May 8, 2018

Mr. Ryan Zinke
Secretary of the Interior
Office of the Secretary
Department of the Interior
18th and "C" Street, N.W.
Washington DC 20202

Subject: Petition to List the Dunes Sagebrush Lizard as a Threatened or Endangered Species and Designate Critical Habitat

Dear Secretary Zinke:

The Center for Biological Diversity and Defenders of Wildlife hereby formally petition to list the dunes sagebrush lizard (*Sceloperus arenicolus*) as a threatened or endangered species under the Endangered Species Act of 1973, as amended (16 U.S.C. 1531 *et seq*.). This petition is filed under 5 U.S.C. § 553(e) and 50 C.F.R. § 424.14, which grant interested parties the right to petition for the issuance of a rule from the Assistant Secretary of the Interior.

The Petitioners also request that critical habitat be designated for *S. arenicolus* concurrent with the listing, as required by 16 U.S.C. § 1533(b)(6)(C) and 50 C.F.R. § 424.12, and pursuant to the Administrative Procedures Act (5 U.S.C. § 553).

The Petitioners understand that this petition sets in motion a specific process, placing defined response requirements on the U.S. Fish and Wildlife Service and specific time constraints on those responses. See 16 U.S.C. § 1533(b).

Petitioners

The Center for Biological Diversity is a national, non-profit conservation organization with more than 1.6 million members and online activists dedicated to protecting diverse native species and habitats through science, policy, education, and the law. It has offices in 11 states and Mexico. Founded in 1947, Defenders of Wildlife is a major national conservation organization focused solely on wildlife and habitat conservation. It has over 1.8 million members and supporters, and is headquartered in Washington, D.C. with field offices in 12 states.

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SUMMARY

The dunes sagebrush lizard (*Sceloporus arenicolus*; hereafter, DSL) is a narrow-ranging habitat specialist that lives in irreplaceable shinnery oak sand dune habitat in parts of southeastern New Mexico and West Texas. The species is currently in danger of extinction (endangered species) or is likely to become an endangered species in the foreseeable future (threatened species) throughout all or a significant portion of its range. The species is affected or will be affected across its entire range by three threat factors recognized in the Endangered Species Act (ESA):

> *Factor A:* The DSL's existence is threatened by present and future habitat modification and destruction, with over 40% of historic shinnery oak habitat already lost and the lizard gone from as much as 86% of previously occupied survey sites. The primary cause of habitat loss has been widespread *oil and gas development* in the shinnery oak sand dune complexes the species prefers. An estimated 35% of DSL habitat has already been compromised by high and very high petroleum well densities across the species' range; further losses are expected, especially in Texas where existing regulatory mechanisms are inadequate to protect the species (Factor D). The threat of habitat loss has recently been exacerbated by the appearance and rapid acceleration of *sand mining* in prime lizard habitat in Texas: in just one year, over 1,000 acres of core DSL habitat and buffer have been lost to new mines, and the rate of loss is expected to accelerate as the construction phase of sand processing facilities is completed. Based solely on currently available mine lease boundaries, over 20,000 acres of DSL habitat and buffer may be lost from Texas. Beyond the immediate loss of DSL habitat, sand mining is removing the sand that DSL habitats require to recover in the long term. In addition to oil and gas development and sand mining, many areas of the species' range have already *been converted, or may be converted in the future, for agriculture and other uses*. Together, oil and gas development, sand mining, and habitat conversion for other uses are the primary drivers of past, current, and likely future rapid loss and fragmentation of the lizard's little remaining habitat.
>
> *Factor D:* Existing regulatory mechanisms have been insufficient to protect the species. While it appears the avoidance requirements of a Candidate Conservation Agreement (CCA) and CCA with Assurances (CCAA) in New Mexico have slowed the loss of the lizard's habitat, the *Texas Conservation Plan (TCP) has failed to conserve the DSL or its habitat*. For example, data show the rate of new oil and gas well approval inside the lizard's range in Texas is the same as outside the range, despite the TCP. The TCP is inadequate for five reasons: it is *structurally defective*, it *has not effectively addressed the threat of oil and gas development*, it *no longer complies with its requirements to the U.S. Fish and Wildlife Service (Service)*, it *relies on unproven mitigation*, and it *does not address the emerging threat of sand mining*. The TCP's structural defects are exacerbated

by low enrollment rate and incomplete protections on over half of all enrolled acres, both of which drive the high continued rate of habitat loss in the lizard's range. The failures of the past six years of voluntary conservation in Texas indicate existing regulatory mechanisms cannot adequately protect the lizard.

Factor E: Other manmade and natural factors, including invasive species, climate change, and contaminants further imperil the species throughout its range. *Invasive species*, including honey mesquite and Malta starthistle, are present threats to the DSL and shinnery oak dune communities, and their establishment is exacerbated by human activities such as oil and gas development in the area. Drought and temperature increases and variability driven by *climate change* may shift the climate envelope for the lizard or the shinnery oak beyond the species' biological limits over the next 50-80 years. A mismatch between the lizard or its preferred vegetation and the presence of sand dunes, even if direct habitat destruction was not an issue, will be perilous in coming decades. And contamination from various mining, drilling, and petroleum transportation activities may harm local populations and significantly impede conservation. When combined with the effects of threat Factor A and the demonstrated inability of existing voluntary mechanisms to protect the DSL and it habitat in Texas, the additional stressors of invasive species, climate change, and contamination are likely to exacerbate the threats to the lizard.

These threats to the DSL have compromised its conservation status. A species is conserved only if it has adequate resilience, redundancy, and representation (the "three Rs"); if any of the Rs is absent or insufficient, now or in plausible future scenarios, then a species is not secure. The DSL is unlikely to have adequate representation in the near future, and resilience and redundancy are likely to continue declining. The most vulnerable populations of the species are found in the Monahans Sandhills of Texas, which are disconnected from populations in the Mescalero Sands of New Mexico. The biological relevance of this separation is evident from genetic data that show unique and widely divergent genetics among the DSL populations in Texas. The threats to the species are likely to cause the loss of Texas populations and the *loss of representation*. Absent ESA protections, the species will not meet the requirements of the three Rs paradigm and cannot be considered conserved.

The modification and destruction of the lizard's habitat (Factor A) is the most severe of past, present, and future threats. Based on the habitat loss that has already occurred, and losses that are likely to occur absent strong avoidance and minimization measures, the petitioners request the designation of critical habitat in occupied and unoccupied suitable habitat across the lizard's range. This should include not only locations where the combination of essential physical and biological features is currently present, but also areas where the individual features are likely to combine and become fully suitable in the future. For example, sand deposits lacking shinnery oak may be colonized by the oak, or may migrate via wind to areas with the oak, to become

suitable for the lizard. Broad critical habitat designation can help stem the loss of habitat that has already caused most of the DSL's decline.

In summary, the present and future threats to DSL and its current and future demographic status, including the loss of representation in Texas, indicate the necessity of listing under the ESA. As described in this petition, the time horizon indicates threatened status is warranted at a bare minimum. However, many threats are immediate and ongoing, such that most Texas populations may be lost on a much shorter horizon, and with them, representation. With the flexible, common-sense protections of the ESA in place, the DSL can be pulled back from its current trajectory on the road to extinction.

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LISTING HISTORY

The Service designated the DSL as a category 2 candidate species in 1982. Information available at that time indicated that a proposed listing was possibly appropriate, but there were insufficient data on its biology and threats. The agency rescinded this designation based on new information in 1985, but re-designated it as a category 2 species in 1994. In 2001, the Service gave notice that it was a candidate species with a priority of 2 for listing because the "magnitude and immediacy of the threats to the species are high." The Center for Biological Diversity submitted a petition to list the DSL in 2002. In 2004, the Service issued a 12-month finding in which they concluded that listing was warranted but precluded by higher priority listings. The Service issued a proposed rule to list the species as endangered in 2010 (U.S. Fish and Wildlife Service 2010[1]). However, in 2012, the Service withdrew the proposed rule (U.S. Fish and Wildlife Service 2012a) largely due to political pressure (Department of the Interior 2014).

On October 20, 2017, the Center and Defenders sent letters to the New Mexico Department of Game and Fish, Texas Department of Parks and Wildlife, and the Texas Comptroller of Public Accounts and Endangered Species Management advising them that we intend in the near future to file a petition with the Service to list the DSL as a threatened or endangered species (Center for Biological Diversity and Defenders of Wildlife 2017a, 2017b, 2017c).

BACKGROUND

SPECIES DESCRIPTION

The DSL (Figure 1) is a small diurnal species in the phrynosomatid lizard genus *Sceloporu*s. It has a maximum snout-vent length of 2.8 inches; its dorsal surface is light golden brown or yellowish with a faint gray-brown band extending from the head to tail (Degenhardt *et al*. 1996).

TAXONOMY

The taxonomic and systematic history of the DSL was discussed by the Service (2010). Since then, additional scientific studies have verified the validity of the species (Chan *et al*. 2009; Chan *et al.* 2013). Both mitochondrial and nuclear DNA support DSL as a monophyletic group nested within the widespread common sagebrush lizard (*S. graciosus*; Chan *et al.* 2009).

DISTRIBUTION

The DSL has the second smallest range of lizard species that are endemic to North America. The majority of its crescent-shaped distribution is located in New Mexico in eastern Chaves County, southernmost Roosevelt County, northern Lea County, and northeastern Eddy and central/southern Lea counties. There is a second, geographically and genetically disjunct population in Texas in Gaines, Andrews, Winkler, Ward and Crane counties (Figure 2). The DSL is found from 2550 to 4594 feet elevation (Painter *et al.* 1999).

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[1] We provide page numbers in the reference entries in LITERATURE CITED as applicable, and if no page numbers are included there, then the entire reference is relevant.

Figure 1. The dunes sagebrush lizard (*Sceloporus arenicolus*) is endemic to shinnery oak sand dunes of eastern New Mexico and West Texas, where it is threatened by a variety of factors. *Credit: Mark L. Watson / Flickr / CC BY-NC-ND*

Figure 2. The dunes sagebrush lizard is a habitat specialist restricted to a shinnery oak sand dune habitats in the Mescalero Sandhills of eastern New Mexico and the Monahans Sandhills of West Texas. If the lizard is lost from either of these two areas, it will have lost essential representation and cannot be considered conserved.

