.0	40	SE	MON	Jun 18, 1997	0	0	0.0	A	L	0	0	0.0	A	L
9.0	41	SE	MON	Jun 18, 1997	0	0	0.0	A	L	0	0	0.0	A	L
9.0	42	SE	MON	Jun 18, 1997	0	0	0.0	A	L	0	0	0.0	A	L
9.0	43	SE	MON	Jun 18, 1997	0	0	0.0	A	L	0	0	0.0	A	L
10.0	44	SE	EUN	Jun 19, 1997	9	8	8.5	P	H	4	3	3.5	P	H
10.0	45	SE	EUN	Jun 19, 1997	8	8	8.0	P	H	3	5	4.0	P	H
10.0	46	SE	EUN	Jun 19, 1997	8	14	11.0	P	H	5	4	4.5	P	H
10.0	47	SE	EUN	Jun 19, 1997	14	14	14.0	P	H	4	4	4.0	P	H
11.0	48	SE	EUN	Jun 20, 1997	4	3	3.5	P	H	1	1	1.0	P	H
11.0	49	SE	EUN	Jun 20, 1997	3	3	3.0	P	H	1	1	1.0	P	H
11.0	50	SE	EUN	Jun 20, 1997	3	5	4.0	P	H	1	1	1.0	P	H
11.0	51	SE	EUN	Jun 20, 1997	5	5	5.0	P	H	1	1	1.0	P	H
11.0	52	SE	EUN	Jun 20, 1997	5	3	4.0	P	H	1	0	0.5	P	L
12.0	53	SE	MON	Jun 21, 1997	8	9	8.5	P	H	4	4	4.0	P	H
12.0	54	SE	MON	Jun 21, 1997	9	10	9.5	P	H	4	4	4.0	P	H
12.0	55	SE	MON	Jun 21, 1997	10	10	10.0	P	H	4	3	3.5	P	H
12.0	56	SE	MON	Jun 21, 1997	10	12	11.0	P	H	3	2	2.5	P	H
12.0	57	SE	MON	Jun 21, 1997	12	9	10.5	P	H	2	3	2.5	P	H
13.0	58	SE	MON	Jun 23, 1997	1	1	1.0	P	H	1	1	1.0	P	H

Table 4. Well density and environmental conditions of the 1997 transects.

Site	Total Transects By Year	WD600 wells/mi2	WD600 wells/km2	Cloud Cover % Start	Cloud Cover % Stop	Cloud Cover % Mean	Wind m/s Start	Wind m/s Stop	Wind m/s Mean	Transect Direction degrees	Ts Start	Ts Stop	Ts Mean	Ta Start	Ta Stop	Ta Mean
7.0	31	3.44	1.33	40.0	35.0	37.50	3.00	2.00	2.50	0	39.1	44.2	41.7	27.7	27.5	27.6
8.0	32	21.76	8.40	0.0	0.0	0.00	0.25	2.75	1.50	135	22.5	28.8	25.7	21.0	23.8	22.4
8.0	33	17.18	6.63	0.0	0.0	0.00	0.25	2.75	1.50	110	28.8	30.5	29.7	23.8	25.1	24.5
8.0	34	14.89	5.75	0.0	0.0	0.00	0.25	2.75	1.50	100	30.5	38.2	34.4	25.1	28.7	26.9
8.0	35	17.18	6.63	0.0	0.0	0.00	0.25	2.75	1.50	130	38.2	39.5	38.9	28.7	29.9	29.3
8.0	36	16.03	6.19	0.0	0.0	0.00	0.25	2.75	1.50	130	39.5	43.8	41.7	29.9	31.3	30.6
8.0	37	12.60	4.86	0.0	0.0	0.00	0.25	2.75	1.50	90	43.8	48.8	46.3	31.3	32.3	31.8
9.0	38	6.87	2.65	3.0	3.0	3.00	0.50	5.00	2.80	275	23.0	26.3	24.7	21.8	24.8	23.3
9.0	39	2.29	0.88	3.0	3.0	3.00	0.50	5.00	2.80	260	26.3	34.2	30.3	24.8	26.3	25.6
9.0	40	0.00	0.00	3.0	3.0	3.00	0.50	5.00	2.80	270	34.2	35.8	35.0	26.3	27.8	27.1
9.0	41	0.00	0.00	3.0	3.0	3.00	0.50	5.00	2.80	290	35.8	38.8	37.3	27.8	28.2	28.0
9.0	42	0.00	0.00	3.0	3.0	3.00	0.50	5.00	2.80	280	38.8	40.6	39.7	28.2	30.2	29.2
9.0	43	0.00	0.00	3.0	3.0	3.00	0.50	5.00	2.80	275	40.6	45.5	43.1	30.2	31.0	30.6
10.0	44	19.47	7.52	20.0	15.0	17.50	7.00	5.50	6.30	120	25.8	29.8	27.8	24.4	26.8	25.6
10.0	45	18.33	7.07	20.0	15.0	17.50	7.00	5.50	6.30	130	29.8	33.5	31.7	26.8	29.2	28.0
10.0	46	25.20	9.73	20.0	15.0	17.50	7.00	5.50	6.30	125	33.5	39.6	36.6	29.2	31.8	30.5
10.0	47	32.07	12.38	20.0	15.0	17.50	7.00	5.50	6.30	125	39.6	47.1	43.4	31.8	33.0	32.4
11.0	48	8.02	3.09	50.0	30.0	40.00	2.25	4.50	3.40	130	30.5	37.2	33.9	25.0	28.0	26.5
11.0	49	6.87	2.65	50.0	30.0	40.00	2.25	4.50	3.40	120	37.2	39.2	38.2	28.0	30.8	29.4
11.0	50	9.16	3.54	50.0	30.0	40.00	2.25	4.50	3.40	140	39.2	45.5	42.4	30.8	34.0	32.4
11.0	51	11.45	4.42	50.0	30.0	40.00	2.25	4.50	3.40	290	45.5	44.5	45.0	34.0	33.2	33.6
11.0	52	9.16	3.54	50.0	30.0	40.00	2.25	4.50	3.40	285	44.5	47.4	46.0	33.2	35.6	34.4
12.0	53	19.47	7.52	5.0	5.0	5.00	1.00	1.00	1.00	220	22.6	29.2	25.9	18.7	22.9	20.8
12.0	54	21.76	8.40	5.0	5.0	5.00	1.00	1.00	1.00	210	29.2	30.5	29.9	22.9	25.2	24.1
12.0	55	22.91	8.84	5.0	5.0	5.00	1.00	1.00	1.00	200	30.5	31.0	30.8	25.2	24.9	25.1
12.0	56	25.20	9.73	5.0	5.0	5.00	1.00	1.00	1.00	220	31.0	39.2	35.1	24.9	27.8	26.4
12.0	57	24.05	9.28	5.0	5.0	5.00	1.00	1.00	1.00	170	39.2	50.0	44.6	27.8	30.2	29.0
13.0	58	2.29	0.88	15.0	5.0	10.00	2.50	9.00	5.80	115	29.5	34.0	31.8	24.8	25.7	25.3

Table 4. Well density and environmental conditions of the 1997 transects.

