

**MANAGEMENT PLAN FOR THE SAND DUNE LIZARD,
Sceloporus arenicolus IN NEW MEXICO**

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MANAGEMENT PLAN FOR THE SAND DUNE LIZARD, *Sceloporus arenicolus* IN NEW MEXICO

EXECUTIVE SUMMARY

Current Species Status: The sand dune lizard, *Sceloporus arenicolus* is endemic to a small area of shinnery oak habitat in parts of southeast New Mexico and adjacent Texas. In New Mexico, the species is

known to exist as fragmented populations within an area of ca. 2,312 sq km (892.6 sq mi) in parts of Chaves, Eddy, Lee, and Roosevelt counties. However, within this area the potential and occupied habitat consists of only 1,697.3 sq km (655.3 sq mi). Total extent of the range in Texas is unknown although it includes parts of Andrews, Crane, Gaines, Ward, and Winkler counties. In New Mexico large populations occur on lands managed by the U.S. Department of Interior, Bureau of Land Management, (BLM) although important populations occur on New Mexico state and private lands as well. Historic population sizes of *S. arenicolus* are unknown, although the chemical treatment and removal of shinnery oak and oil and gas extraction activities has caused the decrease or extirpation of some populations since the species was discovered in southeast New Mexico in 1960. The New Mexico Department of Game and Fish (NMGF) first listed *S. arenicolus* as a Group 2 Endangered Species on 24 Jan 1975, and it is currently listed as threatened. The species was listed as a Category 2 Notice of Review Species by the U.S. Fish and Wildlife Service (USFWS) in 1994, (it is currently considered a Species of Concern), and is listed as a Sensitive Species by BLM. *Sceloporus arenicolus* receives no formal protection in Texas.

Habitat Requirements and Limiting Factors: This small, terrestrial lizard is restricted to sand dune formations inhabited by shinnery oak, *Quercus havardii*. Shinnery oak dunes support dense patches of shinnery oak and scattered sandsage, *Artemisia filifolia*, as co-dominant plant species and patches of open sand and wind-created sandy blowouts. Throughout the range in New Mexico and Texas elevation varies from ca. 780-1400 m (ca. 2550-4595 ft). Fitzgerald et al. (1997) found significant differences in the composition of sand between sites occupied and unoccupied by *S. arenicolus*, with occupied sites having slightly coarser sand than unoccupied sites. The species is threatened by activities which remove the shinnery oak, alter the dominant vegetation structure, increase the percentage of grasses, disrupt the morphology of the sand dunes, or otherwise degrade suitable habitat.

Management Objective: To conserve *S. arenicolus* in its known habitat on public lands and to ensure the long-term viability of populations of the species through the maintenance and protection of its habitat. The Desired Future Condition of the range of *S. arenicolus* is a landscape that will provide sustainable, healthy ecosystems to maintain well-connected, persistent *S. arenicolus* populations.

Coordination With Agency And Landowner Personnel: During the field research and the coordination of activities which resulted in the issuance of this Management Plan, frequent and open communication with landowners and agency personnel was of paramount importance in reaching the decisions and recommendations contained herein. The Resource Management Plans of the BLM Roswell Resource Area and the Carlsbad Resource Area were frequently consulted and many of the recommendations contained herein are extracted from those documents.

MANAGEMENT PLAN FOR THE SAND DUNE LIZARD, *Sceloporus arenicolus* IN NEW MEXICO

HISTORICAL BACKGROUND

The sand dune lizard, *Sceloporus arenicolus*, is a small, terrestrial, diurnal lizard in the family Phrynosomatidae. The species is endemic to extreme southeast New Mexico and adjacent Texas. In New Mexico the species persists in localized and fragmented populations that occupy four geographically isolated areas that are separated by significant amounts of unsuitable habitat. (Figs. 1, 2, 3, 4). In areas where it is locally abundant, it is a major component of the herpetofauna. Many details of this lizard's distribution and life history have never been published in scientific journals, but are reported in various state and federal agency reports (e.g., Degenhardt and Sena 1976; Fitzgerald et al. 1997; Gorum et al. 1995; Peterson and Boyd 1998; Sias and Snell 1996, 1998; Snell et al. 1991 [1992], 1993, 1994, 1997; USDI-BLM 1997a, 1997b).

Nomenclature of the sand dune lizard has a long and complex history. The form was originally included with the sagebrush lizard, *Sceloporus graciosus*, described in 1852 (Baird and Girard 1852). Populations of the sagebrush lizard in southeast New Mexico and adjacent Texas were first reported in 1960 (Sabath 1960) and were later described as a unique subspecies, *S. graciosus arenicolous* (Degenhardt and Jones 1972). In 1992, the taxon was recognized as a species (Smith et al. 1992), with molecular and morphological support of this designation provided in 1997 (Wiens and Reeder 1997).

Sceloporus arenicolus is a narrowly endemic species with the second most restricted range of any native lizard in North America. (Only the Coachella Valley fringe-toed lizard, *Uma inornata*, has a smaller range.) Biologists believe the effects of herbicide spraying to control shinnery oak (*Quercus havardii*), the effects of exploration for oil and gas, and the development of oil fields have had serious detrimental effects on populations of this species. Recent research was designed to investigate the long-term effects of such habitat modification on *S. arenicolus* populations.

The sand dune lizard was first listed as a Group 2 Endangered Species on 24 Jan 1975, and it is currently listed as Threatened, by the State of New Mexico Department of Game and Fish (NMDGF). It was listed as a Category 2 Notice of Review species by the U.S. Fish and Wildlife Service (USFWS) in 1994, (it is currently considered a Species of Concern), and is listed as a Sensitive Species by BLM. The species receives no formal protection in Texas, where its current distribution and status are poorly known. Most of the range in Texas occurs on private lands where management options are expected to be limited. Information on the effects of the herbicide treatment of shinnery oak on *S. arenicolus* populations is found in Gorum et al. 1995, Peterson and Boyd 1998, and Snell et al. 1991 [1992]; 1993; 1994; 1997. Data on the effects of oil and gas exploration and oil field development are found in Peterson and Boyd 1998, and Sias and Snell 1996; 1998. Information on distribution of the species is found in Axtell 1988, Censky 1986, Cole 1975, Conant and Collins 1991, Degenhardt et al. 1996, Dixon 1987, Fitzgerald et al. 1997, Garrett and Barker 1987, Painter and Sias 1998, and Stebbins 1985. Information on habitat selection is found in Fitzgerald et al. 1997, Sias and Snell 1998, and Peterson and Boyd 1998. Additional general life history data are in Degenhardt et al. 1996 and Degenhardt and Jones 1972. Wiens and Reeder (1997) provided molecular and morphological evidence in support of the retention of *S. arenicolus* as a full species.