The DSL is restricted to sand dune habitat containing shinnery oak in the Mescalero Sandhills in southeast New Mexico and the Monahans Sandhills of west Texas (Fitzgerald and Painter 2009; Degenhardt *et al*. 1996; Fitzgerald *et al*. 1997; Laurencio *et al*. 2009; Smolensky and Fitzgerald 2010, 2011; Sena 1985). This habitat type, termed "shinnery sands" in some literature, is located in the High Plains Ecoregion (Griffith *et al.* 2004, Griffith *et al.* 2006). The Mescalero Sandhills and Monahans Sandhills overlay the Permian Basin, and consist of ancient parabolic dunes maintained by wind moving sand and partially stabilized by shinnery oak (Walkup *et al.* 2017; Hall and Goble 2008). The two systems are part of a band of dunes in

Figure 3. In New Mexico, the dunes sagebrush lizard is restricted to a narrow band of shinnery oak sand dune habitats in the Mescalero Sandhills of the eastern part of the state.

Texas and New Mexico, but are considered distinct: Monahans has a different geologic substrate and the dunes are more active than the other dune systems to the north (Holliday 2001). These geological differences are mirrored in the genetic variation observed among the DSL populations (see POPULATION STRUCTURE/GENETICS). Both systems have similar size sand grains, which is important to the DSL's natural and life history (see HABITAT REQUIREMENTS). The separation between the disjunct populations in Texas and New Mexico may be partially the result of the narrow sand grain size associated with the DSL (Sena 1985). In addition to the shared sand grain sizes, both systems have active and semi-stabilized sand dunes with a patchy arrangement of open dune blowouts[2] in a matrix of shinnery oak flats (Walkup *et al*. 2017; Fitzgerald and Painter 2009; Ryberg *et al*. 2015; U.S. Fish and Wildlife Service *et al.* 2008). The wind cover and resistance from shinnery oak and associated vegetation promotes the development of parabolic sand dunes (Hall and Goble 2008).

In New Mexico, the species' potential and occupied habitat spans 644 square miles (Painter *et al.* 1999; Figure 3). Fitzgerald *et al.* (1997) noted that "… an outstanding feature of the range is its narrow shape." The DSL's range is only about 16 miles at its widest, with some areas less than 1 mile wide. Because of this narrowness, the animal is vulnerable to breaks in its distribution caused by habitat loss and other factors that potentially disrupt dispersal. Painter *et al.* (1999) noted "… the species may not disperse into areas of suitable habitat, even across narrow barriers of unsuitable habitat." Fitzgerald *et al.* (1997) documented the species does not occupy apparently suitable habitat south of Jal in New Mexico, even though that habitat is separated from suitable habitat only by a narrow band of unsuitable habitat. At present, it is unknown whether the DSL formerly occupied this area, or if it never extended its range further south. In New Mexico, approximately 49% of the DSL's range is on Bureau of Land Management (BLM) lands, 20% on state lands, and 31% on private lands (Painter *et al*. 1999).

Fitzgerald *et al*. (2011) surveyed the DSL in Texas, concluding that six counties had a total of 197,606 acres with a very high to low likelihood of occurrence, and four counties had a total of 68,865 acres with a very low likelihood of occurrence (Figure 4). The majority of very high to low likelihood of occurrence (129,240 acres) are located in Andrews and Winkler counties. The DSL may be extirpated from the 45,493 acres in Crane County (Laurencio *et al*. 2007; Fitzgerald 2011; U.S. Fish and Wildlife Service 2010). Except for Monahans State Park, DSL habitat in Texas is located on private lands.

[2] Dune blowouts are bowl-shaped depressions formed when sand is blown against the leeward slope with vegetated arms extending around the sides. They are an emergent landform maintained by complex interactions between wind, sand, and shinnery oak (Walkup *et al*. 2017; Machenberg 1984; Ryberg *et al*. 2015).

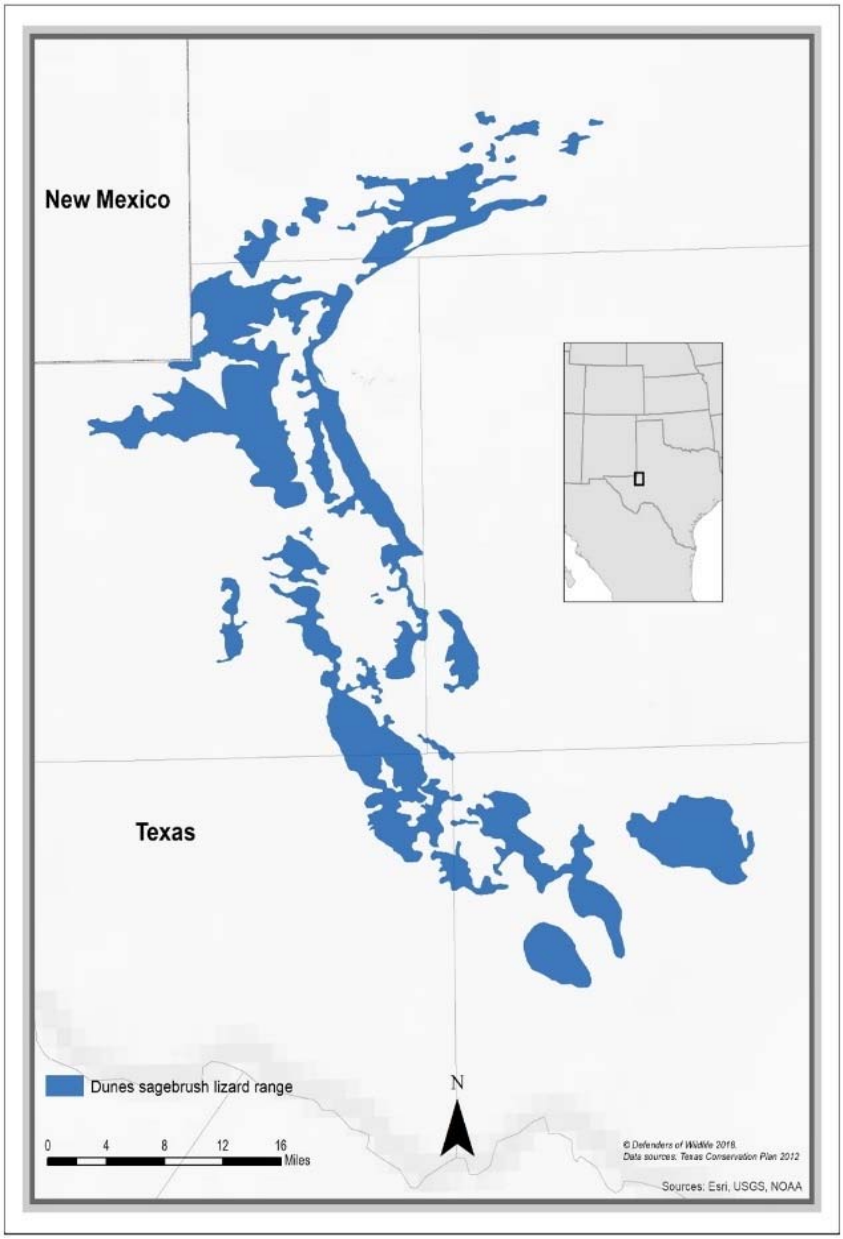

Figure 4. In Texas, the dunes sagebrush lizard is restricted to a narrow band of shinnery oak sand dune habitats in the Monahans Sandhills of the western part of the state.

POPULATION STRUCTURE / GENETICS

There is limited gene flow among DSL subpopulations (Fitzgerald and Painter 2009), because of the patchily distributed habitat. The spatial structure of habitats is reflected in the species' genetics: there are numerous phylogroups based on mitochondrial DNA and microsatellite variation (Chan *et al.* 2009, 2011; Figure 5, right). The major haplotype clusters (separated by lines with dots in Figure 5 [right]) are spatially clustered, with northern, central, and southern groups (Figure 5 [left]). The southern group (dark gray, light gray, tan, and black haplotypes) is

restricted to the Monahans Sandhills of Texas and contains the most divergent and diverse haplotypes of any group (Chan *et al.* 2011). Fitzgerald and Painter (2009) speculated the species expanded from the northern to the southern portion of its distribution. The wide separation (22 miles) of the Mescalero and Monahans Sandhills is likely the ultimate cause for the genetic divergence between the Monahans- and Mescalero-related phylogroups.

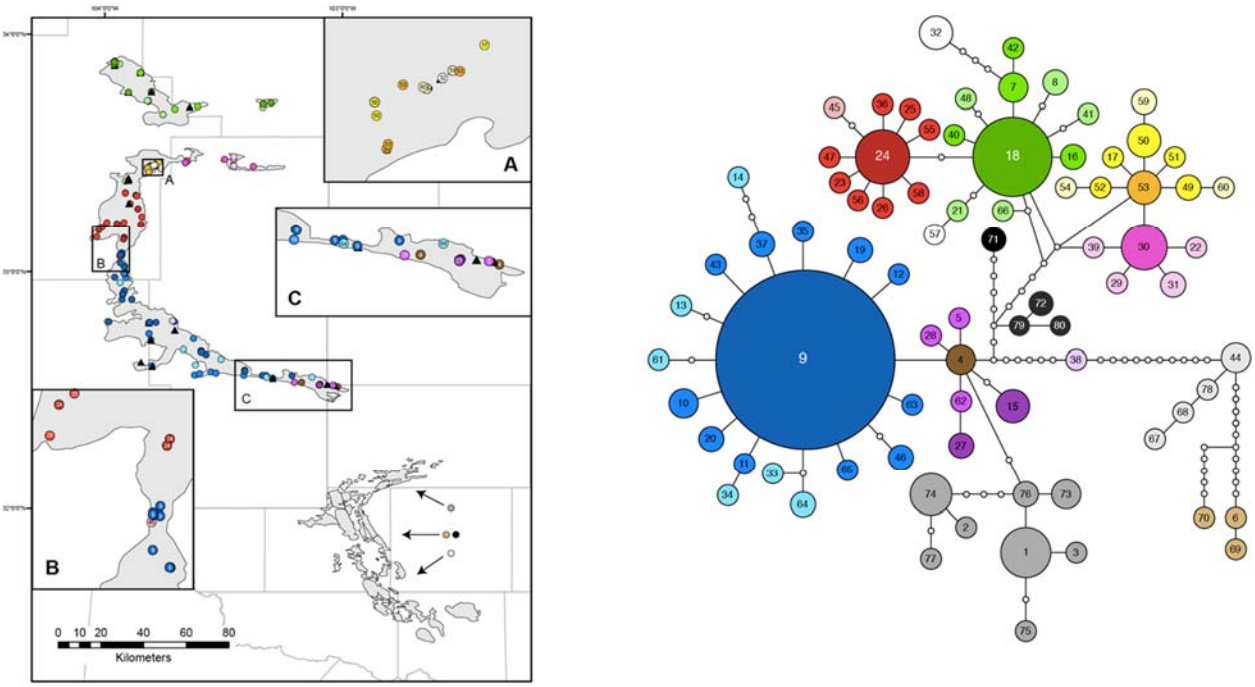

Figure 5. The geographic distribution of dunes sagebrush lizard phylogroups based on mtDNA variation (left) and the haplotype network (right). *These nine color-identified groups cluster into northern (e.g., green, red, yellow subnetworks), central (e.g., blue, purple, dark brown subnetworks), and southern (e.g., gray, light brown subnetworks) clades. The precise locations of samples from the Monahans Sandhills in Texas are not reported for privacy reasons. From Chan et al. (2011; their Figure 2, page 16).*