Site	Total Transects By Year	Relief at 1/3 into Transect m	Relief at 2/3 into Transect m	Mean Relief of Transect m	Open Sand % at 1/3 into Transect	Open Sand % at 2/3 into Transect	Mean Open Sand of Transect %	Number of Blowouts	Number of Man Objects	Time Start	Time Stop	Mean Time of Transect
7.0	31	2.44	2.97	2.71	37.50	23.13	30.31	43	3	11:28	11:53	11:40:30
8.0	32	2.90	2.29	2.59	38.75	21.50	30.13	15	31	8:24	8:49	8:36:30
8.0	33	1.07	1.53	1.30	20.00	16.88	18.44	27	14	8:58	9:23	9:10:30
8.0	34	3.51	1.45	2.48	37.50	35.00	36.25	27	10	9:37	10:02	9:49:30
8.0	35	2.06	1.68	1.87	21.25	15.00	18.13	28	10	10:13	10:38	10:25:30
8.0	36	1.37	2.67	2.02	32.50	28.75	30.63	38	16	10:53	11:18	11:05:30
8.0	37	2.14	1.45	1.79	26.25	23.75	25.00	37	6	11:28	11:53	11:40:30
9.0	38	3.05	2.29	2.67	20.00	18.75	19.38	37	0	7:42	8:07	7:54:30
9.0	39	2.36	3.58	2.97	33.75	31.25	32.50	27	7	8:17	8:42	8:29:30
9.0	40	2.21	0.92	1.56	28.75	12.50	20.63	60	4	8:51	9:16	9:03:30
9.0	41	1.45	1.60	1.53	30.00	26.25	28.13	43	3	9:24	9:49	9:36:30
9.0	42	3.20	3.58	3.39	33.75	43.75	38.75	25	3	10:00	10:25	10:12:30
9.0	43	1.53	1.37	1.45	31.25	26.88	29.06	41	1	10:33	10:58	10:45:30
10.0	44	1.68	1.14	1.41	16.25	8.75	12.50	29	21	8:10	8:35	8:22:30
10.0	45	0.76	2.06	1.41	3.75	15.63	9.69	54	6	8:43	9:08	8:55:30
10.0	46	2.14	3.81	2.97	19.38	36.25	27.81	27	35	9:22	9:47	9:34:30
10.0	47	3.05	1.37	2.21	22.50	20.63	21.56	46	21	9:59	10:24	10:11:30
11.0	48	4.88	3.43	4.15	48.75	38.75	43.75	33	0	9:05	9:30	9:17:30
11.0	49	3.97	1.30	2.63	41.25	15.00	28.13	43	4	9:40	10:05	9:52:30
11.0	50	1.45	1.07	1.26	15.63	11.88	13.75	35	6	10:11	10:36	10:23:30
11.0	51	1.75	3.43	2.59	18.75	40.00	29.38	40	7	10:50	11:15	11:02:30
11.0	52	1.91	1.53	1.72	21.25	13.75	17.50	49	14	11:25	11:50	11:37:30
12.0	53	2.90	1.98	2.44	33.75	18.75	26.25	29	8	7:36	8:01	7:48:30
12.0	54	4.37	4.27	4.30	31.67	38.75	35.71	20	0	8:09	8:34	8:21:30
12.0	55	1.45	1.83	1.61	20.00	26.67	22.86	32	5	8:45	9:16	9:00:30
12.0	56	2.06	1.83	1.95	35.00	22.50	28.75	27	7	9:27	9:52	9:39:30
12.0	57	2.90	1.83	2.36	53.75	37.50	45.63	32	7	10:09	10:34	10:21:30
13.0	58	3.74	4.27	4.00	48.75	63.75	56.25	27	0	8:52	9:17	9:04:30

Table 4. Well density and environmental conditions of the 1997 transects.

Site	Total Transects By Year	Region	Specific Region	Date	WC600 Start	WC600 Stop	WC 600 Mean	WC 600 P/A	WC 600 L(=<.5)/H	WC300 Start	WC300 Stop	WC300 Mean	WC300 P/A	WC 300 L(=<.5)/H
13.0	59	SE	MON	Jun 23, 1997	1	1	1.0	P	H	1	0	0.5	P	L
13.0	60	SE	MON	Jun 23, 1997	1	1	1.0	P	H	0	0	0.0	A	L
13.0	61	SE	MON	Jun 23, 1997	1	0	0.5	P	L	0	0	0.0	A	L
13.0	62	SE	MON	Jun 23, 1997	0	0	0.0	A	L	0	0	0.0	A	L
14.0	63	SE	EUN	Jun 24, 1997	3	1	2.0	P	H	0	0	0.0	A	L
14.0	64	SE	EUN	Jun 24, 1997	1	1	1.0	P	H	0	0	0.0	A	L
14.0	65	SE	EUN	Jun 24, 1997	1	3	2.0	P	H	0	1	0.5	P	L
14.0	66	SE	EUN	Jun 24, 1997	3	3	3.0	P	H	1	1	1.0	P	H
14.0	67	SE	EUN	Jun 24, 1997	3	2	2.5	P	H	1	1	1.0	P	H

Table 4. Well density and environmental conditions of the 1997 transects.

Site	Total Transects By Year	WD600 wells/mi2	WD600 wells/km2	Cloud Cover % Start	Cloud Cover % Stop	Cloud Cover % Mean	Wind m/s Start	Wind m/s Stop	Wind m/s Mean	Transect Direction degrees	Ts Start	Ts Stop	Ts Mean	Ta Start	Ta Stop	Ta Mean
13.0	59	2.29	0.88	15.0	5.0	10.00	2.50	9.00	5.80	135	34.0	39.3	36.7	25.7	27.3	26.5
13.0	60	2.29	0.88	15.0	5.0	10.00	2.50	9.00	5.80	140	39.3	45.8	42.6	27.3	31.8	29.6
13.0	61	1.15	0.44	15.0	5.0	10.00	2.50	9.00	5.80	115	45.8	49.0	47.4	31.8	32.2	32.0
13.0	62	0.00	0.00	15.0	5.0	10.00	2.50	9.00	5.80	70	49.0	48.0	48.5	32.2	32.2	32.2
14.0	63	4.58	1.77	0.0	0.0	0.00	6.25	3.00	4.60	330	28.0	31.2	29.6	22.0	23.2	22.6
14.0	64	2.29	0.88	0.0	0.0	0.00	6.25	3.00	4.60	345	31.2	37.0	34.1	23.2	25.2	24.2
14.0	65	4.58	1.77	0.0	0.0	0.00	6.25	3.00	4.60	310	37.0	43.0	40.0	25.2	30.0	27.6
14.0	66	6.87	2.65	0.0	0.0	0.00	6.25	3.00	4.60	245	43.0	43.9	43.5	30.0	30.3	30.2
14.0	67	5.73	2.21	0.0	0.0	0.00	6.25	3.00	4.60	245	43.9	47.3	45.6	30.3	31.8	31.1

Table 4. Well density and environmental conditions of the 1997 transects.

Site	Total Transects By Year	Relief at 1/3 into Transect m	Relief at 2/3 into Transect m	Mean Relief of Transect m	Open Sand % at 1/3 into Transect	Open Sand % at 2/3 into Transect	Mean Open Sand of Transect %	Number of Blowouts	Number of Man Objects	Time Start	Time Stop	Mean Time of Transect
13.0	59	2.52	2.06	2.29	46.25	35.00	40.63	28	4	9:22	9:47	9:34:30
13.0	60	2.14	0.69	1.41	35.00	10.63	22.81	45	0	9:54	10:19	10:06:30
13.0	61	2.59	2.36	2.48	32.50	37.50	35.00	40	4	10:24	10:49	10:36:30
13.0	62	1.98	0.76	1.37	27.50	32.50	30.00	35	0	10:56	11:21	11:08:30
14.0	63	2.82	1.98	2.40	15.63	23.75	19.69	25	0	8:12	8:37	8:24:30
14.0	64	1.22	2.67	1.95	8.13	30.00	19.06	26	1	8:45	9:10	8:57:30
14.0	65	5.03	5.34	5.19	46.25	51.25	48.75	27	0	9:19	9:44	9:31:30
14.0	66	4.96	4.27	4.61	53.75	45.00	49.38	15	0	9:57	10:22	10:09:30
14.0	67	3.05	1.60	2.33	25.63	20.00	22.81	40	1	10:32	10:57	10:44:30

Table 5. Reptile counts on the 1996 transects.