RANGE AND DISTRIBUTION OF *S. arenicolus*

Sceloporus arenicolus is restricted to sand dune formations inhabited predominately by shinnery oak. Shinnery oak dunes support dense stands of shinnery oak and scattered sandsage, *A. filifolia*, as co-dominant plant species (Fig. 5; Table 1).

Table 1. Percent vegetative cover in each Area.

Vegetation Cover NM GAP	<u>Area 1</u> 465.7 sq km	<u>Area 2</u> 34.3 sq km	<u>Area 3</u> 162.0 sq km	<u>Area 4</u> 1,649.6 sq km
Plains-Mesa Broadleaf Sand- Scrub (Shinnery oak)	70.5%	73.9%	82.0%	73.4%
Chihuahuan Broadleaf Deciduous Desert Scrub	7.3%	--	3.4%	10.0%
Short Grass Steppe	19.4%	--	8.5%	10.4%
Mid-Grass Prairie	2.3%	26.1%	6.0%	1.1%
Chihuahuan Desert Grassland	0.5%	--	--	4.6%
Tall Grass Prairie	--	--	--	0.6%
Basin/Playa	--	--	0.2%	--

The range of *S. arenicolus* in New Mexico is crescent-shaped (Fig. 6), extending from the vicinity of Milnesand, Roosevelt County and northwest of Kenna, Chaves County, to west of the Mescalero Ridge (Caprock), and arcing southeasterly to the border with Texas south of Hobbs, Lea County (Degenhardt et al. 1996; Fitzgerald et al. 1997). The distribution of *S. arenicolus* in New Mexico includes ca. 2,312 sq km (892.6 sq mi) and is separated into four areas. These areas contain only 1,697.3 sq km (655.3 sq mi) potential or occupied habitat (Table 2) and includes ca. 70% state and federal lands and 30% private lands (Fig 7; Table 3).

Table 2. The area of potential or occupied shinnery oak habitat within each area. The potential or occupied habitat occurring in each area ranges between 70-80%.

Area No.	Area (sq. km)	% Shinnery Oak	Potential/Occupied Habitat (sq km)
1	465.7	70.5%	328.32
2	34.3	73.9%	25.35
3	162	82%	132.84
4	1649.6	73.4%	1210.81
TOTAL	2312		1697.32

Note: Area 4 alone represents 71.3% of the range of *S. arenicolus* in New Mexico: Area 1, 19.3%; Area 2, 1.5%; and Area 3, 7.8%. Areas 1, 2, and 3 comprise only 28.7% of the total geographic range of *S. arenicolus* in New Mexico. These small populations are subject to a higher extinction risk and a lower probability of long-term persistence as a result of the small areas occupied.

Table 3. Percentage land jurisdiction in each Area occupied by *S arenicolus*. When interpreting these data, the total size of the Area must be considered. Lands under State or Federal government jurisdiction account for ca. 70% of the range of *S. arenicolus*; private lands represent ca. 30%. Total land area is 2311.6 sq km or 892.5 sq mi.

Land Jurisdiction	<u>Area 1</u>	<u>Area 2</u>	<u>Area 3</u>	<u>Area 4</u>
NM GAP	465.7 sq km	34.3 sq km	162.0 sq km	1,649.6 sq km
BLM	22.7%	--	--	62.1%
State	15.2%	23.1%	68.1%	16.7%
Private	62.1%	76.9%	31.9%	21.1%
Other	--	--	--	< 1%

In Texas, where the distribution and extent of habitat modification has not been well studied, the species is known to occur in Andrews, Crane, Gaines, Ward, and Winkler counties (Axtell 1988; Dixon 1987; Painter and Sias 1998). The most salient characteristic of the range of *S. arenicolus* is its small size. The geographic range (1697 sq km), is the second smallest of any lizard endemic to North America; *Uma inornata*, the Coachella Valley fringe-toed lizard has a total range of only 31.72 sq km (Muth 1991). The core of the range of *S. arenicolus* is the Mescalero Sands region of eastern Chaves and northeastern Eddy Counties. The range is more or less continuous from the localities near Crossroads, Lea County, through the Mescalero Sands to the border with Texas south of Hobbs. The northwest portion of the range appears separated from the Mescalero Sands by a gap of about 23.8 km (15 miles). Three localities in Roosevelt County are isolated by 25.6 km (16 mi) from the closest localities to the west and by 27.5 km (17 mi) from the closest locality to the south. Extensive surveys in potential habitats extending from the WIPP site southeasterly to Jal suggest that *S. arenicolus* does not occur in this region (Fig. 8). Additionally, biologists at the WIPP site sampled lizard fauna with pitfall traps in the best available habitat and did not find *S. arenicolus* (D.C. Lynn, pers. comm.). This distribution pattern is intriguing, because *S. arenicolus* occurs in Texas south-southeast of Jal, and the shinnery dunes at WIPP and near Jal appear suitable for *S. arenicolus*. It is possible the range of *S. arenicolus* never encompassed this area, or that unknown characteristics of the habitat and biotic factors prohibit *S. arenicolus* from occupying areas of potential habitat in this region. Finally, it is plausible that *S. arenicolus* once occurred in the area but went extinct due to natural or anthropomorphic causes. The conspicuous absence of *S. arenicolus* in this region emphasizes that the species may not disperse into areas of suitable habitat, even across narrow barriers of unsuitable habitat.

An outstanding feature of the range of *S. arenicolus* is its narrow shape. At its widest points in the Mescalero Sands, the range spans only 16.7 to 25.7 km (10-16 mi). The narrowest points

occur at two sites: 1) E of NM Hwy 18 at T20S R37/38 E and 2) W of NM Hwy 8 at T20S R35E. These sites occur along the southeast edge of the range in New Mexico and are less than 1 mile in width (Sias and Snell 1998) (Fig. 3). Because active shinnery dunes are not contiguous throughout the majority of the range, there is the possibility that practically all of the range of *S. arenicolus* has edge-like characteristics (Fig. 8).