NATURAL HISTORY AND HABITAT REQUIREMENTS

HABITAT REQUIREMENTS

The DSL is an ecological specialist that occurs primarily in dune blowouts within sand dune complexes dominated by shinnery oak (Degenhardt *et al*. 1997; Fitzgerald *et al*. 1997; Snell *et al*. 1997; Fitzgerald and Painter 2009; Figure 6), but uses shinnery oak flats between blowouts for dispersal (Fitzgerald *et al*. 2005; Leavitt *et al*. 2011; Johnson *et al*. 2016).

Figure 6. Dunes sagebrush lizard habitat in Texas. *From BIO-WEST (2018).*

One study found 90% of 169 captures were within 20 meters of a 5-meter blowout, with 40% of those captures within three meters of a blowout (Fitzgerald *et al.* 2005). The species avoids shallow blowouts and is found in large dune blowouts that are deep (> 3 m) and long (32.9m; Fitzgerald *et al.* 1997). One hypothesis for this selectivity is that these dunes have more area for the species to thermoregulate and avoid predators (U.S. Fish and Wildlife Service 2010). In pristine shinnery dune habitat, large deep blowouts have more edge for cover, more open sand, and steeper slopes (Fitzgerald *et al.* 1997). The deeper blowouts present a much larger three-dimensional surface with more microsites that meet the species' thermoregulatory and water balance needs, and provide for foraging, cover from predators, and reproduction (U.S. Fish and Wildlife Service 2008). Within the larger and deeper blowouts, DSL selected cooler substrates and more northerly and easterly aspects of the habitat, rather than random points or especially southern exposures (Fitzgerald *et al*. 1997; Fitzgerald and Painter 2009). The shape of the blowouts within DSL habitat affects its rate of population growth, with more complex shapes positively related to juvenile survival and fertility, but negatively related to adult survival (Ryberg *et al*. 2014). In addition, the spatial configuration of blowouts in continuous habitats regulates the amount of lizard "neighborhoods" (=diversity), which is positively correlated to recruitment (Ryberg *et al*. 2013).

Sand grain size is an important determinant of which areas the species uses: DSLs do not occur across large areas where the sand grain is too fine (U.S. Fish and Wildlife Service 2010; Fitzgerald and Painter 2009). As noted in DISTRIBUTION, the separation of populations in Texas

and New Mexico may be partially the result of the narrow sand grain size with which the DSL is associated (Sena 1985). Laboratory and field experiments indicate that the DSL prefers sites with medium sand grains (250-354 μm) and not fine and extra fine grains (Fitzgerald *et al*. 1997). Fine-grained sand may inhibit effective respiration when the animals bury in the sand to escape predators, for thermoregulation, or to sleep (Fitzgerald *et al*. 1997; Fitzgerald and Painter 2009; Degenhardt *et al*. 1996). The behavior of burying in sand may also play an important role in moisture control, which is a component of thermoregulation (Bogert 1949; see also Tattersall *et al.* 2006). Individuals that were radio-tagged moved approximately 20 feet while underneath the surface of the sand (Fitzgerald and Painter 2009).

Most individual DSLs have small home ranges. One study found the average home range to be 436 m^2, and the largest documented home range was 28,000 m^2 (Hill and Fitzgerald 2007). Most recaptures occurred within the blowout of first capture (Painter *et al*. 1999). Due to habitat heterogeneity and specialization, individuals are patchily distributed across suitable habitat and areas of apparently suitable habitat may be unoccupied because of local extinction or isolation (Fitzgerald *et al.* 1997).

DSL dispersal is complex. Mark-recapture studies found the animal has high site fidelity and there may be little or no movement among disjunct populations (Snell *et al*. 1997). One gravid female followed using radio telemetry moved approximately 200 meters through shinnery oak habitat (Fitzgerald *et al*. 2005). This individual returned to the original capture site after she had moved, and the authors concluded the movement was probably for egg laying and not for dispersal. Another study found one gravid female moved >150 meters (Fitzgerald *et al*. 2005). A third study documented a long-distance dispersal of an individual that apparently moved through flat shinnery oak covered areas lacking blowouts and that contained mesquite and roads (Leavitt *et al*. 2011; Johnson *et al*. 2016). A second individual in that study moved 117 meters, including across a caliche-covered road, but the identity of that animal is in question (Leavitt *et al*. 2011; Johnson *et al*. 2016). However, no other similar long-distance dispersal has been described (Johnson *et al*. 2016). Therefore, it appears the DSL breeds and forages almost exclusively in blowouts within shinnery oak-covered dunes, and rarely crossing other habitat types (Johnson *et al.* 2016). Painter (2004) recommended that "*Dispersal corridors of unsprayed (= application of herbicides) shinnery oak flats at least 500 m wide should be retained between occupied and suitable unoccupied habitat that is separated by <2000 m.*" His recommendation was based on monitoring data from pitfall traps, which suggested that shinnery flats are important as dispersal corridors for juveniles and females seeking egg deposition sites. In addition, experts contacted by Painter (2004) suggested that it would not be wise to consider any currently unoccupied patch of suitable habitat within its overall range or along the edge of the range as being useless to the species. Many areas that could serve as connections between occupied habitat for the lizard have not been restored (Johnson *et al.* 2016: figures 16-33).

Genetic data provide additional insight into DSL dispersal. Recent analyses of microsatellite data collected near Maljamar, New Mexico, reveal some differentiation across 12 kilometers (Johnson *et al.* 2016). Occasional long-distance dispersal could contribute to gene flow, but it is

likely rare relative to shorter movements by multiple individuals, which will contribute to population connectivity over moderate distances (Johnson *et al*. 2016). Whether gene flow is maintained by cumulative shorter movements of many individuals across generations, longer dispersal of individuals, or both, preservation of large tracts of shinnery oak with blowouts is needed to "*…maintain historical levels of connectivity, prevent local extinction, and avoid the loss of genetic diversity due to genetic drift in reduced populations*" (Johnson *et al*. 2016; Chan *et al*. 2009). Healthy, non-declining source populations also are important for providing dispersing individuals in order to prevent local extinction of sub-populations and breakdown of connectivity at broader scales (Johnson *et al*. 2016).

The landscape inhabited by the DSL is dynamic, with natural processes causing suitable habitat for the DSL to move through time. These new habitats may serve as primary habitats or as corridors for dispersal. The sand dune ecosystem can be destroyed or damaged by habitat fragmentation that impedes the natural shift and movement of sand, causing the dune structure to collapse. This was reiterated by Fitzgerald *et al*. (2012) who emphasized that the long-term conservation of the DSL requires recognition that the range, distribution, and populations of the species are dynamic entities that, over time, move across the landscape. "The viewpoint that the range and distribution of DSL is static is illogical and dangerous not only to sand dune lizards, but also to the unique shinnery dunes environment. Ecosystem engineering by humans, either by default through the indirect effects of activities that fragment the landscape (e.g., construction of roads), or directly by removing shinnery oak in areas where DSL does not occur presently can only be justified by a short term and static view of a landscape that is obviously dynamic" (Fitzgerald *et al.* 2012).

Diet and predators

The DSL is an ambush-forager that eats a variety of invertebrates such as grasshoppers, crickets, beetles, ants, spiders, termites, and other arthropods (Fitzgerald and Painter 2009; Fitzgerald *et al*. 2011; Degenhardt *et al.* 1996; Fitzgerald 2011).

A number of snakes, raptors, and mammals are known or potential predators of the DSL (Fitzgerald *et al*. 2011). Hill and Fitzgerald (2007) reported that five out of 20 females were eaten by snakes: four by coachwhips (*Masticophus flagellum*) and the fifth by an unidentified snake. The loggerhead shrike (*Lanius ludovicianus*) has been recorded to predate on this species (Fitzgerald *et al*. 2011).

Reproduction and survival

The DSL is active between April and October (Fitzgerald and Painter 2009; Sartorius *et al*. 2002; U.S. Fish and Wildlife Service 2010). Female lizards reach sexual maturity in their first spring after hatching, with vitellogenesis beginning in late April (Degenhardt *et al.* 1996). Mating occurs from May to early July (Fitzgerald and Painter 2009) and females produce 1-2 clutches with 3-6 eggs per clutch (Degenhardt *et al*. 1996). The females move out of their territories and construct nests about 18 cm deep in loose sand between the moist and dry sand layers (Fitzgerald and Painter 2009). The first clutch is laid in late June and the second in late July (Degenhardt *et*

al. 1996; Sena 1985). Hatching occurs between late July and late September. Shinnery oak flats between blowouts are used for movement by females seeking nesting sites and dispersal of recent hatchlings (Painter 2007; U.S. Fish and Wildlife Service 2010). Juvenile and adult survival has not been calculated for the DSL but some individuals live for 3-4 years (Fitzgerald and Painter 2009). Snell *et al.* (1997) concluded the possibility of extinction of the species is compounded by its short lifespan and relatively reduced reproductive output.