Site	Total Transects By Year	Sa Total	Sa M	Sa F	Us Total	Us M	Us F	Ct	Cs	Hm	Su	Pc	Pm	No ID Lizard	To	To Tracks	Snakes All Species	Snake Tracks	*Heterodon nasicus*	*Masticophis flagellum*
1.0	1	8	2	1	16	8	6	2	0	0	0	0	0	0	0	0	0	0	0	0
1.0	2	6	1	10	5	10	4	2	0	0	0	0	0	0	1	0	0	0	0	0
1.0	3	5	1	1	11	6	5	0	0	0	0	0	0	2	0	0	0	2	0	0
2.0	5	2	0	0	5	3	2	0	0	0	1	0	0	1	1	3	0	0	0	0
2.0	6	7	1	3	10	5	5	1	0	0	1	0	0	0	0	2	0	0	0	0
2.0	7	2	1	0	14	7	7	0	0	0	2	0	0	0	0	1	0	0	0	0
2.0	8	1	0	0	4	3	1	0	0	2	2	0	0	1	0	0	0	0	0	0
3.0	9	5	0	1	8	3	5	0	0	1	2	0	0	0	0	0	0	2	0	0
3.0	10	3	0	1	12	4	8	4	0	0	0	0	0	0	0	0	0	0	0	0
3.0	11	2	0	0	20	6	6	0	0	0	1	0	0	2	0	0	0	1	0	0
3.0	12	1	0	0	3	1	1	2	1	0	1	0	0	0	0	0	0	0	0	0
4.0	13	5	1	0	3	1	1	0	0	0	1	0	0	1	1	0	1	1	0	0
4.0	14	2	0	0	6	3	2	1	0	1	0	0	0	1	0	0	1	3	1	0
4.0	15	14	1	1	12	3	9	0	0	0	2	0	0	0	0	0	0	2	0	0
4.0	16	1	0	0	11	2	3	0	0	0	0	0	0	1	0	1	0	1	0	0
5.0	17	2	0	0	17	9	8	2	0	0	1	0	0	0	0	0	0	0	0	0
6.0	19	8	0	0	7	2	4	0	0	1	1	0	0	1	0	0	0	2	0	0
6.0	20	4	0	1	15	7	8	0	0	0	2	0	0	2	1	0	0	0	0	0
6.0	21	3	0	1	19	8	11	0	1	2	0	0	0	1	0	5	0	3	0	0
6.0	22	0	0	0	4	0	0	1	0	0	0	0	0	0	0	1	0	2	0	0
7.0	23	8	0	0	10	3	5	1	0	0	0	0	0	0	1	0	0	0	0	0
7.0	24	6	1	1	6	3	2	0	1	1	1	0	0	2	0	0	0	0	0	0
7.0	25	3	1	0	14	7	7	0	0	0	1	0	0	0	0	0	0	0	0	0
7.0	26	5	2	1	3	1	2	0	0	0	1	0	0	2	0	0	0	0	0	0
8.0	27	4	0	1	10	3	7	0	0	0	0	0	0	2	0	0	0	0	0	0
8.0	28	0	0	0	16	9	7	0	0	0	1	0	0	2	0	3	0	1	0	0
8.0	29	3	1	0	19	10	7	0	0	0	0	0	0	0	0	3	0	1	0	0
8.0	30	3	0	0	11	7	4	0	0	1	0	0	0	2	0	1	0	0	0	0
9.0	31	4	0	1	0	0	0	0	0	1	1	0	0	1	0	0	2	6	2	0

Table 5. Reptile counts on the 1996 transects.

Site	Total Transects By Year	*Crotalus viridus*	*Sistrurus catenatus*	*Pituophis melanoleucus*	*Arizona elegans*	Us Hatchling	Sa Hatchling	Total Reptiles	Total Lizards	Total Whiptails	Total Turtles (To + To Tracks)	Total Snakes (Snakes All Sps.+ Snake Tracks)
1.0	1	0	0	0	0	0	0	26	26	2	0	0
1.0	2	0	0	0	0	0	0	14	13	2	1	0
1.0	3	0	0	0	0	0	0	20	18	0	0	2
2.0	5	0	0	0	0	0	0	13	9	0	4	0
2.0	6	0	0	0	0	0	0	21	19	1	2	0
2.0	7	0	0	0	0	0	0	19	18	0	1	0
2.0	8	0	0	0	0	0	0	10	10	0	0	0
3.0	9	0	0	0	0	0	0	18	16	0	0	2
3.0	10	0	0	0	0	0	0	19	19	4	0	0
3.0	11	0	0	0	0	0	0	26	25	0	0	1
3.0	12	0	0	0	0	0	0	8	8	3	0	0
4.0	13	0	0	1	0	0	0	13	10	0	1	2
4.0	14	0	0	0	0	0	0	15	11	1	0	4
4.0	15	0	0	0	0	0	0	30	28	0	0	2
4.0	16	0	0	0	0	0	0	15	13	0	1	1
5.0	17	0	0	0	0	0	0	22	22	2	0	0
6.0	19	0	0	0	0	0	0	20	18	0	0	2
6.0	20	0	0	0	0	0	0	24	23	0	1	0
6.0	21	0	0	0	0	0	0	34	26	1	5	3
6.0	22	0	0	0	0	0	0	8	5	1	1	2
7.0	23	0	0	0	0	0	0	20	19	1	1	0
7.0	24	0	0	0	0	0	0	17	17	1	0	0
7.0	25	0	0	0	0	0	0	18	18	0	0	0
7.0	26	0	0	0	0	0	0	11	11	0	0	0
8.0	27	0	0	0	0	0	0	16	16	0	0	0
8.0	28	0	0	0	0	0	0	23	19	0	3	1
8.0	29	0	0	0	0	0	0	26	22	0	3	1
8.0	30	0	0	0	0	0	0	18	17	0	1	0
9.0	31	0	0	0	0	0	0	15	7	0	0	8

Table 5. Reptile counts on the 1996 transects.

Site	Total Transects By Year	Total Reptiles Without Sa	Total Reptiles Without Sa, Us	Total Lizards Without Sa	Total Lizards Without Sa, Us	Sex Ratio Sa M - F	Sex Ratio Us M - F
1.0	1	18		18	2	1	2
1.0	2	8		7	2	-9	6
1.0	3	15		13	2	0	1
2.0	5	11		7	2	0	1
2.0	6	14		12	2	-2	0
2.0	7	17		16	2	1	0
2.0	8	9		9	5	0	2
3.0	9	13		11	3	-1	-2
3.0	10	16		16	4	-1	-4
3.0	11	24		23	3	0	0
3.0	12	7		7	4	0	0
4.0	13	8		5	2	1	0
4.0	14	13		9	3	0	1
4.0	15	16		14	2	0	-6
4.0	16	14		12	1	0	-1
5.0	17	20		20	3	0	1
6.0	19	12		10	3	0	-2
6.0	20	20		19	4	-1	-1
6.0	21	31		23	4	-1	-3
6.0	22	8		5	1	0	0
7.0	23	12		11	1	0	-2
7.0	24	11		11	5	0	1
7.0	25	15		15	1	1	0
7.0	26	6		6	3	1	-1
8.0	27	12		12	2	-1	-4
8.0	28	23		19	3	0	2
8.0	29	23		19	0	1	3
8.0	30	15		14	3	0	3
9.0	31	11		3	3	-1	0

Table 5. Reptile counts on the 1996 transects.

Site	Total Transects By Year	Sa Total	Sa M	Sa F	Us Total	Us M	Us F	Ct	Cs	Hm	Su	Pc	Pm	No ID Lizard	To	To Tracks	Snakes All Species	Snake Tracks	*Heterodon nasicus*	*Masticophis flagellum*
9.0	34	15	2	4	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0
9.0	35	6	3	2	0	0	0	0	0	1	1	0	0	0	0	0	1	0	0	1
10.0	36	9	2	2	4	3	1	0	0	0	0	0	0	0	0	4	0	1	0	0
10.0	37	7	0	1	0	0	0	0	0	0	0	1	0	1	0	6	0	2	0	0
10.0	38	10	2	2	0	0	0	0	0	0	0	0	0	1	0	3	0	1	0	0
11.0	39	19	2	2	6	1	5	4	0	0	0	0	0	4	0	0	1	0	0	1
11.0	40	10	3	6	5	2	3	4	1	6	0	0	0	2	0	0	0	0	0	0
11.0	41	9	3	1	9	5	4	8	1	1	2	0	0	1	0	0	0	1	0	0
11.0	42	6	2	0	2	0	2	0	1	0	1	0	0	1	0	0	0	0	0	0
12.0	43	14	5	3	1	0	1	1	0	0	2	0	0	3	0	0	0	0	0	0
12.0	44	3	3	0	4	0	4	0	0	1	1	0	0	0	0	0	0	4	0	0
12.0	45	11	1	1	3	2	1	0	0	0	1	0	0	3	0	0	0	3	0	0
12.0	46	8	2	3	1	0	1	0	0	0	1	0	0	3	0	0	0	0	0	0
13.0	47	4	2	1	6	3	3	4	0	0	0	0	0	2	0	4	0	0	0	0
13.0	48	1	1	0	9	2	7	1	0	0	2	0	0	3	0	1	0	0	0	0
13.0	49	8	0	0	10	4	6	5	0	0	0	0	0	3	0	1	0	0	0	0
13.0	50	8	2	2	11	5	6	4	0	1	0	0	0	7	0	1	0	0	0	0
14.0	51	14	6	4	2	0	1	8	0	0	0	0	0	2	0	2	0	1	0	0
14.0	52	6	3	2	7	4	3	3	1	0	2	0	0	3	1	0	0	2	0	0
14.0	53	12	5	2	4	0	4	7	1	2	1	0	0	3	0	1	1	2	1	0
14.0	54	11	3	3	13	4	4	3	0	2	0	0	0	1	0	0	0	0	0	0
15.0	55	0	0	0	22	12	8	0	0	1	0	0	0	1	0	0	0	0	0	0
15.0	57	2	0	1	9	2	5	0	0	1	0	0	0	3	0	1	0	0	0	0
15.0	58	5	1	1	30	19	11	2	0	2	0	0	0	0	0	0	0	0	0	0
15.0	59	5	0	0	20	12	8	4	0	0	0	0	0	1	0	1	0	1	0	0
16.0	60	10	6	2	13	4	7	0	0	0	1	0	0	2	0	0	0	10	0	0
16.0	61	4	2	1	14	6	8	0	0	1	1	0	0	1	0	0	0	7	0	0
16.0	62	12	4	4	13	8	5	0	0	1	0	0	0	1	0	0	0	7	0	0
16.0	63	18	5	5	18	9	9	1	0	0	0	0	0	0	0	3	0	12	0	0

Table 5. Reptile counts on the 1996 transects.