Two Historic localities (Fig. 1) are puzzling and are likely in error. Data for the westernmost locality were given as “1 mi. W Hagerman” (TAIC 1991). As shinnery oak habitat does not exist in this region, either the specimen is misidentified or the collecting data are in error. The locality given as “Eunice” (MVZ 27131) is imprecise; the specimen was likely collected in occupied habitat slightly to the north of Eunice. Although these localities are likely in error, it raises the possibility they represent extinct populations. See Fitzgerald et al. (1997) for additional information on these specimens.

SYNTHESIS OF INFORMATION FROM TEXAS

The status and distribution of *Sceloporus arenicolus* has received little attention in Texas, where the range is extremely limited and fragmented by areas of unsuitable habitat. The extent of habitat loss to herbicide spraying or oil and gas exploration and/or extraction is unknown. The species is known to occur in only five Texas counties. Dixon (1988), Censky (1986), and Axtell (1988) provided the only detailed county distribution maps for the species in Texas. Painter and Sias (1998) provided data on specimens from Gaines County.

HABITAT REQUIREMENTS OF *S. arenicolus*

The habitat requirements of *S. arenicolus* are highly specialized. The sand dune lizard occurs only in the microhabitat comprised of sand dune blowouts associated with active shinnery oak dunes (Snell et al. 1997, Fitzgerald et al. 1997, Sias and Snell 1998). Recapture data from the Mescalero Sands indicated that individual *S. arenicolus* have relatively small home ranges, with the majority of recaptures occurring within the blowout of original capture (*unpubl. data*).

Sceloporus arenicolus is not found at sites lacking shinnery dune habitat. Even at shinnery dune sites where the lizard does occur, it was not found in other microhabitats, such as the extensive shinnery areas between blowouts. Habitat selection studies demonstrate that *S. arenicolus* is a habitat and microhabitat specialist, occurring exclusively within blowouts and open sand patches in shinnery dune habitat. Sand dune lizards prefer large deep blowouts; small blowouts were underutilized while large ones were used significantly more than expected based on their availability in the field (Sias and Snell 1998). There were significant differences in composition of sand between sites of presence and absence of *S. arenicolus*, implying that it may not occur in areas with high percentages of sand particles smaller than 250 μm (Fitzgerald et al. 1997).

Not all shinnery oak dune habitat is occupied (Fig. 8), as described above in "Range and Distribution". In recent studies (Fitzgerald et al. 1997), trained biologists could not visually discern microhabitat differences between apparently suitable habitats that were occupied by *S. arenicolus* and apparently suitable habitats that were not occupied. For example, the shinnery dunes near the WIPP site and Jal appeared more suitable for *S. arenicolus* than many occupied sites within the known range. The fact that *S. arenicolus* was found at 50% (72 of 144) of sites in the shinnery oak region of southeast New Mexico show there is a high probability the lizards will occur in such habitat, but also indicates it is unavoidable that site surveys are required to demonstrate *S. arenicolus* occurs at a site. Thus, it is impossible to accurately predict whether *S. arenicolus* will be absent from any area of shinnery dunes based on macroscopic variables measured from afar, such as remote sensing data. Remote sensing methods would need to distinguish between shinnery flats and shinnery dunes and reveal topographic differences of < 3 m to account for the characteristic "bumpiness" of shinnery dunes without blowouts. These considerations imply that habitat mapping based on remote sensing (e.g. LANSAT thematic mapper data) would be somewhat useful for locating patches of suitable habitat, but would not be able to precisely predict if a site were occupied by *S. arenicolus*.

LAND-USE PRACTICES OF POTENTIAL THREATS TO *S. arenicolus*

TEBUTHIURON APPLICATION

It is clear that tebuthiuron application results in dramatic reductions of sand dune lizard numbers. We may infer that increase in the amount of grass cover, dune stabilization, and decrease in dune relief (i.e., less deep, less active, and more vegetated blowouts) are a consequence of shinnery oak removal, and this pattern of habitat alteration does not favor the persistence of sand dune lizards.

A five-year study utilizing pitfall traps in tebuthiuron treated and adjacent untreated shinnery oak habitat in the Mescalero Sands, Chaves County, New Mexico showed overall reductions of *S. arenicolus* numbers between 70-94% in the treated pastures compared to the untreated pastures. In several pairs of sites, reductions were 100%. Populations of *S. arenicolus* did not exist in these treated pastures despite good populations in the adjacent untreated pastures. At least 100,000 acres of the Mescalero Sands have been treated for shinnery oak and many more areas are slated to be treated (Peterson and Boyd 1998). After treatment, former *S. arenicolus* habitat can be considered either lost or greatly reduced in quality for the species. Therefore, it is reasonable to assume the population trends for this species have been downward since the initiation of the tebuthiuron treatment program (Gorum et al. 1995; Snell and Landwer 1992; Snell et al. 1993; 1994).

OIL AND GAS EXTRACTION ACTIVITIES

Oil and gas extraction activities are detrimental to sand dune lizards to the extent that they destroy suitable habitat that results in localized and spatially widespread population reductions. Caliche roads and well pads fragment sand dune lizard habitat, and directly reduce the amount of available habitat. Studies during 1995 reported a 39% reduction in *S. arenicolus* on plots of land 0-80 m away from individual oil/gas wells compared to plots >190 m from wells. Studies during 1996-97 documented a negative relationship between oil/gas well density and the abundance of *S. arenicolus*. A regression analysis of data collected during these studies predicted a 25% decline in *S. arenicolus* populations at well densities of ca.14 wells/section and a 50% decline at ca.25 wells/per section (Sias and Snell 1998). The detrimental effects of oil exploration on populations of *S. arenicolus* are unknown, but they are not expected to be long term if such oil exploration is not accompanied by the construction of persistent structures or other activities that permanently alter shinnery oak dunes.

Intensely developed oil fields with well densities ≥ 25 wells per section exist in shinnery oak habitat in at least four regions in southeast New Mexico. The following symbolic codes in parentheses correspond to areas in Sias and Snell (1998) (Fig. 10). Region 1 (DEV) is 6 mi W and 1 mi N of Maljamar. Region 2 (CON.N) is SW of Maljamar and is N of Hwy. 529, S of Hwy. 82 and W of Lea Co. Rd 33. Region 3 (EUN) is N of Eunice and Monument Draw on both sides of Hwy. 18 and runs into Texas. Region 4 (MON) 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. *Sceloporus arenicolus* persists and may be abundant in certain areas of these regions (Sias and Snell 1998) that have existed for several decades. Therefore, 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 and reduced population size all increase the risk of local extinction in these areas compared to undeveloped areas.