THREATS ANALYSIS

The ESA requires the Service to evaluate whether any of five threat factors are affecting a species' conservation status and threatening its existence now or in the foreseeable future. In the following sections, we provide detailed information to demonstrate that three of the five

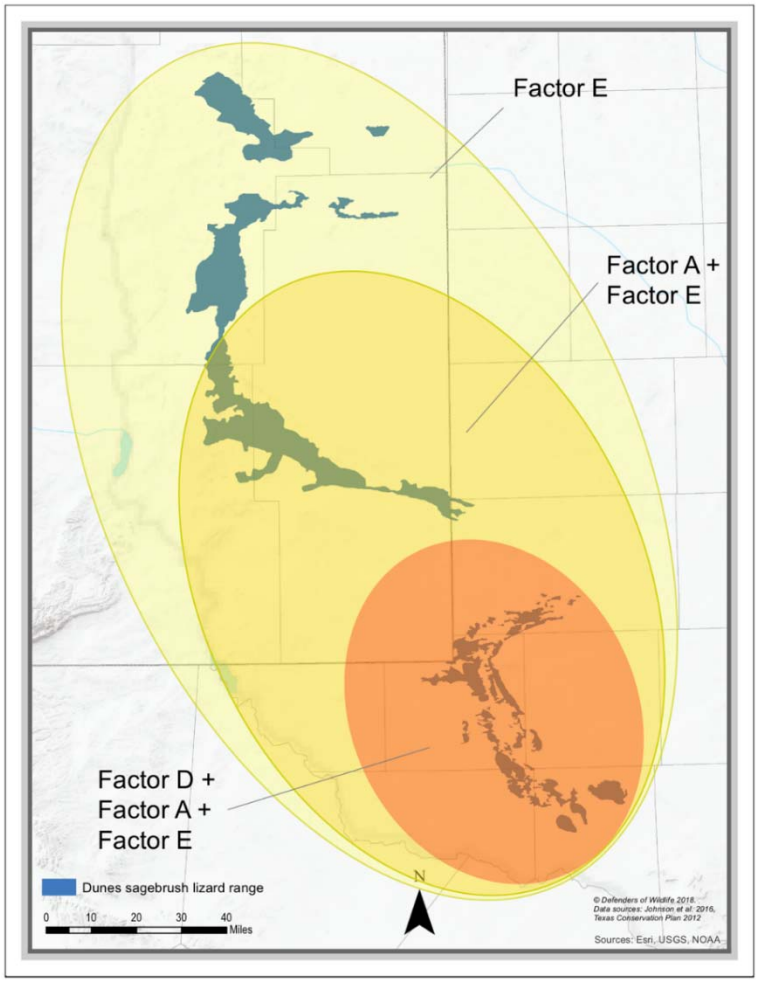

Figure 7. The dunes sagebrush lizard is subject to one or more threats across its entire range. *Factor A (habitat modification and destruction) is concentrated in the southern portion of the species range in New Mexico and across its entire range in Texas. Habitat loss in the Texas portion of the range is directly related to Factor D, inadequate regulatory mechanisms. Factor E, all other natural and manmade factors, is present across the species' entire range in the form of threats from invasive species, climate change, and contaminants.*

factors—Factors A, D, and E—threaten the conservation of DSL today, and are expected to continue or become greater threats in the future. These threats are spatially structured, and all portions of the DSL range are subject to at least one of the threats (Figure 7).

FACTOR A: THE PRESENT OR THREATENED DESTRUCTION, MODIFICATION, OR CURTAILMENT OF THE DSL'S HABITAT OR RANGE

Range-wide habitat loss and destruction is the most significant threat to the continued existence of the DSL. This threat is manifest in multiple forms: oil and gas development and operations (Sias and Snell 1998; Peterson and Boyd 1998), sand mining (Defenders of Wildlife 2017; Texas Comptroller of Public Accounts 2017), conversion for agriculture, road construction, and off-road vehicle use (U.S. Fish and Wildlife Service 2010). Over 20 years ago, researchers concluded, "[s]ignificant amounts of habitat alteration have already occurred throughout the range of the species and there is little doubt that the current distribution is a small part of a larger range in the past" (Snell *et al*. 1997). This threat has continued across most of the DSL's range, and, absent intervention, is near-certain to continue.

OIL AND GAS DEVELOPMENT AND OPERATIONS

The impacts of oil and gas development and operations on the DSL are both direct and indirect. The most obvious direct effects are from the construction of roads, well pads, and associated infrastructure that results in loss of DSL habitat. The removal of shinnery oak has been associated with reductions in DSL populations by as much as 70-94% (Snell *et al.* 1994), and compaction of sandy soil by oil and gas development makes habitat unsuitable for the DSL (Painter *et al.* 1997). In general, these threats reduce patch size, which is associated with decreases in survival and reproduction (demographic parameters) of *Sceloporus* lizards (Hokit and Branch 2003). Other details of dune structure have been related to DSL demographic parameters, such that dune modification directly influences vital rates (Ryberg et al. 2015). Further, oil and gas development and operations are likely to kill or harm DSLs by crushing or burying lizards.

In Texas, a recent report from BIO-WEST (2017) documented 487 disturbances to DSL habitat and associated buffers totaling 2,370 acres between April 2012 and September 2016; almost half of this loss occurred in habitat identified as "very high" likelihood of occurrence (see Fitzgerald *et al.* 2011). This acreage accounts for the total amount of direct habitat lost, but does not consider indirect effects to the species, such as fragmentation and edge effects. As discussed in **THREATS ANALYSIS: FACTOR D**, those losses occurred despite the putative protections of the TCP, which was finalized in February 2012.

Trenches and holes for pipeline and well development may be a direct threat to the DSL. Lizards and other species may fall or enter trenches and holes excavated for oil and gas well development and associated activities (see, e.g., Doody *et al.* 2003). The animals may have difficulty escaping, making them susceptible to crushing, entombment, or otherwise being injured or killed (U.S. Fish and Wildlife Service *et al.* 2008). Given the extensive use of

pipelines across the DSL's range, and the possibilities for future development, trenches may be a substantial, if transient, threat to the species.

Indirect effects are as problematic for the DSL's conservation as the direct effects. In particular, the network of roads connecting well pads and associated infrastructure creates a grid-like pattern of fragmentation (Leavitt and Fitzgerald 2013; Walkup *et al.* 2017). Spatial patterns of road density parallel those for well density (BIO-WEST 2018); we expect their density to increase as more wells and more sand mines are constructed in the DSL's range, further increasing fragmentation. As stated in the "manual" for DSL management in Texas (Texas A&M 2016a):

> Research consistently points to the quality and connectivity of large contiguous areas of suitable habitat as the main factor affecting DSL persistence. Habitat fragmentation and degradation from roads and well pads have been identified as a threat to suitable habitats and DSL populations range-wide.

Oil and gas roads fragment habitat and create vehicle hazards to the animal (Dinerstein *et al*. 2000). In its conference opinion on the New Mexico CCA/A, the Service (2008) summarized the effects of roads:

> The negative impacts of roads going through habitat include increased soil compaction, decreased stability of microclimates, behavioral modification, loss of habitat and habitat quality, inhibited access to resources, subdivisions of populations into smaller more vulnerable habitat patches, division of the ecosystem with artificial linear gaps, generation of abrupt edges, and introduction of non-native, invasive weed species, and mortality due to collisons [sic]…

Fragmentation reduces connectivity among occupied and unoccupied habitat patches, and reduces the quality and quantity of shinnery dune habitat (Smolensky and Fitzgerald 2011). Fragmented sites have fewer, smaller, and more dispersed dune blowouts than unfragmented sites (Levitt and Fitzgerald 2013; Hibbitts *et al.* 2013). The DSL is found in sandy habitats other than blowouts (e.g., disturbed blowouts and barren sandy patches), and some evidence suggests it will cross sand and caliche roads, but not paved roads (Sias and Snell 1998; Johnson *et al.* 2016). Additional observations indicate the animal may bask on caliche roads and that these roads are not absolute movement barriers (Johnson *et al*. 2016). As oil and gas development and sand mining operations continue in the DSL's range, caliche roads may become paved to handle the increased traffic. Such conversion would likely turn moderate barriers for the DSL into significant barriers, effectively increasing population fragmentation without increasing the footprint of infrastructure. Direct mortality from vehicles has been documented only once for this species. Roads may affect the animal through its avoidance of road surfaces, cars, or noise (e.g., Anderson *et al.* 2006; Hibbitts *et al.* 2017).

SAND MINING

Sand mining operations in the DSL's habitat are a recent and significant threat that was not considered when the TCP was originally developed or when the Service withdrew its proposed listing rule for the species (Defenders of Wildlife 2017; Dexheimer 2017; Paul 2017a,b; Collier 2017; DiChristopher 2017). The mining involves removing large quantities of sand from dunes that provide habitat for the animal and that likely provide sand carried by the wind to create or replenish sand dunes in nearby habitat. In West Texas, approximately 18 sand mining companies have started mining or plan to start operations within or near the known range of the species. Using an automated change detection algorithm and manual verification with satellite imagery, Defenders estimated that, as of March 2018, approximately 1,079 acres of lizard habitat and associated buffers have been destroyed or disturbed by mining operations since February 2017 (Defenders of Wildlife 2017; Table 1; Figure 8). In the greater landscape around the lizard's range, 935 additional acres of natural habitat have been destroyed or disturbed. These totals highlight just how quickly a few sand mines can eliminate core DSL habitat. Using the change detection data, we estimate the median sand mine processing plant footprint is 74 acres. We also find that, averaged across the 13 existing mines, the lateral expansion of mines occurs at about 12.2 acres per month per mine (9.6 - 14.7 acres/month, 95% CI), but the value may be as high as 36.7 acres per month, as in the case of the Fairmount-Santrol mine.

Table 1. Current and possible future DSL habitat losses from sand mining in Texas.