Site	Total Transects By Year	*Crotalus viridus*	*Sistrurus catenatus*	*Pituophis melanoleucus*	*Arizona elegans*	Us Hatchling	Sa Hatchling	Total Reptiles	Total Lizards	Total Whiptails	Total Turtles (To + To Tracks)	Total Snakes (Snakes All Sps.+ Snake Tracks)
9.0	34	0	0	0	0	0	0	17	17	1	0	0
9.0	35	0	0	0	0	0	0	9	8	0	0	1
10.0	36	0	0	0	0	0	0	18	13	0	4	1
10.0	37	0	0	0	0	0	0	17	9	0	6	2
10.0	38	0	0	0	0	0	0	15	11	0	3	1
11.0	39	0	0	0	0	0	0	34	33	4	0	1
11.0	40	0	0	0	0	0	0	28	28	5	0	0
11.0	41	0	0	0	0	0	0	32	31	9	0	1
11.0	42	0	0	0	0	0	0	11	11	1	0	0
12.0	43	0	0	0	0	0	0	21	21	1	0	0
12.0	44	0	0	0	0	0	0	13	9	0	0	4
12.0	45	0	0	0	0	0	0	21	18	0	0	3
12.0	46	0	0	0	0	0	0	13	13	0	0	0
13.0	47	0	0	0	0	0	0	20	16	4	4	0
13.0	48	0	0	0	0	0	0	17	16	1	1	0
13.0	49	0	0	0	0	0	0	27	26	5	1	0
13.0	50	0	0	0	0	0	0	32	31	4	1	0
14.0	51	0	0	0	0	0	0	29	26	8	2	1
14.0	52	0	0	0	0	0	0	25	22	4	1	2
14.0	53	0	0	0	0	0	0	34	30	8	1	3
14.0	54	0	0	0	0	0	0	30	30	3	0	0
15.0	55	0	0	0	0	0	0	24	24	0	0	0
15.0	57	0	0	0	0	0	0	16	15	0	1	0
15.0	58	0	0	0	0	0	0	39	39	2	0	0
15.0	59	0	0	0	0	0	0	32	30	4	1	1
16.0	60	0	0	0	0	0	0	36	26	0	0	10
16.0	61	0	0	0	0	0	0	28	21	0	0	7
16.0	62	0	0	0	0	0	0	34	27	0	0	7
16.0	63	0	0	0	0	0	0	52	37	1	3	12

Table 5. Reptile counts on the 1996 transects.

Site	Total Transects By Year	Total Reptiles Without Sa	Total Reptiles Without Sa, Us	Total Lizards Without Sa	Total Lizards Without Sa, Us	Sex Ratio Sa M - F	Sex Ratio Us M - F
9.0	34	2		2	2	-2	0
9.0	35	3		2	2	1	0
10.0	36	9		4	0	0	2
10.0	37	10		2	2	-1	0
10.0	38	5		1	1	0	0
11.0	39	15		14	8	0	-4
11.0	40	18		18	13	-3	-1
11.0	41	23		22	13	2	1
11.0	42	5		5	3	2	-2
12.0	43	7		7	6	2	-1
12.0	44	10		6	2	3	-4
12.0	45	10		7	4	0	1
12.0	46	5		5	4	-1	-1
13.0	47	16		12	6	1	0
13.0	48	16		15	6	1	-5
13.0	49	19		18	8	0	-2
13.0	50	24		23	12	0	-1
14.0	51	15		12	10	2	-1
14.0	52	19		16	9	1	1
14.0	53	22		18	14	3	-4
14.0	54	19		19	6	0	0
15.0	55	24		24	2	0	4
15.0	57	14		13	4	-1	-3
15.0	58	34		34	4	0	8
15.0	59	27		25	5	0	4
16.0	60	26		16	3	4	-3
16.0	61	24		17	3	1	-2
16.0	62	22		15	2	0	3
16.0	63	34		19	1	0	0

Table 5. Reptile counts on the 1996 transects.

Site	Total Transects By Year	Sa Total	Sa M	Sa F	Us Total	Us M	Us F	Ct	Cs	Hm	Su	Pc	Pm	No ID Lizard	To	To Tracks	Snakes All Species	Snake Tracks	*Heterodon nasicus*	*Masticophis flagellum*
16.0	64	12	4	5	13	7	6	0	0	0	0	0	0	0	0	4	0	12	0	0
17.0	65	4	1	2	9	5	4	2	1	0	0	0	0	1	0	1	0	5	0	0
17.0	66	5	2	0	7	5	2	0	0	1	1	0	0	3	0	3	0	3	0	0
17.0	67	1	0	0	14	8	6	4	0	0	2	0	0	0	0	1	0	4	0	0
17.0	68	6	0	4	16	5	11	0	2	0	2	0	0	0	0	5	0	1	0	0
18.0	69	1	1	0	5	5	0	1	0	0	0	0	0	0	0	9	0	1	0	0
18.0	70	2	0	0	8	2	6	0	0	0	1	0	0	2	0	4	0	0	0	0
18.0	71	3	2	0	8	2	6	1	0	0	1	0	0	4	0	7	0	0	0	0
18.0	72	4	2	1	5	2	3	2	0	0	0	0	0	1	0	2	0	1	0	0
19.0	73	7	2	2	13	8	5	6	1	0	1	0	0	2	0	0	0	2	0	0
19.0	74	1	0	0	10	2	7	12	0	2	1	0	0	1	0	0	0	3	0	0
19.0	75	9	2	3	8	3	4	7	2	0	2	0	0	1	0	1	0	0	0	0
19.0	76	6	1	3	7	3	4	5	0	3	1	0	0	2	0	0	0	0	0	0
21.0	78	7	2	0	11	8	3	0	0	0	0	1	0	2	0	10	0	2	0	0
21.0	79	10	2	3	11	3	8	0	1	1	1	0	0	0	0	5	0	3	0	0
21.0	80	7	1	2	11	4	7	5	0	0	0	0	0	0	0	7	1	3	0	0
21.0	81	2	0	0	15	7	8	4	3	0	0	0	0	0	0	5	0	4	0	0
21.0	82	6	2	1	17	8	9	0	2	0	0	1	0	2	0	7	0	0	0	0
22.0	83	3	0	0	4	1	3	2	3	0	0	0	0	0	0	1	0	1	0	0
22.0	84	3	1	3	3	2	4	1	2	0	0	0	0	1	0	0	0	2	0	0
23.0	85	1	0	1	17	6	7	1	0	0	0	0	0	2	1	2	0	1	0	0
23.0	86	1	0	0	20	6	6	0	0	0	0	0	0	0	0	2	0	1	0	0
23.0	87	2	0	0	10	1	5	5	0	1	0	0	0	1	0	11	0	3	0	0
23.0	88	4	0	1	11	2	4	1	1	0	0	0	0	1	0	9	0	1	0	0
24.0	89	26	7	6	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0
24.0	90	15	1	4	1	0	0	0	0	0	2	0	0	4	0	0	0	0	0	0
24.0	91	31	5	10	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
24.0	92	22	4	8	1	1	0	0	0	0	0	0	0	3	0	0	1	0	0	1
24.0	93	19	2	4	2	0	1	0	0	0	0	0	0	2	0	0	1	0	0	1

Table 5. Reptile counts on the 1996 transects.