With additional development of oil and gas resources, loss of shinnery oak habitat in the Region 4 (MON) oil fields will occur, resulting in further fragmentation of the *S. arenicolus* populations. In this area (T20S, R36E, secs. 24, 23, 22, 21) and further west the habitat for *S. arenicolus* is less than a mile wide. Fragmentation of this narrow band of shinnery oak dunes may create a barrier to *S. arenicolus* movement and gene flow. Region 1 (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 to the south are extensive tebuthiuron treated areas where *S. arenicolus* marginally exists. Unrestricted future development in the Region 1 (DEV) would destroy a source population with the potential to eventually recolonize Tebuthiuron treated areas to the north and west.

Region 2 (CON.N) oil fields occupy the entire width of *S. arenicolus* range SW of Maljamar. Although *S. arenicolus* is still abundant in Region 2 (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.

Region 3 (EUN) 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 ca. 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.

Pipeline cuts in shinnery oak habitat may benefit sand dune lizard by creating suitable habitat, or they may be neutral for *S. arenicolus*. Pipeline cuts create a microhabitat that is similar to natural dune blowout microhabitat, and it may be used by sand dune lizards. There are no data available, but pipeline cuts could serve as dispersal corridors for sand dune lizards. However, it should be noted that leaks in pipelines may cause direct mortality to *S. arenicolus* occupying pipeline cuts.

ORV USE

Recreational ORV use in the Mescalero Sands has not been studied as it relates to persistence of herpetofauna, but we presume at the present ORV activity is relatively limited within the range of *S. arenicolus*. Only the Mescalero Sands North Dune ORV Area is 100% open to this activity (USDI-BLM 1997a) and activity there is mostly limited to occasional use by nearby residents (*pers. obs.*). Concentrated ORV use may erode the shinnery edges of blowouts and present problems to inactive *S. arenicolus* buried in the sand.

LIVESTOCK GRAZING

Livestock grazing occurs throughout the range of *S. arenicolus*. The direct effects of livestock grazing on *S. arenicolus* have not been specifically investigated. High stocking densities of cattle are thought to have transformed much of the shinnery oak ecosystems from grass-oak communities to systems dominated by shinnery oak, to have increased annual grasses and forbs at the expense of perennial grasses, and to have increased bare ground, subjecting soils to increased wind erosion (Peterson and Boyd 1998 and numerous references therein). Both high- and low-density populations of *S. arenicolus* are found in grazed shinnery oak dune pastures, however they are not found in extensive open sand dunes, a habitat formation potentially associated with heavy grazing. Large herbivores probably have an important ecological impact that needs to be formally documented. The unstudied implication is that some grazing may help maintain shinnery oak dunes. The indirect effects of grazing, specifically grazing as a land use activity that incited shinnery oak removal with herbicides, are well documented.

FIRE

Although the shinnery oak ecosystem has evolved under the influence of fire (Peterson and

Boyd 1998), data are lacking on the response of shinnery oak to management ignited fires or wildfire. There are no published studies on the effects of fire in the shinnery oak habitat as it relates to the persistence of herpetofaunal populations. There are possible indirect effects of burning related to increases or decreases in forb and grass production depending upon the timing and intensity of fire and the available moisture (Peterson and Boyd 1998 and references therein). Slosser et al. (1985) reported a burn in shinnery had little effect on vegetative composition but decreased leaf litter for 3 years following treatment. These authors noted that top-kill of shinnery oak was near 100%, but within 8 months frequency of oak occurrence had equalized between burned and unburned treatment due to vigorous oak resprouting.

MANAGEMENT RECOMMENDATIONS

As far as known, habitat destruction appears to be the single greatest threat to the continued existence of *S. arenicolus*. Of the land use practices known to regularly occur within the range of *S. arenicolus* (i.e., ORV use, livestock grazing, oil/gas development, and the use of Tebuthiuron for shinnery oak control), two, oil/gas extraction activities and the use of Tebuthiuron for shinnery oak control, have the greatest potential to cause significant reductions in populations of *S. arenicolus*. The small range and fragmented distribution of *S. arenicolus* in New Mexico suggests that an additional level of management and monitoring practices should be implemented on Areas 1, 2, and 3 (see Table 2 for discussion). Recommendations to maintain viable populations of *S. arenicolus* on public lands in southeast New Mexico are provided below.

TEBUTHIURON APPLICATION

Comparisons between Tebuthiuron treated and adjacent untreated shinnery oak habitat in the Mescalero Sands, Chaves County, New Mexico showed overall reductions of *S. arenicolus* numbers between 70-94% in the treated pastures compared to the untreated pastures (Snell et al. 1997 and references therein). Thus, all Tebuthiuron use in habitat occupied by *S. arenicolus* should cease, and an untreated buffer zone of at least 500 m should be established around all occupied habitat, as there is frequent evidence of Tebuthiuron drift into adjacent pastures. All potential habitat scheduled for Tebuthiuron treatment should be surveyed for *S. arenicolus* prior to application and if *S. arenicolus* is found, the area should be removed from the Tebuthiuron treatment program. This is particularly important in narrow portions of the range.

OIL AND GAS EXTRACTION ACTIVITIES

Data from investigations of oil and gas extraction activities (Sias and Snell 1996, 1998) suggest that moderate density oil field development does not present an imminent threat to *S. arenicolus* populations, although it is important to note that there are localized and spatially widespread reductions. At high levels of well density where 50% declines in *S. arenicolus* populations were predicted (ca. 25 wells/section), measures that reduce oil field impacts on *S. arenicolus* should be implemented, including avoiding constructing caliche roads and well pads in shinnery oak dunes, reducing the overall amount of roads built through shinnery oak habitat, reducing the size of caliche well pads and caliche roads, and strictly limiting the density of oil wells in shinnery oak habitat.