		Feb 2017 - March 2018 (acres)	Future[1] (acres)
Lizard Habitat	Very High	501	6,572
	High	0	25
	Low	214	2,918
	Very Low	207	10,431
	Subtotal	922	19,946
Buffer Zone (200m)		157	2,999
Greater Landscape[2]		935	37,133
Total		2,014	60,078

[1] Based on lease boundaries data
[2] Within 5 miles of buffer zone

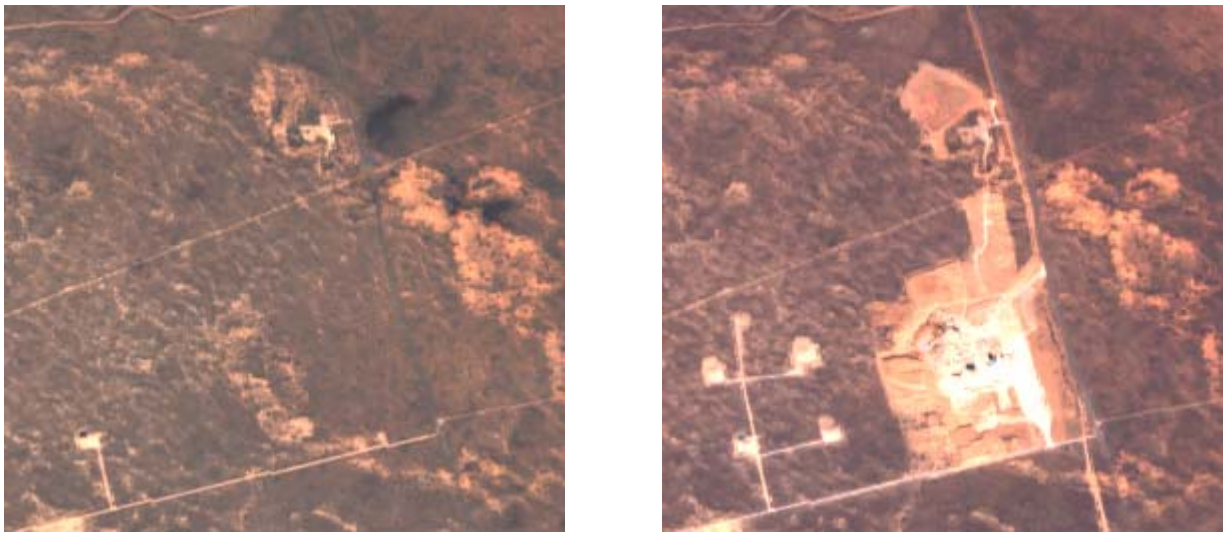

Figure 8. The destruction of dunes sagebrush lizard habitat and adjacent habitat necessary for connectivity is obvious in satellite imagery. *Images of US Silica sand mine site before operations in June 2017 (left) and after site construction in February 2018 (right). Note that this footprint is primarily for the frac sand processing plant, not the mine itself, which is expected to be much larger. Additional mine sites and updated information are available at https://defenders.maps.arcgis.com/apps/Shortlist/index.html?appid=6327fb7cbf6d417dabffb29d5b118eca.*

Based on lease holding information from eight sand mining companies, an additional ~23,000 acres of lizard habitat and buffers could be lost in total to sand mining operations (Figure 9). This would exceed 10% of the lizard's range in Texas, including almost 11% of "very high" quality habitat. Additionally, ~37,000 acres in the greater landscape could be lost to sand mining (Table 1). These values could underestimate the amount of future habitat loss because they are based only on lease information from the sand mine companies that are currently operating in the region and have made public their future operating plans. As of March 2018, six other sand mine sites have become established within or near lizard habitat, which have not released their lease boundary information. We discuss additional regulatory limitations related to the sand mine threat below, under **FACTOR D**.

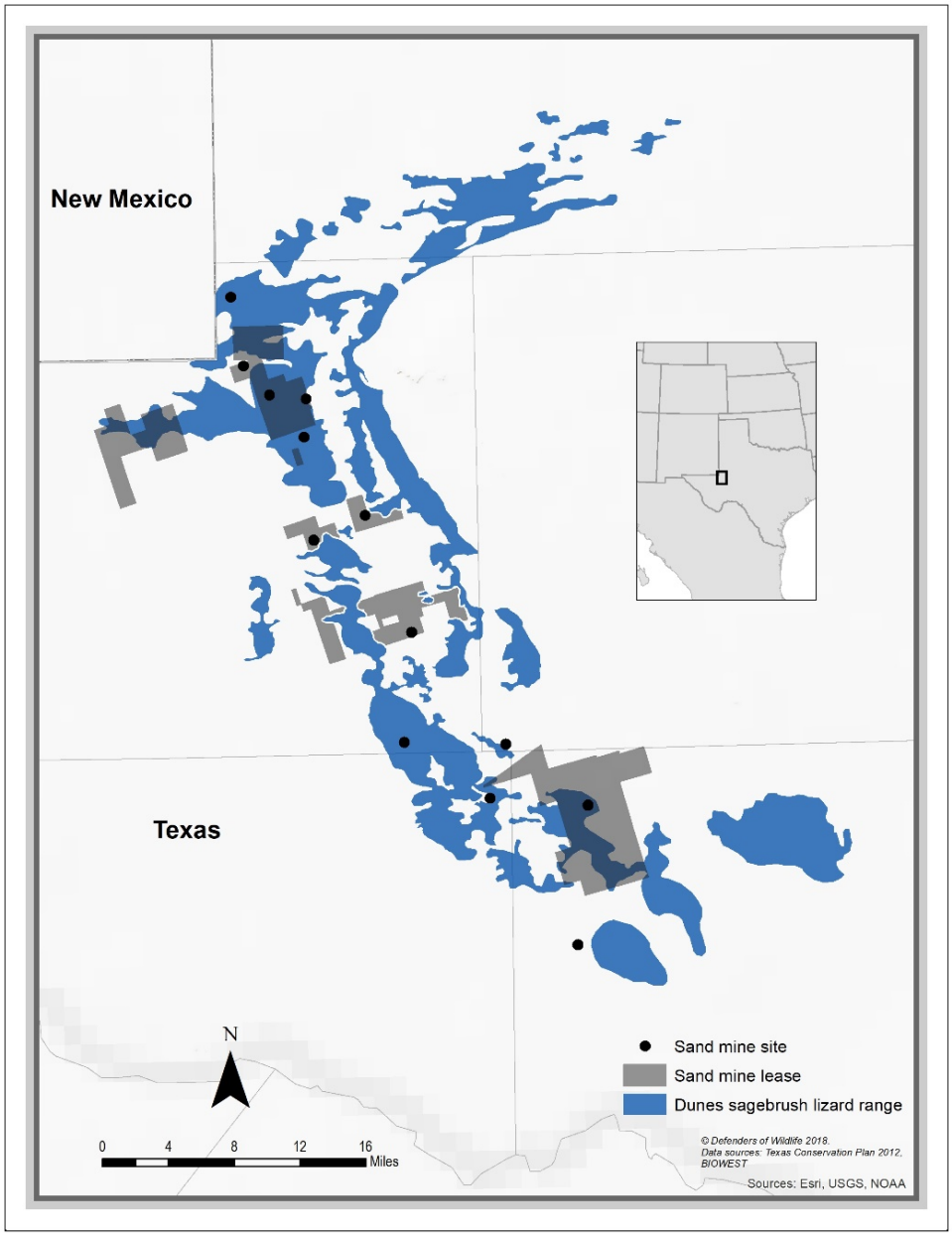

Figure 9. Sand mining for fracture drilling threatens the core of dunes sagebrush lizard habitat in Texas. DSL range and likelihood of occurrence (blue polygons) are overlaid with markers for sand mining operation sites (black dots) and lease boundaries (gray polygons) in Texas as of March 2018.

In addition to the direct effects to the DSL and the immediate loss of habitat resulting from the sand mining, the long term indirect adverse effects to the DSL could be extremely significant. The shinnery sands is an extremely dynamic landscape ecosystem that is created and maintained by windblown sand stabilized by shinnery oaks, with the Monahans-Andrews dunes being the most active of the dune fields on or adjacent to the Llano Estacado and the Great Plains (Holliday 2001). Although portions of the Mescalero and Monahans Sandhills may not be currently inhabited by the DSL, these areas may be an important source of sand for creating or maintaining suitable habitat. The sand mining operations, even if located outside of areas containing DSL, may negatively impact the species by removing the sand needed to create new habitat that the species may colonize in the future.

OTHER HABITAT THREATS: VEGETATION TREATMENTS, LIVESTOCK GRAZING, AND OFF-ROAD VEHICLES

In addition to oil and gas development and sand mining, there are three other prominent threats to the DSL and its habitat: vegetation treatments for agricultural expansion, livestock grazing, and off-road vehicles (ORVs). None alone is a severe threat, but combined they could significantly harm the DSL.

For many years, Tebuthiuron use was the primary method to remove shinnery oak to expand grazing land for livestock. The herbicide is no longer authorized for use on BLM lands, but as of 2010 continues to be used on New Mexico State Lands Department property and on private lands (U.S. Fish and Wildlife Service 2010). Some 100,000 acres of shinnery oak habitat in New Mexico were treated with Tebuthiuron between 1983 and 1998, and 1,000,000 acres in Texas (Peterson and Boyd 1998). However, it is unknown what percentage of these treatments occurred in DSL habitat (that is, in or around shinnery sand dune blowouts). Smolensky and Fitzgerald (2011) reported that the number of *S. arenicolous* declined by 78% within 5 years at sites where shinnery oak was removed by spraying compared to paired control sites.

The effects of livestock grazing on the DSL have not been specifically investigated, exclusive of Tebuthiuron treatment. At sites where most shin-oak had been killed, there were fewer lizards under heavy grazing than in lightly grazed areas, but heavily grazed untreated areas had slightly more lizards than those that were lightly grazed (Snell *et al.* 1993). Painter *et al*. (1999) reports that DSLs "…are not found in extensive open sand dunes, a habitat formation potentially associated with heavy grazing." Peterson and Boyd (1998) noted high stocking rates may result in loss of perennial grasses and increased bare ground and wind erosion. Two other studies in the southwest have determined that livestock grazing results in reduced abundance of lizard species (Bock *et al*. 1991; Jones 1981). Together, the evidence suggests that livestock grazing may negatively affect DSL abundance and needs further study.