Site	Total Transects By Year	*Crotalus viridus*	*Sistrurus catenatus*	*Pituophis melanoleucus*	*Arizona elegans*	Us Hatchling	Sa Hatchling	Total Reptiles	Total Lizards	Total Whiptails	Total Turtles (To + To Tracks)	Total Snakes (Snakes All Sps.+ Snake Tracks)
16.0	64	0	0	0	0	0	0	41	25	0	4	12
17.0	65	0	0	0	0	0	0	23	17	3	1	5
17.0	66	0	0	0	0	0	0	23	17	0	3	3
17.0	67	0	0	0	0	0	0	26	21	4	1	4
17.0	68	0	0	0	0	0	0	32	26	2	5	1
18.0	69	0	0	0	0	0	0	17	7	1	9	1
18.0	70	0	0	0	0	0	0	17	13	0	4	0
18.0	71	0	0	0	0	0	0	24	17	1	7	0
18.0	72	0	0	0	0	0	0	15	12	2	2	1
19.0	73	0	0	0	0	0	0	32	30	7	0	2
19.0	74	0	0	0	0	0	0	30	27	12	0	3
19.0	75	0	0	0	0	0	0	30	29	9	1	0
19.0	76	0	0	0	0	0	0	24	24	5	0	0
21.0	78	0	0	0	0	0	0	33	21	0	10	2
21.0	79	0	0	0	0	0	0	32	24	1	5	3
21.0	80	1	0	0	0	0	0	34	23	5	7	4
21.0	81	0	0	0	0	0	0	33	24	7	5	4
21.0	82	0	0	0	0	0	0	35	28	2	7	0
22.0	83	0	0	0	0	0	0	14	12	5	1	1
22.0	84	0	0	0	0	0	0	12	10	3	0	2
23.0	85	0	0	0	0	4	0	25	21	1	3	1
23.0	86	0	0	0	0	8	0	24	21	0	2	1
23.0	87	0	0	0	0	4	0	33	19	5	11	3
23.0	88	0	0	0	0	5	0	28	18	2	9	1
24.0	89	0	0	0	0	0	1	29	29	0	0	0
24.0	90	0	0	0	0	1	0	22	22	0	0	0
24.0	91	0	0	0	0	0	1	32	32	0	0	0
24.0	92	0	0	0	0	0	1	27	26	0	0	1
24.0	93	0	0	0	0	1	4	24	23	0	0	1

Table 5. Reptile counts on the 1996 transects.

Site	Total Transects By Year	Total Reptiles Without Sa	Total Reptiles Without Sa, Us	Total Lizards Without Sa	Total Lizards Without Sa, Us	Sex Ratio Sa M - F	Sex Ratio Us M - F
16.0	64	29		13	0	-1	1
17.0	65	19		13	4	-1	1
17.0	66	18		12	5	2	3
17.0	67	25		20	6	0	2
17.0	68	26		20	4	-4	-6
18.0	69	16		6	1	1	5
18.0	70	15		11	3	0	-4
18.0	71	21		14	6	2	-4
18.0	72	11		8	3	1	-1
19.0	73	25		23	10	0	3
19.0	74	29		26	16	0	-5
19.0	75	21		20	12	-1	-1
19.0	76	18		18	11	-2	-1
21.0	78	26		14	3	2	5
21.0	79	22		14	3	-1	-5
21.0	80	27		16	5	-1	-3
21.0	81	31		22	7	0	-1
21.0	82	29		22	5	1	-1
22.0	83	11		9	5	0	-2
22.0	84	9		7	4	-2	-2
23.0	85	24		20	3	-1	-1
23.0	86	23		20	0	0	0
23.0	87	31		17	7	0	-4
23.0	88	24		14	3	-1	-2
24.0	89	3		3	3	1	0
24.0	90	7		7	6	-3	0
24.0	91	1		1	1	-5	0
24.0	92	5		4	3	-4	1
24.0	93	5		4	2	-2	-1

Table 6. Reptile counts on the 1997 transects.

Site	Total Transects By Year	Sa Total	Sa M	Sa F	Us Total	Us M	Us F	Ct	Cs	Hm	Su	Pc	Pm	No ID Lizard	To	To Tracks	Snakes All Species	Snake Tracks	*Heterodon nasicus*	*Masticophis flagellum*
1.0	1	11	1	1	45	26	18	2	0	0	0	0	0	5	0	2	0	0	0	0
1.0	2	7	1	0	32	9	19	6	0	1	0	0	0	4	0	4	0	0	0	0
1.0	3	9	1	0	26	10	9	2	0	0	0	0	0	2	0	3	0	0	0	0
1.0	4	3	0	0	21	10	8	1	0	0	1	0	0	3	0	0	0	0	0	0
2.0	5	5	0	0	32	16	14	2	0	0	0	0	0	8	0	0	0	0	0	0
2.0	6	1	0	0	19	8	7	1	0	1	0	0	0	5	0	1	0	0	0	0
3.0	7	14	4	2	26	16	8	0	0	0	0	0	0	4	1	1	0	2	0	0
3.0	8	14	3	2	26	12	12	0	0	1	0	0	0	3	1	3	0	3	0	0
3.0	9	14	2	0	25	9	12	3	0	0	0	0	0	6	0	2	0	1	0	0
3.0	10	23	2	3	35	22	9	2	0	2	0	0	0	8	0	3	0	3	0	0
3.0	11	6	0	0	22	9	13	0	1	2	0	0	0	8	0	3	1	2	0	1
3.0	12	16	1	3	28	10	16	1	0	5	1	0	0	7	0	1	0	0	0	0
4.2	14	6	1	0	20	8	7	3	0	2	0	0	0	3	0	1	0	1	0	0
4.2	15	9	1	0	20	8	10	0	0	2	1	0	0	1	0	0	1	4	0	0
4.2	16	7	0	2	22	12	6	3	0	0	1	0	0	4	0	1	0	1	0	0
4.2	17	1	0	0	24	9	11	0	0	2	2	0	0	3	0	1	2	1	1	1
4.2	18	6	1	1	34	16	12	0	1	0	1	0	0	2	0	1	0	1	0	0
5.0	19	4	0	1	31	13	15	1	1	1	0	0	0	3	0	2	0	0	0	0
5.0	20	3	1	0	52	21	27	1	1	0	0	0	0	2	1	7	1	0	0	1
5.0	21	1	1	0	23	11	11	0	1	9	0	0	0	4	0	1	0	3	0	0
5.0	22	2	0	0	21	10	8	0	0	2	1	0	0	5	0	4	0	1	0	0
6.0	23	16	4	1	29	16	12	1	1	0	0	0	0	2	0	10	0	1	0	0
6.0	24	13	4	2	45	25	18	7	0	0	0	0	0	2	0	3	1	1	0	1
6.0	25	5	1	1	31	14	14	4	1	1	0	0	0	4	0	4	0	1	0	0
6.0	26	1	1	0	35	20	14	4	1	0	0	0	0	2	0	4	0	1	0	0
7.0	28	13	2	3	35	16	18	0	0	0	0	0	0	5	0	5	0	0	0	0
7.0	29	1	0	0	30	17	13	0	5	2	0	0	0	3	0	1	0	0	0	0
7.0	30	14	1	2	37	21	14	1	2	1	0	0	0	1	1	2	1	1	0	1
7.0	31	12	2	1	32	16	16	2	3	0	0	0	0	5	0	6	0	0	0	0

Table 6. Reptile counts on the 1997 transects.

Site	Total Transects By Year	*Crotalus viridus*	*Sistrurus catenatus*	*Pituophis melanoleucus*	*Arizona elegans*	Us Hatchling	Sa Hatchling	Total Reptiles	Total Lizards	Total Whiptails	Total Turtles (To + To Tracks)	Total Snakes (Snakes All Sps.+ Snake Tracks)
1.0	1	0	0	0	0	0	0	65	63	2	2	0
1.0	2	0	0	0	0	0	0	54	50	6	4	0
1.0	3	0	0	0	0	0	0	42	39	2	3	0
1.0	4	0	0	0	0	0	0	29	29	1	0	0
2.0	5	0	0	0	0	0	0	47	47	2	0	0
2.0	6	0	0	0	0	0	0	28	27	1	1	0
3.0	7	0	0	0	0	0	0	48	44	0	2	2
3.0	8	0	0	0	0	0	0	51	44	0	4	3
3.0	9	0	0	0	0	0	0	51	48	3	2	1
3.0	10	0	0	0	0	0	0	76	70	2	3	3
3.0	11	0	0	0	0	0	0	45	39	1	3	3
3.0	12	0	0	0	0	0	0	59	58	1	1	0
4.2	14	0	0	0	0	0	0	36	34	3	1	1
4.2	15	0	0	0	0	0	0	38	33	0	0	5
4.2	16	0	0	0	0	0	0	39	37	3	1	1
4.2	17	0	0	0	0	0	0	36	32	0	1	3
4.2	18	0	0	0	0	0	0	46	44	1	1	1
5.0	19	0	0	0	0	0	0	43	41	2	2	0
5.0	20	0	0	0	0	0	0	68	59	2	8	1
5.0	21	0	0	0	0	0	0	42	38	1	1	3
5.0	22	0	0	0	0	0	0	36	31	0	4	1
6.0	23	0	0	0	0	0	0	60	49	2	10	1
6.0	24	0	0	0	0	0	0	72	67	7	3	2
6.0	25	0	0	0	0	0	0	51	46	5	4	1
6.0	26	0	0	0	0	0	0	48	43	5	4	1
7.0	28	0	0	0	0	0	0	58	53	0	5	0
7.0	29	0	0	0	0	0	0	42	41	5	1	0
7.0	30	0	0	0	0	0	0	61	56	3	3	2
7.0	31	0	0	0	0	0	0	60	54	5	6	0

Table 6. Reptile counts on the 1997 transects.