Three courses of action are recommended to reduce the effect of individual wells. Large blowouts often occur in clusters separated by dense shinnery flats. Locating caliche pads in these shinnery flats causes much less damage to the habitat of *S. arenicolus*. The dimensions of the pad should be kept as small as possible to avoid additional habitat destruction. Enhanced well and battery pollution control measures should be installed in areas of high well density where the cumulative effects of many small sources of pollution may amount to a significant source of mortality.

Because the overall range of *S. arenicolus* is small and highly fragmented (Fig. 3), patterns of oil and gas field development that create large holes of unsuitable habitat in occupied shinnery dune habitat are not recommended. Large scale reductions in potential habitat will unquestionably lower the probability of continued survival for this species. At the scale of a square mile (section) or greater, future oil field developments that sacrifice some areas and “preserve” other areas of shinnery oak are not recommended. At the smaller scale of individual wells ($\leq 1/4$ sq. mi) where blowout clusters occur in shinnery flats, wells should be placed in dense shinnery flats and not in the blowouts.

Because oil field development is pervasive throughout the southern region of *S. arenicolus* range, future development in this region should be carefully monitored. In an area centered on the Eddy-Lea County line and south of Hwy. 529 (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) there is shinnery oak habitat harboring one of the most dense and largest *S. arenicolus* populations in the Loco Hills to Eunice area. High priority should be given to conserving the habitat and spatial attributes of this core area, because the area is surrounded by high well density oil fields that span the entire width of *S.*

arenicolus habitat in this region. This area therefore occupies a strategic position for a source population and is important to prevent further fragmentation of the geographic range.

ORV USE

In *S. arenicolus* occupied or potential habitat, ORV use should be restricted when possible. Where ORV use is limited or restricted, waivers can be considered for activities such as maintenance of permitted range improvements, geophysical exploration, pipeline construction or maintenance, access for individuals, or oil and gas operations. While each waiver should be reviewed separately, care should be taken not to allow extensive use in occupied or potential sandy habitat of *S. arenicolus*. If such use is considered essential, the proposed activity should be completed during the warmer months of the year when *S. arenicolus* is active (May-Sept.).

LIVESTOCK GRAZING

Livestock grazing in the Mescalero Sands has not been studied as it relates to persistence of the herpetofauna, however we presume that a grazing plan that consists of moderate stocking rates and that does not include the chemical treatment of shinnery oak would not be detrimental to *S. arenicolus* populations.

FIRE

Additional research to investigate the role of fire in restoring and maintaining the shinnery oak ecosystem should be carried out. Periodic prescribed fires may represent an alternative to chemical treatment of shinnery oak that would allow BLM to achieve the desired plant community type for the informed management of *S. arenicolus* (USDI-BLM 1997b).

CONSERVATION OF *S. arenicolus*

Concerns over the limited range and threats of continued herbicide treatment and oil and gas extraction activities in the occupied habitat of *S. arenicolus* suggest that habitat protection and knowledge of the species' biology are essential for its management and long-term viability. A determination of the total range and the conservation of populations and habitat are essential aspects of the management of this species. The viability of known populations needs to be determined through continuous long-term monitoring at previously established sites.

Conservation of *S. arenicolus* populations and habitat will be ongoing and concurrent with the identification of management needs and appropriate means for site-specific management for

conservation of the species. This Management Plan is based on the perspective that it is important to conserve all known populations. However, current knowledge of metapopulation dynamics emphasizes the relatively greater risk of extirpation faced by small, isolated local populations, which describes the current condition of *S. arenicolus*. We believe that conservation of all *S. arenicolus* populations is necessary for long-term maintenance of *S. arenicolus* and achievement of the goals of this Plan. Considering the species' extremely small range, habitat specialization, limited mobility, and historic land uses in the region by humans, it is very likely that some *S. arenicolus* populations have been extirpated. Given these biological factors and uncertainties of future land management policies, it is prudent to conserve all extant *S. arenicolus* localities to allow the greatest potential for connectivity between populations of these lizards. Note that Area 1 and Area 2 (Table 3) are 62.1% and 76.9% private land where limited management possibilities exist.

For the long-term conservation of *S. arenicolus*, it is very important to understand that the range, distribution, and populations of the lizards are dynamic entities that move across the landscape. Considering the dynamic nature of the shinnery dunes landscape, the habitat specificity of the lizards, and the finding that they were absent from more than 25% of suitable locations surveyed within their present range, it is imprudent to consider currently unoccupied patches of habitat within the range or along the edge of the range as useless to *S. arenicolus*. Ecosystem engineering by humans, either by default through indirect effects of activities that fragment the landscape (e.g., construction of roads), or directly by removing shinnery oak in areas where *S. arenicolus* do not occur presently can only be justified by a short term and static view of a landscape that is obviously dynamic (refer to Fitzgerald et al. 1997).

FUTURE RESEARCH

Serious questions remain about the applied ecology and population biology of *S. arenicolus* that can only be answered through carefully conducted research. For example, there are very limited data on the egg and juvenile stages in the life cycle of *S. arenicolus*. These life stages may depend to a large degree on shinnery areas between blowouts, but there is a lack of information on juvenile dispersal, activity of juveniles, or habitat preferences of juveniles. Similarly, data do not exist on the preferred nesting microhabitat for *S. arenicolus*. Adult *S. arenicolus* do not use shinnery flats and are almost never found away from dune blowouts, however almost nothing is known about dispersal of these adult lizards. Because sand dune lizard populations are scattered across the Mescalero Dunes landscape, a certain amount of dispersal must occur. Hence many

important questions remain about the importance of inter-blowout areas, and dispersal mechanisms of *S. arenicolus*.

Studies into the metapopulation dynamics of *S. arenicolus*, using genetic markers in conjunction with field studies on juvenile movements would be a useful line of research. Because research on early life stages of *S. arenicolus* pulls together several different aspects of habitat requirements, metapopulation dynamics, and demography, this area may be the most pressing research need at this time. Additional studies need to investigate genetic differentiation in the isolated populations and in the north-south pattern of distribution, if such differentiation exists.

Several other areas of future research may also be immediately applicable to the situation of *S. arenicolus*. Investigations into the feasibility of habitat restoration of altered shinnery oak dunes is one research topic that is useful and feasible. Substantial areas of treated shinnery oak exist that are surrounded by occupied habitat, e.g., numerous sites west of Crossroads, NM. This area and others are extremely likely to have once been occupied habitat before shinnery oak was removed, and would be good candidate sites for experiments in habitat restoration of sand dune lizards.