Similar to the case for livestock grazing, there have been no specific investigations of the effects of off-road vehicles (ORV) on DSLs. However, the general impacts of ORVs on habitat and animals indicate the threat should be considered. The U.S. Department of Transportation synthesized the literature on the effects of roads and vehicles on reptiles and amphibians (Andrews *et al*. 2006). Their section on ORVs highlights the concerns of the threat:

> This issue is of particular concern due to the increase in off-road vehicle production and the degree of recreational use…. Between 1982 and 1986, the number of all-terrain vehicles (ATVs) sold in the U.S. tripled to more than 2.5 million (Davis et al. 1999). Accurate estimates regarding the number of vehicles that travel off road are difficult to attain because in addition to registered off-road vehicles (ORVs), street-licensed vehicles and unregistered drivers also participate in this recreational activity. Data are lacking and are generally based on indirect measurements such as fuel reports from state governments (Forman et al. 2003). An Oak Ridge National Laboratory study suggests that privately owned pickups and sport-utility vehicles traveled 36.2 billion km and motorcycles traveled 3.1 billion km offroad in the U.S. in 1997 alone (Davis et al. 1999). Research suggests that ecological impacts are comparable across vehicle type and are correlated with intensity of use and sensitivity of the environment (Stokowski and LaPointe 2000).

They noted animals can be run over by vehicles and indirectly harmed by vehicle-associated contaminants. Researchers have flagged the issue for DSLs, noting that ORV use may erode the shinnery oak edges of blowouts and kill inactive DSLs buried in the sand (Painter *et al*. 1999). ORVs have been found to reduce the abundance of other lizard species in at least one other study (Busack and Bury 1974). With increased access associated with increased infrastructure development, we expect an increase in the threat of ORVs harming the DSL.

FACTOR B: OVERUTILIZATION FOR COMMERCIAL, RECREATIONAL, SCIENTIFIC, OR EDUCATIONAL PURPOSES

There is no information to suggest that DSL is threatened by any aspect of overuse.

FACTOR C: DISEASE OR PREDATION

While DSL is subject to predation (see Background, above) and is likely susceptible to disease, there is no information to suggest that either is a significant threat to the species.

FACTOR D: THE INADEQUACY OF EXISTING REGULATORY MECHANISMS

The recent history of attempts at DSL conservation includes extensive use of existing, non-ESA regulatory mechanisms. These have proven inadequate for several reasons. The status of the DSL under Texas and New Mexico laws does not provide for habitat protection. The DSL is listed by the New Mexico Department of Game and Fish as endangered under the New Mexico Wildlife Conservation Act, and is classified as Sensitive by the Bureau of Land Management. Additionally, New Mexico Natural Heritage lists the species as critically imperiled and a Species of Conservation Need (Johnson et al. 2016). Unfortunately, none of these designations allows for habitat protection for the species. The DSL is not listed as threatened or endangered in Texas. Additionally, there are no state- or federally-listed species within the DSL range that help protect its habitat.

The Service withdrew a proposed listing for the species in 2012 largely because of the New Mexico CCA/As and the TCP, both of which were designed to help protect habitat for the species. Unfortunately, the TCP has not met its habitat protection target after 3 years. Among the many problems with the plan (U.S. Fish and Wildlife Service 2018c), nobody, including the administrator of the plan, knows exactly how much DSL habitat is fully protected in Texas. One individual originally part of the effort stated it may be close to only 10% of DSL habitat, and a recent analysis by the Texas Comptroller of Public Accounts (CPA) indicates that 82% of oil and gas wells on property enrolled in the TCP have lease stratification problems (discussed below). Data indicate the New Mexico CCA/As have resulted in a substantial reduction of new oil and gas wells in certain parts of the DSL's range in New Mexico, but a lack of avoidance in others. Further, no data are available to determine whether habitat restoration activities are resulting in increasing DSL populations. We discuss each of these broad issues in the sections below.

Inadequacy of the Texas Conservation Plan

The withdrawal of the proposed rule to list the DSL was largely based on the New Mexico CCA/A and the TCP. In its current form, the TCP cannot adequately conserve the species in Texas. To illustrate the ineffectiveness of the TCP, we show that the rate of oil and gas well approval *inside* DSL habitat is no different from the rate of approval *outside* of habitat, before or after the plan was adopted (Figure 10 and Appendix A).

In 2011, approximately 27,084 acres of the DSL range in Texas exceeded 13 wells/mi^2 for active oil and gas wells. This threshold was surpassed for an additional 3,507 acres from 2012-2017. Most of the increase was the result of oil and gas development in existing high-density areas (>13 wells/mi^2) that elevated neighboring areas above this threshold. Of these increased acres, we identified approximately 39, 10-acre blocks (383 acres) that had one or more newly active wells after 2011.

Examining active/producing wells may underestimate the true effects of oil and gas activities in the lizard's range. A more comprehensive estimate requires us to include other types of wells, including dry, plugged, inactive, and injection. When those additional wells are included, 63,167 acres exceed 13 wells/mi^2 as of 2011. And from 2012 to 2017, an additional 2,031 acres exceeded this threshold, including 74 acres where wells were approved in previously low-density areas. All these changes occurred during a downturn in the petroleum market, but still correspond to continuing negative impacts on DSL populations at the rate of 585 acres per year solely from oil and gas development within areas ostensibly protected by the TCP.

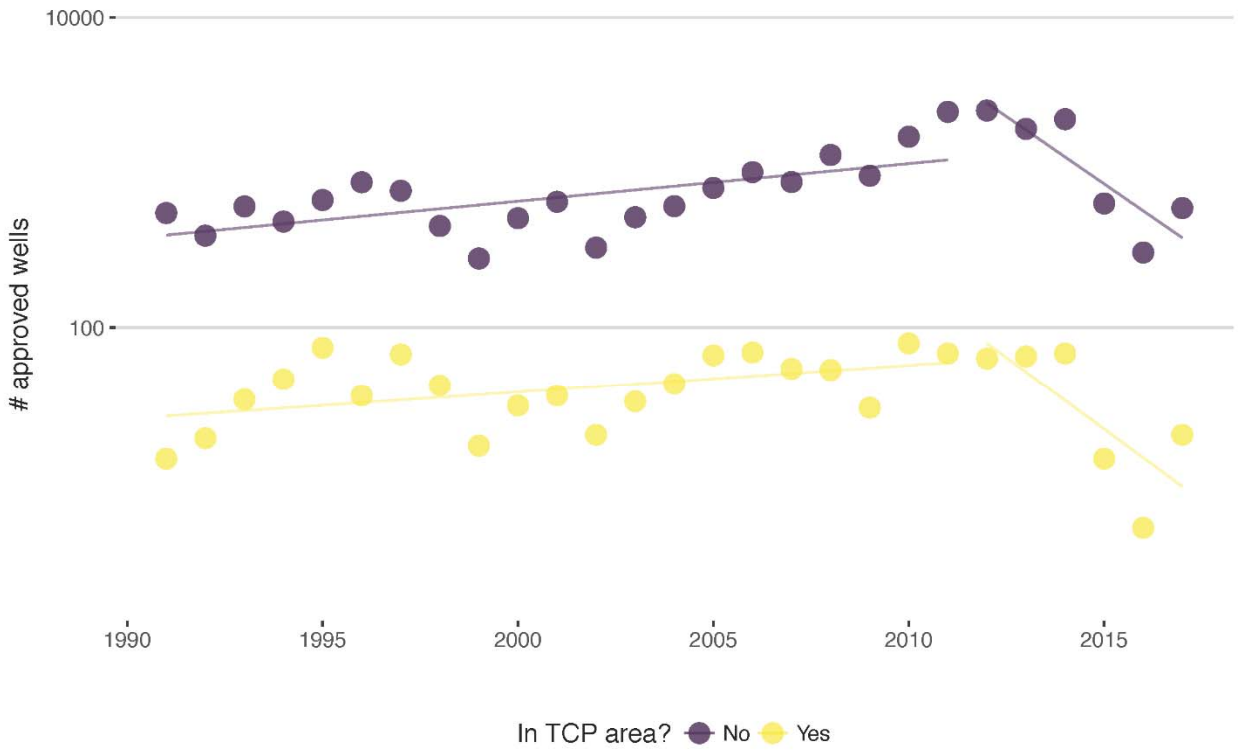

Figure 10. The Texas Conservation Plan (TCP), in place since 2012, has had no effect on the rate of oil and gas well approval in dunes sagebrush lizard (DSL) habitat. *Using data from the Texas Railroad Commission, we identified wells as being sited inside the TCP area (that is, DSL habitat; yellow) or outside the area (purple) but within the five-county range of the DSL in Texas. While the number of wells approved inside the TCP area has declined since 2012, the rate of new well approvals declined at about the same rate outside the TCP area. Note the y-axis is log10-scaled to accommodate the wide difference in numbers of wells between the two areas. In contrast, the same analysis illustrates an effect of the New Mexico CCA/As (Appendix A).*

In the sections below, we discuss five reasons the current TCP is inadequate to conserve the DSL: it is structurally defective, it has not effectively addressed the threat of oil and gas development, it no longer complies with its requirements to the Service, it relies on unproven mitigation techniques, and it does not address the emerging threat of sand mining.

Structural Defects

The current TCP is structurally defective because it cannot effectively conserve the DSL, does not allow for adequate monitoring of conservation outcomes, and sets authorized incidental take levels based on anticipated land use rather than the conservation needs of the species. This section describes those flaws and explains why a new conservation plan is needed.

First, many of the conservation measures in the TCP are diluted by discretionary or qualifying language. Neither the Service nor the public can properly assess the extent to which participants need to comply with these measures because they are given tremendous latitude to decide, on their own, when and how rigorously to implement the measures. Below are several examples:

- "When feasible in the reasonable judgment of the Participant, Well Sites should be developed outside of DSL (DSL) Habitat."
- "When feasible in the reasonable judgment of the Participant, utilize closed loop drilling systems to reduce pit construction and heavy equipment activity."
- "When feasible in the reasonable judgment of the Participant, avoid DSL Habitat; if necessary, lay lines over DSL Habitat via foot, while seismic truck can be located 200 meters from lines."
- "Utilize directional drilling for avoidance of DSL Habitat, when practical."
- "Limit seismic surveying to areas outside of DSL Habitat or utilize walk-in geophone (or other smaller seismic surveying equipment) where possible."
- "When feasible, schedule temporary surface disturbance activities such as installation of lines during periods of seasonal DSL inactivity (i.e., October to March)."