Site	Total Transects By Year	Total Reptiles Without Sa	Total Reptiles Without Sa, Us	Total Lizards Without Sa	Total Lizards Without Sa, Us	Sex Ratio Sa M - F	Sex Ratio Us M - F
1.0	1	54	9	52	7	0	8
1.0	2	47	15	43	11	1	-10
1.0	3	33	7	30	4	1	1
1.0	4	26	5	26	5	0	2
2.0	5	42	10	42	10	0	2
2.0	6	27	8	26	7	0	1
3.0	7	34	8	30	4	2	8
3.0	8	37	11	30	4	1	0
3.0	9	37	12	34	9	2	-3
3.0	10	53	18	47	12	-1	13
3.0	11	39	17	33	11	0	-4
3.0	12	43	15	42	14	-2	-6
4.2	14	30	10	28	8	1	1
4.2	15	29	9	24	4	1	-2
4.2	16	32	10	30	8	-2	6
4.2	17	35	11	31	7	0	-2
4.2	18	40	6	38	4	0	4
5.0	19	39	8	37	6	-1	-2
5.0	20	65	13	56	4	1	-6
5.0	21	41	18	37	14	1	0
5.0	22	34	13	29	8	0	2
6.0	23	44	15	33	4	3	4
6.0	24	59	14	54	9	2	7
6.0	25	46	15	41	10	0	0
6.0	26	47	12	42	7	1	6
7.0	28	45	10	40	5	-1	-2
7.0	29	41	11	40	10	0	4
7.0	30	47	10	42	5	-1	7
7.0	31	48	16	42	10	1	0

Table 6. Reptile counts on the 1997 transects.

Site	Total Transects By Year	Sa Total	Sa M	Sa F	Us Total	Us M	Us F	Ct	Cs	Hm	Su	Pc	Pm	No ID Lizard	To	To Tracks	Snakes All Species	Snake Tracks	*Heterodon nasicus*	*Masticophis flagellum*
8.0	32	18	6	1	14	10	4	10	0	2	0	0	0	5	1	5	0	1	0	0
8.0	33	16	8	4	15	6	9	4	1	1	0	0	0	2	0	3	0	0	0	0
8.0	34	10	4	1	22	7	15	16	1	2	3	0	0	4	0	5	0	0	0	0
8.0	35	17	6	3	25	7	17	15	3	0	2	0	0	2	0	8	0	0	0	0
8.0	36	3	1	2	40	14	24	15	0	3	0	0	0	11	0	3	0	0	0	0
8.0	37	8	1	4	16	10	6	10	1	3	1	0	0	3	0	3	0	2	0	0
9.0	38	13	5	3	17	8	5	5	1	3	1	0	0	2	0	4	0	0	0	0
9.0	39	28	10	6	12	4	8	6	0	0	0	0	0	0	0	1	1	1	1	0
9.0	40	24	6	3	22	12	8	2	0	3	1	0	0	3	1	2	0	1	0	0
9.0	41	16	3	4	18	11	7	8	1	6	0	0	0	4	0	6	1	1	1	0
9.0	42	33	10	9	12	5	7	5	1	2	0	0	0	1	0	5	0	0	0	0
9.0	43	20	5	5	18	6	12	5	0	8	3	0	0	3	0	2	0	0	0	0
10.0	44	14	6	1	6	4	2	2	0	1	0	0	0	4	0	1	0	0	0	0
10.0	45	9	1	4	7	5	2	1	0	1	2	0	0	1	0	0	0	2	0	0
10.0	46	6	1	0	8	5	3	4	0	0	0	0	0	3	0	2	0	0	0	0
10.0	47	5	0	1	10	5	5	2	0	4	0	0	0	2	0	11	0	0	0	0
11.0	48	19	2	3	14	8	5	5	0	2	1	0	0	2	0	3	0	1	0	0
11.0	49	12	4	2	11	4	7	8	1	2	2	0	0	0	0	4	0	0	0	0
11.0	50	7	2	5	13	7	6	4	0	3	2	0	0	2	0	5	0	0	0	0
11.0	51	15	4	2	8	2	6	6	0	1	1	0	0	1	0	1	0	0	0	0
11.0	52	5	0	1	19	5	13	5	0	1	1	0	0	0	0	6	0	0	0	0
12.0	53	11	6	3	6	4	2	4	0	2	1	0	0	2	1	0	0	0	0	0
12.0	54	7	3	1	2	1	1	9	1	0	1	0	0	0	1	2	0	0	0	0
12.0	55	13	7	1	8	3	5	3	0	8	1	0	0	1	0	0	1	2	0	0
12.0	56	15	3	3	7	4	3	7	1	6	0	0	0	1	1	5	2	0	0	2
12.0	57	16	3	3	9	8	1	18	1	3	0	1	0	1	0	4	0	2	0	0
13.0	58	24	11	3	7	2	5	5	0	2	1	0	0	1	1	5	0	1	0	0
13.0	59	36	13	9	11	6	5	6	0	8	1	0	0	3	0	3	0	0	0	0
13.0	60	14	1	5	18	7	10	6	0	8	1	0	0	8	0	8	0	1	0	0

Table 6. Reptile counts on the 1997 transects.

Site	Total Transects By Year	*Crotalus viridus*	*Sistrurus catenatus*	*Pituophis melanoleucus*	*Arizona elegans*	Us Hatchling	Sa Hatchling	Total Reptiles	Total Lizards	Total Whiptails	Total Turtles (To + To Tracks)	Total Snakes (Snakes All Sps.+ Snake Tracks)
8.0	32	0	0	0	0	0	0	56	49	10	6	1
8.0	33	0	0	0	0	0	0	42	39	5	3	0
8.0	34	0	0	0	0	0	0	63	58	17	5	0
8.0	35	0	0	0	0	0	0	72	64	18	8	0
8.0	36	0	0	0	0	0	0	75	72	15	3	0
8.0	37	0	0	0	0	0	0	47	42	11	3	2
9.0	38	0	0	0	0	0	0	46	42	6	4	0
9.0	39	0	0	0	0	0	0	49	46	6	1	2
9.0	40	0	0	0	0	0	0	59	55	2	3	1
9.0	41	0	0	0	0	0	0	61	53	9	6	2
9.0	42	0	0	0	0	0	0	59	54	6	5	0
9.0	43	0	0	0	0	0	0	59	57	5	2	0
10.0	44	0	0	0	0	0	0	28	27	2	1	0
10.0	45	0	0	0	0	0	0	23	21	1	0	2
10.0	46	0	0	0	0	0	0	23	21	4	2	0
10.0	47	0	0	0	0	0	0	34	23	2	11	0
11.0	48	0	0	0	0	0	0	47	43	5	3	1
11.0	49	0	0	0	0	0	0	40	36	9	4	0
11.0	50	0	0	0	0	0	0	36	31	4	5	0
11.0	51	0	0	0	0	0	0	33	32	6	1	0
11.0	52	0	0	0	0	0	0	37	31	5	6	0
12.0	53	0	0	0	0	0	0	27	26	4	1	0
12.0	54	0	0	0	0	0	0	23	20	10	3	0
12.0	55	0	0	0	1	0	0	37	34	3	0	3
12.0	56	0	0	0	0	0	0	45	37	8	6	2
12.0	57	0	0	0	0	0	0	55	49	19	4	2
13.0	58	0	0	0	0	0	0	47	40	5	6	1
13.0	59	0	0	0	0	0	0	68	65	6	3	0
13.0	60	0	0	0	0	0	0	64	55	6	8	1

Table 6. Reptile counts on the 1997 transects.