Another line of future research that should be pursued relates to the roles of grazing and fire, how these phenomena affect vegetation structure in the shinnery dune system, and what are the consequences of grazing activities, lack of burning, and prescribed burning on sand dune lizard populations.

No detailed investigation of the status of *S. arenicolus* populations have been carried out in Texas. To more fully understand this species throughout its range, baseline studies to include status and distribution, an analyses of shinnery oak removal programs, and the extent of oil and gas development in shinnery oak dunes should be implemented in Texas.

Finally, more work remains to be done to analyze current and predicted loss of suitable habitat throughout the range of the sand dune lizard.

SUMMARY OF AGENCY RESPONSIBILITIES

About 70% of *S. arenicolus* occupied habitat occurs on federal and state public lands in New Mexico (Fig. 6; Table 2). Almost 100,000 acres of this shinnery oak dominated habitat have been treated with the herbicide Tebuthiuron in the last 15 years and it is to soon to tell how many of these acres will return as shinnery oak habitat (Peterson and Boyd 1998). It was believed that the shinnery in New Mexico had expanded considerably in historical times (York and Dick-Peddie 1969). However, mid-nineteenth-century survey records and present-day boundaries are remarkably similar (Gross and Dick-Peddie 1979). The shinnery range has not increased perceptibly in recent years (McIlvain 1954); in fact, it has decreased, due to oak-control efforts and

conversion to cultivation. Dhillion et al. (1994) consider the community threatened in Texas, as do Bailey and Painter (1994) for shinnery habitat in New Mexico. If we assume that the entire 100,000 acres of shinnery oak habitat sprayed (Peterson and Boyd 1998) was within the *S. arenicolus* range then we assume that ca. 24% of the total habitat of *S. arenicolus* in New Mexico has been eliminated (i.e., $655.2 \text{ sq mi} \times 640 = 419,328 \text{ acres}$; $419,328 \text{ acres} / 100,000 = \sim 24\%$). Considering this reduction in suitable habitat, the proper and informed management of *S. arenicolus* in southeast New Mexico is critical to its continued existence.

UNITED STATES DEPARTMENT OF THE INTERIOR – BUREAU OF LAND MANAGEMENT

BLM should continue an active role in the management of *S. arenicolus* on public lands. Through the completion of scientifically rigorous investigations conducted by qualified researchers, it is well known that the widespread use of Tebuthiuron in potential or occupied habitat is the single biggest threat to the continued existence of *S. arenicolus*. Therefore, special consideration should be given to the use of this herbicide for the chemical treatment and/or removal of shinnery oak. Recommendations include: 1) Tebuthiuron should not be applied on or within 500 meters of any habitat known to be occupied by *S. arenicolus*, 2) Tebuthiuron use is discouraged on or near any potential habitat, and 3) prior to Tebuthiuron application on or near to any potential habitat, thorough, site-specific surveys for *S. arenicolus* should be completed.

Oil and gas extraction activities should be carefully monitored. New wells should not be placed in occupied or potential microhabitat (blowout complexes), and well density should not exceed 25 wells/section, when we can expect a 50% reduction in *S. arenicolus* populations (see Sias and Snell 1998 for a complete discussion). At these well densities, sound environmental practices should be implemented. No refineries nor other large industrial installations should be constructed in occupied or potential habitat. Instead they should be placed in adjacent non-shinnery oak habitat. BLM should require the petroleum industry to perform regular inspection and maintenance programs within the oil/gas fields and along pipeline routes that reduce and repair leaks.

In addition, BLM should ensure that any unforeseen land management activities in or near any potential *S. arenicolus* habitat should be reviewed by a panel of experts, including the NMGF staff herpetologist, knowledgeable in the distribution and habitat requirements of *S. arenicolus*.

When available and appropriate, funding should be provided for regular monitoring programs at previously established sites. All new localities of *S. arenicolus* that were not illustrated on the USDI-BLM 1:100,000 Topographic Land Status maps provided with Fitzgerald, et al. (1997), should be reported to the NMGF staff herpetologist or other individuals knowledgeable in

the distribution of *S. arenicolus*. BLM should continue to recognize *S. arenicolus* as a Species of Concern in the Carlsbad and Roswell Resource Areas and should continue to follow the regulations mandated by USDI-BLM (1997a, 1997b), including Appendix 1 Surface Use and Occupancy Requirements (pages AP1-1-4) and Appendix 2 Roswell District Conditions of Approval (page AP2-18).

UNITED STATES DEPARTMENT OF THE INTERIOR – UNITED STATES FISH AND WILDLIFE SERVICE

USFWS should continue an active role in the monitoring of *S. arenicolus* on public lands. When available, funding should be provided to the appropriate state or federal agency for regular monitoring programs at a random sample of all previously occupied sites, every 3-5 years. *Sceloporus arenicolus* should be maintained on the informal USFWS List of Species of Concern. The appropriateness of this listing should be reviewed annually, and to ensure the long-term protection and survival, the species should be elevated to the appropriate level if additional rigorous data indicate.

NEW MEXICO DEPARTMENT OF GAME AND FISH

NMGF should continue an active role in the monitoring of *S. arenicolus* on public lands and should confirm the continued existence of *S. arenicolus* a minimum of once every 3 years at a random sample of previously established monitoring sites on Mescalero Sands. Habitat quality should also be assessed at each of these sites. Funding should be provided for this regular monitoring, and methodology should be similar to that used by Fitzgerald et al. (1997). Under authority and direction of the Wildlife Conservation Act, *S. arenicolus* should be maintained on the NMGF List of Threatened and Endangered Species. The appropriateness of the current listing as Threatened should be reviewed biannually, and to ensure the long-term protection and survival, the species should be elevated to the appropriate level if indicated by additional rigorous data.

NEW MEXICO STATE LAND OFFICE

NMSLO should initiate an active role in the management of *S. arenicolus* on public lands. Special consideration should be given to the use of Tebuthiuron for the chemical treatment and/or removal of shinnery oak. Recommendations include: 1) Tebuthiuron should not be applied on or within 500 meters of any habitat known to be occupied by *S. arenicolus*, 2) Tebuthiuron use is discouraged on or near any potential habitat, and 3) prior to Tebuthiuron application on or near to any potential habitat, thorough, site-specific surveys for *S. arenicolus* should be completed.