All this discretion means that the TCP is nearly silent about what conservation measures will actually be implemented. To understand implementation, a person must review each certificate of inclusion used to enroll plan participants.

All but one of these certificates, however, are considered confidential information under Texas law and thus cannot be disclosed to the Service or the public. In response to one of Defenders' Texas Public Information Act request, the CPA indicated that the certificates, in their entirety, are "confidential by law, and excepted from public access under Texas Government Code, Section 552.101" (Texas Comptroller of Public Accounts 2012a). That provision protects from disclosure any information relating to the specific location, species identification, or quantity of any animal or plant covered by a candidate conservation plan in Texas, if that information was collected by a Texas state agency from a private landowner participating in the conservation plant. The CPA had interpreted this confidentiality provision so expansively that it refused to disclose any portion of a certificate unless a participant consents to disclosure in writing (Texas Comptroller of Public Accounts 2012b). By this logic, every sentence of every certificate contains information relating to the location, identification, or quantity of DSL. The Office of the Texas Attorney General had affirmed this expansive interpretation in an opinion dated December 3, 2012 (Texas Attorney General Office 2012). Because the Service had no way to independently verify the contents of individual certificates of inclusion or to know what conservation measures each plan participant has agreed to, the Service cannot ensure that the TCP, as currently written, is sufficient to conserve the DSL.

The problems with the confidentiality of the certificates became even more evident in recent years. For example, a 2017 briefing document from Service Field Supervisor Charles Ardizzone explains the following:

> The Service and CPA have found that the Standard Certificate of Inclusion (CI) used by the majority (11 of 13) of Participants to enroll in the TCP does not describe the mitigation/offset procedures contained in the TCP. This is significant because the Standard CI is the basis of enforcement of the conservation measures and mitigation

> procedures in the TCP. The absence of clear mitigation/offset procedures in the Standard CI is also inconsistent with the Alternate CI, which clearly recognizes the mitigation procedures of the TCP. We have worked with the CPA to amend/revise the Standard CI to clarify mitigation procedures and make the Standard and Alternate CIs more consistent….The Standard CIs do not contain mitigation/offset procedures or requirements per the TCP and Appendix F of the TCP….The proposed changes to the Standard CIs will have to be agreed upon by the Participants per the TCP (U.S. Fish and Wildlife Service 2017b).

These findings contradict the incorrect statements in the Service's 2012 withdrawal decision that "[m]itigation measures, such as habitat improvement and mesquite removal, are priorities in the plan" and that "if habitat loss is unavoidable, the permittee must secure mitigation commensurate with the impact prior to authorizing any habitat loss…." The findings also reveal the difficulty for the Service to effectively monitor implementation of the TCP, considering that the agency was unable to identify this problem until five years after the TCP was finalized.

These structural defects of the TCP are unsurprising considering that the Service approved the plan hastily and under strong political pressure. The TCP was prepared under the leadership of Susan Combs, then the Texas State Comptroller (now serving as Acting Assistant Secretary of the Interior for Fish and Wildlife and Parks). The former U.S. Fish and Wildlife Service's State Supervisor for Texas gave sworn testimony that "at the conclusion, the – we ended up with a Texas Plan for conservation of the DSL that in my opinion and the opinion of those who – who know this and do this work everyday, this plan was not only not enforceable, but it wasn't even verifiable. We weren't allowed to know where the impacts to the species occurred or where the mitigation to offset those impacts was" (Department of the Interior 2014). He stated under oath that "I was under the opinion, as are many others, that the failure to list this lizard, the failure to come up with a listing as warranted decision was politically motivated to keep from listing a lizard in oil country" (Department of the Interior 2014). The Service's former Texas State Supervisor said "…a [Department of Interior] solicitor in the Albuquerque office… reviewed the Texas Plan and determined it was not legally sufficient and refused to sign it, and advised the service of that" (Department of the Interior 2014). According to the testimony of the former Texas State Supervisor, the former Regional Director of the U.S. Fish and Wildlife Service's Southwest Region told a group of Service employees that "[t]here is no way we were going to list the lizard in the middle of oil country during an election year" (Department of the Interior 2014). The former Regional Director testified in this same hearing that "I do remember saying that. But the caveat was, without a sufficient conservation plan" (Department of the Interior 2014). Despite the deficiencies in the Service's withdrawal decision, it was upheld by the U.S. Circuit Court for the District of Columbia in 2016. The sworn testimony of the two Service officials was not considered in the decision because it was not in the administrative record before the court. But the fact remains that the TCP was drafted and approved without incorporating measures to ensure its effectiveness.

The transparency problems with the TCP have also resulted in several compliance problems. For example, Defenders used satellite images in 2013 to reveal unreported and unauthorized habitat disturbance under the TCP (Defenders 2013). In response to our findings, the CPA at the time denied the existence of the new oil pads and roads and defended the conservation plan. In 2014, however, it formally acknowledged that "some participants [in the TCP] did not properly notify or report these" disturbances (Texas Comptroller of Public Accounts 2014). One participant was apparently "using the wrong maps in their planning" while another simply "failed to notify" the CPA about its activities (*ibid*). This is an example of how the transparency limitations of the TCP impede its effectiveness.

Another example comes from the CPA's 2016 decision to fire the Texas Habitat Conservation Foundation, the organization charged with overseeing implementation of the TCP, after state records revealed lapses in performance. As reported in the Austin American-Statesman (Dexheimer 2016):

> The conservation plan calls for lizard habitat hit by surface disturbances to be mitigated, or repaired — removing abandoned concrete well pads and roads, for example. But between 2013 and 2014, the foundation failed to do such mitigation work on several sites over approximately 20 acres, the comptroller's office determined. Rather, it removed mesquite plants from separate pieces of land, considered a cheaper and less-effective protection for the species.
>
> The plan to protect the dunes sagebrush lizard also requires the foundation to make sure that oil companies and landowners implement conservation measures to protect sensitive habitat on which they work. Instead, the comptroller's office said it discovered that the Texas Habitat Conservation Foundation had simply permitted the companies to self-report once a year on whether they had done the required work.
>
> In one instance, three acres of lizard habitat that had been disturbed was never reported to the comptroller's office, as required by the plan.

While implementation of the TCP has improved considerably since Glenn Hegar became Comptroller, the underlying deficiencies in the TCP require it to be substantially revised before it can adequately conserve the species in Texas.

Another structural defect of the TCP is its incidental take allowance. The CPA calculated the 21,257 acres of incidental take based entirely on "a worst-case maximum" buildout of oil and gas activity and other land uses. Specifically, Section 9.1 of the TCP explains that "[t]o determine the total number of potential acreage that might be developed by oil and gas operations, including oil and gas production, the maximum available acreage was calculated based on 40-acre spacing units." This calculation led to 5,434 wells, which equates to 17,996 acres of disturbance in the future. Similarly, "[o]ther activities were estimated based on assumptions of minimal impact but with maximum estimates of total acres of DSL Habitat affected." Thus,

rather than starting from the conservation needs of the DSL and then determining the amount of take that can be allowed consistent with achieving the TCP's conservation objective, the TCP shoehorns DSL conservation into the maximum potential disturbance in habitat. This foundation of the TCP must be revamped if the Texas populations are to persist into the foreseeable future.

Ineffectiveness at Addressing Oil and Gas Development

In its 2012 withdrawal decision, the Service acknowledged the significant threat of oil and gas development to the DSL and then stated that "the conservation effort [under the TCP] will be effective at eliminating or reducing threats to the species…" and that the Service is "confident that the conservation effort will be implemented on enrolled acres…." These conclusions were based on several major assumptions about how the TCP would address oil and gas development. Because most of those assumptions have proven incorrect (see Figure 10, above), the TCP cannot adequately address oil and gas development in DSL habitat.

The withdrawal decision was based partly on the assumption that "the majority (71 percent) of mapped lizard habitat in Texas has been enrolled" under the TCP. Based on Service records publicly disclosed after the withdrawal decision, we have learned that the Service never had evidence to support the 71 percent estimate. In every email the Service received from Texas A&M University (TAMU) in the months leading up to the withdrawal decision, TAMU provided the number of enrolled acres but never offered data or other evidence to support those numbers (U.S. Fish and Wildlife Service 2012d). The Service merely took the numbers at face value, without critically evaluating how they were derived or whether they were accurate. This was a fatal oversight: the CPA recently showed that TAMU vastly overestimated the amount of protected habitat and that the Service erroneously relied on that estimate. The overestimation arises from two problems related to multiple leases on properties. The first problem is explained in the following excerpt from an October 2017 letter from the CPA to the Service:

> Numerous mineral leases in the DSL Habitat are severed from the surface estates. In some situations, different lessees can have rights to operate in different stratum, each with a right to use the surface. As a result of this stratification, multiple oil and gas operators could enroll the same section, appearing to increase the percent of DSL habitat in the TCP.
>
> In its December 2013 monthly report, TAMU calculated that the surface enrollment was actually 56 percent. The lower assessment resulted from eliminating duplicate surface enrollment in the stratified leases. The percentage of enrolled habitat has remained relatively constant in the mid-fifties.

The 56 percent enrollment rate undermines not only the Service's 71 percent enrollment figure, but also its conclusion in the 2012 withdrawal decision that "enrollments [in the TCP] will continue and the dunes sagebrush lizard habitat placed under conservation…will increase over time." This discrepancy has real world consequences for the DSL. From 2012 to 2016, surface disturbance on non-enrolled DSL habitat and buffer areas totaled 1,288 acres, whereas surface

disturbance by TCP participants on enrolled properties totaled only 314 acres (Table 2), which is related to a second problem.

Table 2. Estimated habitat loss in acres from disturbances in DSL habitat in Texas from 2012-2016.