Site	Total Transects By Year	Total Reptiles Without Sa	Total Reptiles Without Sa, Us	Total Lizards Without Sa	Total Lizards Without Sa, Us	Sex Ratio Sa M - F	Sex Ratio Us M - F
8.0	32	38	24	31	17	5	6
8.0	33	26	11	23	8	4	-3
8.0	34	53	31	48	26	3	-8
8.0	35	55	30	47	22	3	-10
8.0	36	72	32	69	29	-1	-10
8.0	37	39	23	34	18	-3	4
9.0	38	33	16	29	12	2	3
9.0	39	21	9	18	6	4	-4
9.0	40	35	13	31	9	3	4
9.0	41	45	27	37	19	-1	4
9.0	42	26	14	21	9	1	-2
9.0	43	39	21	37	19	0	-6
10.0	44	14	8	13	7	5	2
10.0	45	14	7	12	5	-3	3
10.0	46	17	9	15	7	1	2
10.0	47	29	19	18	8	-1	0
11.0	48	28	14	24	10	-1	3
11.0	49	28	17	24	13	2	-3
11.0	50	29	16	24	11	-3	1
11.0	51	18	10	17	9	2	-4
11.0	52	32	13	26	7	-1	-8
12.0	53	16	10	15	9	3	2
12.0	54	16	14	13	11	2	0
12.0	55	24	16	21	13	6	-2
12.0	56	30	23	22	15	0	1
12.0	57	39	30	33	24	0	7
13.0	58	23	16	16	9	8	-3
13.0	59	32	21	29	18	4	1
13.0	60	50	32	41	23	-4	-3

Table 6. Reptile counts on the 1997 transects.

Site	Total Transects By Year	Sa Total	Sa M	Sa F	Us Total	Us M	Us F	Ct	Cs	Hm	Su	Pc	Pm	No ID Lizard	To	To Tracks	Snakes All Species	Snake Tracks	*Heterodon nasicus*	*Masticophis flagellum*
13.0	61	26	9	5	14	8	5	8	0	4	1	0	0	3	0	9	0	0	0	0
13.0	62	22	9	5	11	2	9	6	0	3	0	0	0	4	0	4	0	1	0	0
14.0	63	10	3	3	13	8	5	0	0	1	0	0	0	1	1	4	0	0	0	0
14.0	64	10	4	1	12	5	7	0	0	2	0	0	0	2	0	5	0	0	0	0
14.0	65	32	10	11	11	5	5	0	1	1	0	0	0	1	0	4	0	0	0	0
14.0	66	25	7	2	16	4	9	1	0	0	0	0	0	2	0	6	0	0	0	0
14.0	67	18	3	3	12	7	4	0	0	1	1	0	0	2	0	6	0	0	0	0

Table 6. Reptile counts on the 1997 transects.

Site	Total Transects By Year	*Crotalus viridus*	*Sistrurus catenatus*	*Pituophis melanoleucus*	*Arizona elegans*	Us Hatchling	Sa Hatchling	Total Reptiles	Total Lizards	Total Whiptails	Total Turtles (To + To Tracks)	Total Snakes (Snakes All Sps.+ Snake Tracks)
13.0	61	0	0	0	0	0	0	65	56	8	9	0
13.0	62	0	0	0	0	0	0	51	46	6	4	1
14.0	63	0	0	0	0	0	0	30	25	0	5	0
14.0	64	0	0	0	0	0	0	31	26	0	5	0
14.0	65	0	0	0	0	0	0	50	46	1	4	0
14.0	66	0	0	0	0	0	0	50	44	1	6	0
14.0	67	0	0	0	0	0	0	40	34	0	6	0

Table 6. Reptile counts on the 1997 transects.

Site	Total Transects By Year	Total Reptiles Without Sa	Total Reptiles Without Sa, Us	Total Lizards Without Sa	Total Lizards Without Sa, Us	Sex Ratio Sa M - F	Sex Ratio Us M - F
13.0	61	39	25	30	16	4	3
13.0	62	29	18	24	13	4	-7
14.0	63	20	7	15	2	0	3
14.0	64	21	9	16	4	3	-2
14.0	65	18	7	14	3	-1	0
14.0	66	25	9	19	3	5	-5
14.0	67	22	10	16	4	0	3

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Appendix A. A study of the visual identification methods for lizards.

We used cost and time efficient methods in this study to gain a preliminary perspective on possible relations between oil development and Sand Dune Lizard populations. This included reliance on binoculars to identify lizards which was augmented with some hand catching or noosing of specimens of interest. We did not trap or shoot lizards, which means we did not collect museum specimens and we had to be sure of our identifications. In southeast New Mexico walking transects allowed data to be accumulated more rapidly than other techniques and with less impact on populations. These transect studies had some lizards where no identification was possible because of 25 minute time limits. However this was a very small percentage of the total lizards (1996: 121 NoID/1787 total lizards = 6.7%; 1997: 201 NoID/2815 total lizards = 7.1%) and did not influence the results. NoID lizards represented accuracy in data recording.

We used trained observers and herpetologists to conduct these studies. Because of the skills required to conduct fieldwork with *S. arenicolus* we conducted a formal study to verify the accuracy of our identifications in the field. We conducted this study in 1996 at a white sand site in the mid range and a red sand site in the south range of *S. arenicolus*. This represented two different aspects of Shinnery Oak habitat. Three observers walked side by side. When one observer saw a lizard, we maneuvered so that the other two observers could also see the lizard. We then secretly wrote down the identification of the lizard. At this point we confirmed the identification of the lizard by hand catching, shooting or approaching within .25 m for a close look. With this data we checked the agreement between observers and the agreement between the observers and the confirmed identification.

Appendix A table 1 shows the data for this visual identification study. This table indicates the identification of the lizard, and the agreement between observers. In consecutive lizard sightings over a 2 day period we were able to have two or three observers view with binoculars the same lizard in 96 cases. We had 100 consecutive lizard sightings, cases 34, 53, 59 were deleted from the analysis since only one observer saw these lizards, they escaped before the other observers could get a view. In 90 out of 96 cases all three observers saw the lizard, agreed on the species identity and the species identity was confirmed. In 4 of these cases (21, 58, 79, 93) only two observers saw the lizard, they agreed on the species identity and the identification was confirmed. Because of the difficulty of all three observers trying to view a lizard without scaring it, the third observer sometimes got no view of the lizard. In the remaining two cases (6, 13) only one observer was able to get an identification view, the other observers used the No ID category.

This represents a zero error rate for identification (0 false ID's / 280 identifications). In case 60 observer D saw and confirmed the identity of a *S. arenicolus*. This observer then backed off to let the other two observers view the lizard. These observers both identified a *S. undulatus*. However when I checked this situation it became apparent that the three observers were viewing different lizards.

We found no evidence of any errors in identifications or disagreements between observers. On the transects, some questionable lizards were not identified because of the time constraints of catching lizards on a time limited transect. This low error rate was noteworthy since in this identification study 22 of 97 lizards were hatchlings, which is a much higher proportion of hatchlings than the transect counts. The transect counts were done earlier in the season when hatchlings had not emerged. This study included 34 *S. arenicolus*, 45 *Uta stansburiana*, 10 *Holbrookia maculata* and lesser numbers of 5 other lizard species.

Appendix A table 1. Visual identification of lizards and the confirmation of the species identity.

		F = female M = male				HC = hand caught	FPS = scales between femoral pores
						VC-x = visual confirmation at x meters	GTS = granular thigh scales
							RB = rust back
							LDBS = lateral dark stripes with dorsal lateral white stripes
Lizard Number	Date	Observer D	Observer E	Observer K	H = hatchling	Means of Identification Confirmation	Comments
1	29-Jul-96	Pc	Pc	Pc	H	HC	
2	29-Jul-96	Us	Us	Us	H	HC	
3	29-Jul-96	Pc	Pc	Pc		HC	
4	29-Jul-96	Us-F	Us -F	Us -F		Shoot	
5	29-Jul-96	Us-M	Us-M	Us-M		Shoot	
6	29-Jul-96	Us	No Id	No Id			Lizard escaped due to difficulty of 3 observers trying to view and confirm
7	29-Jul-96	Us-F	Us-F	Us-F		Shoot	
8	29-Jul-96	Us	Us	Us	H	HC	
9	29-Jul-96	Us-F	Us-F	Us-F		HC	
10	29-Jul-96	Sa-M	Sa-M	Sa-M		HC	
11	29-Jul-96	Us-M	Us-M	Us-M		HC	
12	29-Jul-96	Us	Us	Us		HC	
13	29-Jul-96	No Id	Us	No View	▯		Lizard escaped trying to get 3rd obs. a view, had fine pattern on dorsum-Su, no bold pattern like Uta

Appendix A table 1. Visual identification of lizards and the confirmation of the species identity.