Oil and gas extraction activities should be carefully monitored. New wells should not be placed in occupied or potential microhabitat, and well density should not exceed 25 wells/section. No refineries nor other large installations should be constructed in occupied or potential habitat. NMSLO should require the petroleum industry to perform regular inspection and maintenance programs within the oil/gas fields and along pipeline routes that reduce and repair leaks.

In addition, NMSLO should ensure that any unforeseen land management activities in or near any potential *S. arenicolus* habitat should be reviewed by a panel of experts, including the NMGF staff herpetologist, knowledgeable in the distribution and habitat requirements of *S. arenicolus*.

When available and appropriate, funding should be provided for regular monitoring programs at previously established sites. All new localities of *S. arenicolus* that were not illustrated on the USDI-BLM 1:100,000 Topographic Land Status maps provided with Fitzgerald, et al. (1997), should be reported to the NMGF staff herpetologist or other individuals knowledgeable in the distribution of *S. arenicolus*.

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FIGURE 6. Total range of the sand dune lizard, *Sceloporus arenicolus*, in southeast New Mexico. Each polygon was drawn around contiguous, tightly grouped clusters of occupied sites.

FIGURE 1. Total known distribution of the sand dune lizard, *Sceloporus arenicolus*, in southeast New Mexico. Each dot may represent more than one locality if such localities are not separated by more than 1.6 km (1 mi). This map includes all surveys completed during the Distribution, Tebuthiuron, and Oil/Gas Studies, as well as the Historic Localities which were established prior to the initiation of these studies in 1991. See Fitzgerald et al. (1997) for exact location of each dot. Coordinates are latitude and longitude.

FIGURE 2. Total known distribution of the sand dune lizard, *Sceloporus arenicolus*, in southeast New Mexico. Each dot may represent more than one locality if such localities are not separated by more than 1.6 km (1 mi). This map illustrates positive as well as negative sites and includes all surveys completed during the Tebuthiuron and Oil/Gas Surveys, as well as the Historic Localities which were established prior to the initiation of these studies in 1991. See Fitzgerald et al. (1997) for exact location of each dot. Coordinates are latitude and longitude.

FIGURE 3. Distribution of the sand dune lizard, *Sceloporus arenicolus*, in southeast New Mexico. Each polygon was drawn around contiguous, tightly grouped clusters of occupied sites. See page 23 for an explanation of the Historic Localities not included with Area 4.

FIGURE 4. Distribution of the sand dune lizard, *Sceloporus arenicolus*, in southeast New Mexico. The total area (sq. km) of each polygon is presented in the legend. Each of these four areas is a discrete population of *S. arenicolus* that is separated by areas of unsuitable habitat as indicated by topography or vegetative type.

FIGURE 7. Distribution of the sand dune lizard, *Sceloporus arenicolus*, in southeast New Mexico plotted over NM GAP Federal, State, and private land jurisdiction. The resolution of this map is not fine enough to show small private land inholdings. Refer to Table 3 for percentage jurisdiction in each Area.

FIGURE 5. Distribution of the sand dune lizard, *Sceloporus arenicolus*, in southeast New Mexico plotted over NM GAP vegetation coverage. Refer to Table 1 for percent vegetation cover in each Area.

FIGURE 9. Distribution of the sand dune lizard, *Sceloporus arenicolus*, in southeast New Mexico plotted over NM GAP shinny oak distribution.

FIGURE 8. Survey sites where no *Sceloporus arenicolus* were found. These sites were investigated during the *S. arenicolus* surveys in southeast New Mexico, and are plotted over the NM GAP vegetation coverage.

FIGURE 10. Select regions (with symbolic codes) that contain the sites where transects were conducted during 1996-97 (See Sias and Snell 1998 for further detail).

APPENDIX 1

MANAGEMENT PLAN FOR THE SAND DUNE LIZARD, *Sceloporus arenicolus* IN NEW MEXICO

TERMINOLOGY

Terms referring to the habitat, distribution, and occurrence of *S. arenicolus* should be clarified. As used in this plan, a **site** is a place where surveys are conducted to determine the presence (**positive locality**) or absence (**negative locality**) of *S. arenicolus*. Surveys generally cover areas $\geq 400 \times 400$ m. Geographical coordinates are given for sites for the practical purposes of mapping, while it is acknowledged that sites are the area surrounding the coordinates.

A **locality** is a place where *S. arenicolus* is verified to occur, as documented by museum voucher specimens. **Historical localities** are places where *S. arenicolus* is known to occur, as documented by voucher specimens not produced as part of recent study. Individual *S. arenicolus* move around in their environment and belong to populations spread throughout their habitat. Thus the geographical coordinates given for a site or locality refer to an area much larger than a single point. **Surveys** prove beyond doubt the presence/absence of *S. arenicolus* at a site, and contiguous habitat allows inference about the occurrence of *S. arenicolus* beyond the scale of a survey site. Continuous shinnery dune complexes where *S. arenicolus* occur are usually larger than a site. It is reasonable to assume that *S. arenicolus* occurs throughout an area of continuous habitat that contains a locality. Conversely, it is unreasonable to assume occurrence of *S. arenicolus* in dune complexes that have not been surveyed, or that are several kilometers from known localities, regardless of habitat similarity. Based on extensive field evaluation of the methods presented in this plan, it is improbable that *S. arenicolus* would be present and not detected in suitable habitat that has been surveyed, although it could be absent from apparently suitable habitat that has not been surveyed.

The **geographical range** of *S. arenicolus* is the entire area encompassed by all occupied localities. **Distribution** refers to the spatial arrangement of localities within the range of *S. arenicolus*. **Suitable habitat** refers to habitat of sufficient similarity to habitat at known localities that it is likely that *S. arenicolus* could occur there. *Sceloporus arenicolus* may not occur in all areas of suitable habitat due to chance, and the dynamic nature of extinction and colonization of suitable habitat through time. **Potential habitat** is any mosaic of habitat types within or near the

range of *S. arenicolus* where it might be feasible to find *S. arenicolus*. For purposes of this plan, potential habitat is restricted to eastern Chaves and Eddy counties, southern Roosevelt County, and Lea County, New Mexico. Potential habitat types are shinnery dunes, shinnery oak flats, open sand dunes, dune grasslands, and mesquite grasslands and scrubland.