Lizard Number	Date	Observer D	Observer E	Observer K	H = hatchling	Means of Identification Confirmation	Comments
14	29-Jul-96	Us-F	Us-F	Us-F		VC-5	Lizard was shot but not found, but identity was first visually confirmed at 5 ft
15	29-Jul-96	Us-M	Us-M	Us-M		HC	
16	29-Jul-96	Us	Us	Us	H	HC	
17	29-Jul-96	Us	Us-F	Us-F	H	VC-2	
18	29-Jul-96	Us-F	Us-F	Us-F		VC-2	
19	29-Jul-96	Us	Us-F	Us-F		VC-2	
20	29-Jul-96	Us-M	Us-M	Us-M		HC	
21	29-Jul-96	No View	Us	Us	H	VC 2-3	
22	29-Jul-96	Us	Us	Us	H	VC-2	
23	29-Jul-96	Us	Us	Us	H	VC-1	
24	29-Jul-96	Us-M	Us-M	Us-M		HC	
25	29-Jul-96	Us-F	Us-F	Us-F		VC 1-2	
26	29-Jul-96	Us	Us	Us	H	VC-2	
27	29-Jul-96	Sa-F	Sa-F	Sa-F		VC-1	
28	29-Jul-96	Sa	Sa	Sa		VC-1	
29	29-Jul-96	Us	Us-F	Us-F		VC-2	
30	29-Jul-96	Sa	Sa	Sa		VC-2	
31	29-Jul-96	Sa-F	Sa-F	Sa-F		VC-1	
32	29-Jul-96	Us	Us	Us		VC-1	Grey stripe on back, likely to be this phase, when wary, that is responsible for many no ID's
33	29-Jul-96	Us-F	Us-F	Us-F		VC-1.5	
34	29-Jul-96	Us	No View	No View	H	VC-1	
35	29-Jul-96	Us-F	Us-F	Us-F		VC-2	
36	29-Jul-96	Us	Us	Us	H	VC-1.5	

Appendix A table 1. Visual identification of lizards and the confirmation of the species identity.

Lizard Number	Date	Observer D	Observer E	Observer K	H = hatchling	Means of Identification Confirmation	Comments
37	29-Jul-96	Us-M	Us-M	Us-M		VC-2	
38	29-Jul-96	Us-F	Us-F	Us-F		VC-2	
39	29-Jul-96	Us-M	Us-M	Us-M		VC-2	
40	29-Jul-96	Us	Us	Us	H	VC-2	
41	29-Jul-96	Us-F	Us-F	Us-F		VC-2	
42	29-Jul-96	Sa	Sa	Sa-M		HC-Sa-M	confirmed Sa-M
43	29-Jul-96	Us	Us	Us	H	VC-2	
44	29-Jul-96	Us-M	Us-M	Us-M		VC-2	
45	29-Jul-96	Us-F	Us-F	Us-F		VC-2	
46	29-Jul-96	Cs	Cs	Cs		VC-2.3	
47	29-Jul-96	Us	Us	Us	H	VC-1	
48	29-Jul-96	Us-F	Us-F	Us-F		VC-2	
49	29-Jul-96	Su	Su	Su		HC	Pale phase-grey dorsum, 5-6 scales between F.P., keeled scales on rear thighs, 2 white lateral stripes
50	29-Jul-96	Sa	Sa	Sa		VC-2	
51	29-Jul-96	Sa	Sa	Sa		HC	
52	29-Jul-96	Sa-F	Sa-F	Sa-F		HC	
53	29-Jul-96	Us	No View	No View	H	VC-1	
54	29-Jul-96	Hm	Hm	Hm	H	HC	
55	29-Jul-96	Us-F	Us-F	Us-F		VC-2	
56	29-Jul-96	Us-M	Us-M	Us-M		VC-2	
57	29-Jul-96	Us	Us	Us	H	VC-2	
58	29-Jul-96	Sa	No View	Sa		VC-8	
59	29-Jul-96	Sa	No View	No View		VC-5	Lizard kept moving when E & K attempted to get a view

Appendix A table 1. Visual identification of lizards and the confirmation of the species identity.

Lizard Number	Date	Observer D	Observer E	Observer K	H = hatchling	Means of Identification Confirmation	Comments
60	30-Jul-96	Sa	Su	Su		VC-1.5	D verified as Sa but the lizard moved and E & K saw another lizard which they both identified as an Su
61	30-Jul-96	Sa-F	Sa-F	Sa-F		VC-1	
62	30-Jul-96	Sa-M	Sa	Sa-M		VC-2	
63	30-Jul-96	Sa-F	Sa-F	Sa-F		HC	FPS=13, LDBS, RB, GTS
64	30-Jul-96	Sa-F	Sa-F	Sa-F		HC	FPS=10, LDBS, RB, GTS
65	30-Jul-96	Sa-M	Sa	Sa		VC-3	
66	30-Jul-96	Sa-F	Sa-F	Sa-F		HC	FPS=11, LDBS, RB, GTS
67	30-Jul-96	Sa-F	Sa-F	Sa-F		HC	HC, FPS=13, LDBS, RB, GTS
68	30-Jul-96	Sa-F	Sa	Sa-F		VC-2	Busy with #67, therefore lizard was not caught
69	30-Jul-96	Sa-F	Sa	Sa-F		HC	FPS=12, LDBS, RB, GTS
70	30-Jul-96	Sa-F	Sa-F	Sa-F		VC-2	
71	30-Jul-96	Sa-F	Sa-F	Sa-F		VC-1	
72	30-Jul-96	Sa-F	Sa-F	Sa-F		VC-1	
73	30-Jul-96	Sa-M	Sa-M	Sa-M		VC-1, HC	
74	30-Jul-96	Sa-M	Sa-M	Sa-M		VC-1, HC	
75	30-Jul-96	Eo	Eo	Eo	H	HC	E &K identified Eo correctly based on field guide description, even though neither had ever seen this species
76	30-Jul-96	Sa	Sa	Sa	H	HC	FPS = 13, GTS, LDBS, white dorsal lateral stripes, RB, yellowish tail
77	30-Jul-96	Cs	Cs	Cs		VC-1	
78	30-Jul-96	Sa-F	Sa-F	Sa-F		HC	FPS=12, LDBS, GTS, RB

Appendix A table 1. Visual identification of lizards and the confirmation of the species identity.

Lizard Number	Date	Observer D	Observer E	Observer K	H = hatchling	Means of Identification Confirmation	Comments
79	30-Jul-96	Sa-F	Sa	No View		Shoot	FPS=14, LDBS, GTS, Light grey and rust colored back
80	30-Jul-96	Sa	Sa	Sa		HC	Confirmed Sa-F, FPS=12, GTS, LDBS
81	30-Jul-96	Sa-F	Sa	Sa		VC-2	LDBS, sex coloration typical
82	30-Jul-96	Us-M	Us-M	Us		VC-2	
83	30-Jul-96	Hm-F	Hm	Hm-F		VC-2	
84	30-Jul-96	Cs-F	Cs	Cs		VC-3, photo	Confirmed Cs-F
85	30-Jul-96	Cs-M	Cs	Cs-M		VC- 2, photo	Confirmed Cs-M
86	30-Jul-96	Sa	Sa-M	Sa		HC	Confirmed Sa-M, Light grey back reduced rust, FPS=12, LDBS, GTS
87	30-Jul-96	Sa-F	Sa-F	Sa-F		VC-2	
88	30-Jul-96	Cc	Cc	Cc		VC-2, HC	Noosed
89	30-Jul-96	Sa-F	Sa-F	Sa-F		VC-2	
90	30-Jul-96	Hm-F	Hm-F	Hm-F		VC-1	
91	30-Jul-96	Pc	Pc	Pc		HC	
92	30-Jul-96	Hm-F	Hm-F	Hm-F		VC-1, photo	
93	30-Jul-96	Hm-F	No View	Hm-F		VC-5	
94	30-Jul-96	Hm-F	Hm-F	Hm-F		VC-6	
95	30-Jul-96	Us-M	Us-M	Us-M		VC-3	
96	30-Jul-96	Hm-M	Hm-M	Hm-M		VC-1, HC	
97	30-Jul-96	Hm	Hm	Hm	H	VC-1, HC	
98	30-Jul-96	Hm-F	Hm-F	Hm-F		VC-8	
99	30-Jul-96	Hm	Hm	Hm	H	VC-1, HC	
100	30-Jul-96	Hm-F	Hm-F	Hm-F		VC-2	