Potential habitat types are classified into 5 microhabitat types. **Shinnery dunes** are active sand dune complexes dominated by shinnery oak (*Q. havardii*). Shinnery dunes are characterized by open blowouts (bowl-shaped depressions among sand dunes) of varying size and with varying densities of grasses and other plants growing in them. **Shinnery oak flats** are sandy soils dominated by shinnery oak with little topographic relief. **Open sand dunes** are large active dunes with steep slopes and open expanses of bare sand and sparse vegetation. **Dune grasslands** are sand dune formations where grasses are dominant over shinnery oak, including areas treated with herbicide for shinnery oak removal. **Mesquite grasslands and mesquite scrub** are areas with varied topographic relief characterized by mesquite (*Prosopis* sp.), shinnery oak, and grasses. Mesquite scrubland sites are often characterized by mesquite hummocks, where clumps of mesquite form hummocks separated by open sandy areas with sparse vegetation including shinnery oak. Other sites are characterized by short grasslands and Tabosa flats, lacking shinnery oak and dominated by grasses and scattered mesquite.

APPENDIX 2

MANAGEMENT PLAN FOR THE SAND DUNE LIZARD, *Sceloporus arenicolus* IN NEW MEXICO

SURVEY METHODOLOGY

These surveys are designed to verify the presence/absence of *S. arenicolus* at a site and provide mapable and repeatable locality data. Surveys should be designed to increase the probability of finding *S. arenicolus* if they occur within a given area. They should be conducted during May and June between 0800 and 1300 h when environmental conditions are most favorable. Surveys should not be initiated until lizard activity is noted within the blowout areas and should be terminated when substrate temperatures reach 45° C (ca. 110° F).

To determine the presence/absence of *S. arenicolus*, observers should walk slowly through potential habitat searching for lizards. At each site, the occurrence and extent of each habitat type should be noted and all habitat types present at every site should be searched. The time and duration of surveys and the number of person-minutes elapsed before first-encounter of *S. arenicolus* should be noted.

If observers are well trained and are very familiar with the species of lizards expected to occur within an area being surveyed, then species identification can be made with the aid of close-focusing binoculars. Otherwise, lizards should be collected by hand or by shooting with revolvers loaded with .22 cal. shot shells. Collecting is necessary to document the presence of the species at all sites with properly documented museum voucher specimens. Voucher specimens, with associated locality and ecological data, are the only permanent verifiable data base of the presence of *S. arenicolus* at a specific place and time. *Sceloporus arenicolus* is difficult to identify even for skilled herpetologists not working regularly with the species in the field.

Surveys should be discontinued if no *S. arenicolus* are found after a maximum of 6 person-hours of searching or if it becomes evident that further searching will not be productive because the entire area has been searched, or because of unfavorable environmental conditions (i.e. extreme temperatures, inappropriate time of day, rain, overcast conditions). Field notes on the other lizard species encountered in the area should be maintained to document the species assemblages of lizards at each site. Unless specific provisions are made in advance with other researchers, all

specimens collected should be deposited with the Division of Herpetology, Museum of Southwestern Biology, University of New Mexico.

Survey site locations should be determined as precisely as possible in the field with a GPS unit. Site locality data are recorded as precisely as practical and should include latitude and longitude as well as UTM and township, range, and section.

During the activity season and with favorable environmental conditions for terrestrial activity, the presence/absence of *S. arenicolus* at any given site can be reliably detected using the above methodology. More detailed methodology used in the Tebuthiuron and oil/gas studies to investigate specific questions more complex than presence/absence are referenced in the appropriate citations throughout this Management Plan. See specifically Snell et al. (1997) and Sias and Snell (1998) and references therein.

APPENDIX 1

TERMINOLOGY USED IN SAND DUNE LIZARD MANAGEMENT PLAN

APPENDIX 2

SURVEY METHODOLOGY RECOMMENDED FOR FUTURE
SURVEYS OF SAND DUNE LIZARD

APPENDIX 3 Snell, H.L. and A. Landwer. 1991 [1992]. Results of preliminary research on the effect of shinnery oak removal on the sand dune lizard, *Sceloporus graciosus arenicolous*, in New Mexico. Final Report to New Mexico Department of Game and Fish. Contract #80-516.6-01. 8 pp.

APPENDIX 4 Snell, H.L., B. Gorum, and A. Landwer. 1993. Results of second years research on the effect of shinnery oak removal on the dune sagebrush lizard, *Sceloporus arenicolous*, in New Mexico. Final Report to New Mexico Department of Game and Fish. Contract #80-516.6-01. 16 pp.

APPENDIX 5 Snell, H.L., L.W. Gorum, M.W. Doles, and C.K. Anderson. 1994. Results third years (1993) research on the effect of shinnery oak removal on populations of the dune sagebrush lizard, *Sceloporus arenicolus*, in New Mexico. Final Report to New Mexico Department of Game and Fish. Contract #80-516.6-01. 13 pp.

APPENDIX 6 Snell, H.L., L.W. Gorum, L.J.S. Pierce, and K.W. Ward. 1997. Results from the fifth year (1995) research on the effect of shinnery oak removal on populations of sand dune lizards, *Sceloporus arenicolus*, in New Mexico. Final Report to New Mexico Department of Game and Fish. Contract #80-516.6-01 13 pp.

APPENDIX 7 Sias, D.S. and H.L. Snell. 1996. The dunes sagebrush lizard *Sceloporus arenicolus* and sympatric reptile species in the vicinity of oil and gas wells in southeastern New Mexico. Final Report for 1995 field studies. Final Report to New Mexico Department of Game and Fish. Contract #80-516.6-01. 32 pp.

APPENDIX 8 Sias, D.S. and H.L. Snell. 1998. The sand dune lizard *Sceloporus arenicolus* and oil and gas development in southeastern New Mexico. Final Report of field studies 1995-1997. Final Report to New Mexico Department of Game and Fish. Contract #80-516.6-01. 27 pp.

APPENDIX 9 Fitzgerald, L.A., C.W. Painter, D.S. Sias, and H.L. Snell. 1997. The range, distribution and habitat of *Sceloporus arenicolus* in New Mexico. Final Report to New Mexico Department of Game and Fish. Contract #80-516.6-01. 31 pp.

APPENDIX 10 Complete Set of 1:100,000-Scale Topographic Maps showing the Distribution of *Sceloporus arenicolus* in SE New Mexico.