Likelihood of Occurrence	Surface Disturbances by Participants on Enrolled Property		Surface Disturbances by Non-Participants on Enrolled Property		Surface Disturbances on Non-Enrolled Property	
	Habitat Polygon	200m Buffer	Habitat Polygon	200m Buffer	Habitat Polygon	200m Buffer
Very High	115.78	75.84	311.93	88.96	379.14	149.66
High	4.16	0.00	76.16	21.81	58.67	15.81
Low	44.77	1.34	58.70	20.14	86.85	117.25
Very Low	72.73	0.37	133.61	64.92	365.56	114.72
Total	237.44	77.55	580.41	195.84	890.22	397.45

From BIO-WEST (2017).

The Service's 71 percent estimate never properly considered the fact that the conservation measures that apply to a participant do not apply to nonparticipants with rights to operate in different stratum on the same property. Put differently, a property cannot be considered completely protected for the DSL unless all lessees on that property enroll in the TCP. The Service had merely assumed that stratification was not a problem, as evidenced by internal Service communications such as the following email from Michelle Shaughnessy only a month before the withdrawal decision: "However, if we assume (which is a good assumption) that the three large companies are not subleasing and actually own the surface and mineral rights then we have 152,000 acres of habitat covered which equates to 77% (U.S. Fish and Wildlife Service 2012b)." But according to the October 2017 letter from the CPA, this assumption was unfounded and by no means "good." The letter explains that "no effort…was made to identify the percentage of habitat on a particular lease in which the surface was shared between a participant and a non-participant that leased from a different stratum." Only in early 2017, "at the request of the Service…[did the] CPA analyze the percentage of habitat in which the surface was shared between a participant and a non-participant that leased from a different stratum." The October 2017 letter revealed the seriousness of this problem:

> Over the first five and one-half years of the TCP, 776 acres of the surface enrolled by a participant was disturbed by non-participant activities. For comparison, the amount of surface disturbance by a participant on enrolled habitat was approximately 300 acres…

This problem was also highlighted in BIO-WEST's (2017) report documenting that TCP participants had contributed only 315 acres or 13% of the total amount of the disturbance to DSL habitat from 2012 to 2016.

In April 2018, the CPA completed its analysis of the percentage of DSL habitat completely protected (i.e., all lease holders for a property are participants) under the TCP. It found 82% of wells on enrolled property—235 of 285 wells—were stratified (BIO-WEST 2018; Table 3). The report does not provide the surface acres that are compromised by these stratified wells, but strongly suggests that the Service's 71 percent estimate vastly overstated the ability of the TCP to protect the DSL. This revelation demolishes a central premise of the Service's withdrawal decision for Texas.

Table 3. Numbers of stratified and non-stratified wells in the Texas Conservation Plan as of April 2018.

	Participant wells on TCP Enrolled Property	Stratified Wells on TCP Enrolled Property	Participant well on Non-Enrolled Habitat	Non-Participant Wells in Non-Enrolled habitat	Total Wells
2012	19	40	0	27	86
2013	6	46	1	33	86
2014	8	24	1	49	82
2015	8	61	0	34	103
2016	2	52	1	8	63
2017	4	12	0	18	34
TOTAL	**47**	**235**	**3**	**169**	**454**

From BIO-WEST (2018, Table 1).

Existing analyses give examples of current stratification problems, but not the extent of possible stratification problems. The petitioners cannot provide a precise estimate of the possible extent of the stratification problem because we cannot access certain data (e.g., TCP enrollments), but we can illustrate the possible extent of the problem using a simple analysis of available data. In short, we used oil and gas well data from the Texas Railroad Commission to ask how often multiple well owners occur within each section across the DSL's range in Texas. If any particular block has more than one well owner listed, then we assume there is the *possibility* of stratification, which is not accounted for in the TCP. Put another way, we imagine subdividing the landscape into artificial parcels and then asking how many of those artificial parcels have multiple well owners[3]. If stratification is not an issue, then we should see very few cases of multiple well owners within a single block. We found 51% of DSL habitat in Texas may be

[3] Is it possible that real parcel boundaries reduce the frequency of possible stratification areas? Yes, it could. However, we know that stratification has been responsible for the majority of surface disturbance since the start of the TCP (BIO-WEST 2018).

susceptible to stratification (Figure 11); however, we expect that this is an underestimate because of data limitations (see Appendix B for details).

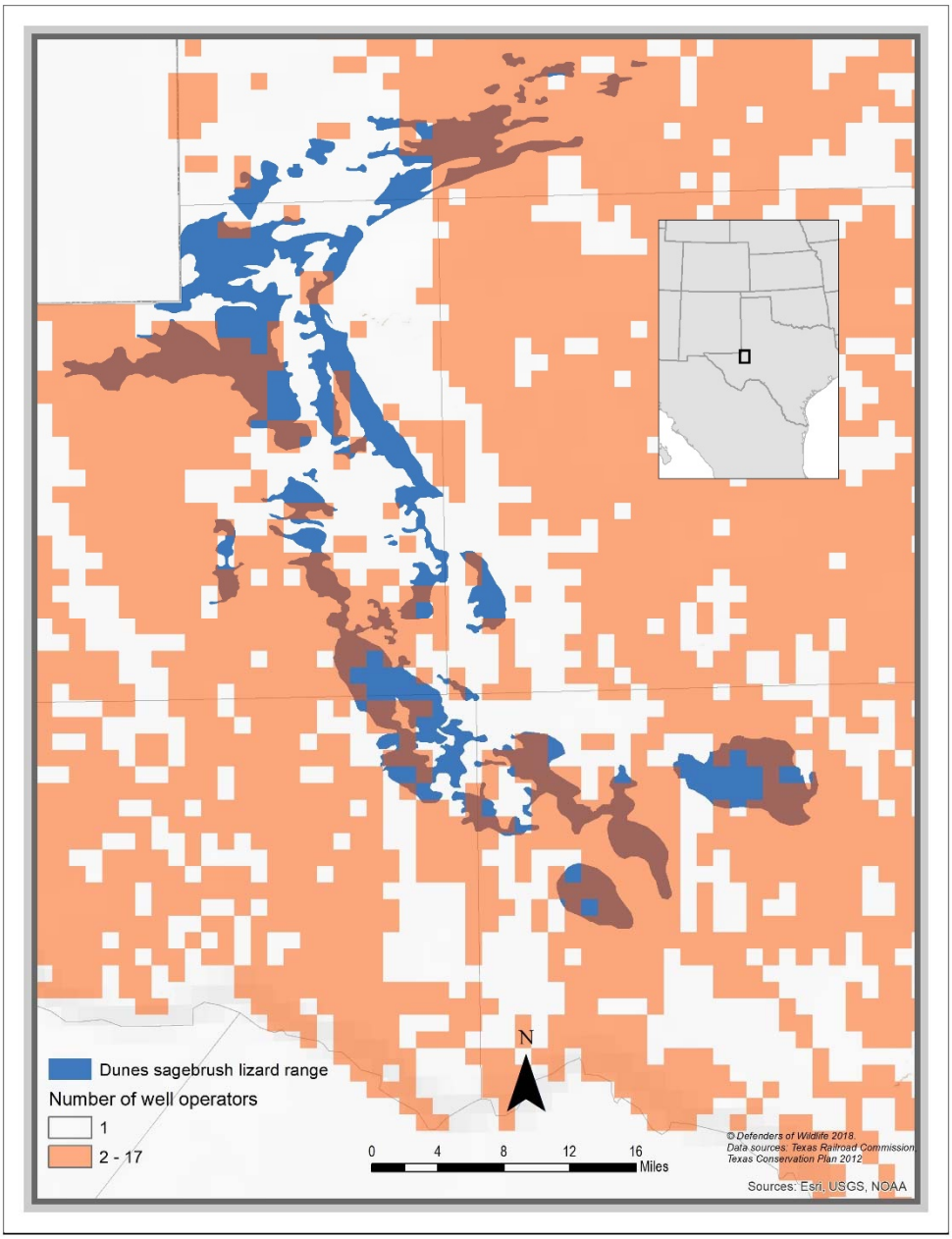

Figure 11. Stratification—where multiple owners may have rights to resources at different depths of the same surface acre—is likely a significant problem for protecting the dunes sagebrush lizard with the Texas Conservation Plan (TCP). *We used well ownership data from the Texas Railroad Commission to determine how many owners occurred in section-sized (1 mi^2) blocks across the lizard's range in Texas. Areas with > 1 owner/lessee (orange) could have one party enroll in the TCP while a second owner/lessee does not enroll and then destroys or modifies the surface stratum. We expect this analysis underestimates the amount of stratification because it is based only on well data, not parcel ownership data, and because we expect many parcels to be much larger than a single section, which will increase the chances of overlapping multiple resource owners/lessees.*

One final problem with the Service's reliance on the TCP is that the agency was unable to directly monitor, evaluate, or enforce the 1% limit on habitat loss within the first three years of the TCP. For this limit to take effect, logic dictates that at least 99% of the habitat had to be protected. If unprotected habitat exceeded 1%, neither the Service nor the CPA could cap habitat loss at that amount. But far less than 99% of all mapped habitat had been protected at the time of the withdrawal decision or today. The TCP states that there were 217,367 acres of mapped habitat in Texas (including a 10% buffer). To protect at least 99% of this habitat, the CPA had to enroll 215,193 acres. The withdrawal decision states that only 138,640 acres of mapped habitat had been enrolled as of May 2012, accounting for only 64% of the total habitat. And as discussed earlier, the actual percentage of enrolled habitat is considerably lower. The Service thus had no basis in its withdrawal decision for being "confident that…the loss of habitat will be limited to 1 percent in the first three years of the plan."

The problems with the existing TCP were significant enough to warrant the CPA to prepare a draft revision to the TCP in early 2018, a move that the Service supported: "Due to your ongoing TCP evaluation and the discrepancies you identified, the FWS supports the CPA's plan to revise the TCP to address the issues your letter identified" (U.S. Fish and Wildlife Service 2018). In fact, the Service expressed concern about continued enrollment under the existing TCP, stating that "[i]f significant enrollment occurs prior to completing your proposed revisions, the revisions may provide the species little or no benefit because the old program will largely dominate the TCP implementation." Thus, in stark contrast to how the Service viewed the TCP in 2012, the agency's current perspective is one of outward apprehension about the plan's effectiveness.

Ineffectiveness of Compensatory Mitigation

The TCP's reliance on unproven compensatory mitigation is a problem for DSL conservation: there is little or no evidence that actions like shinnery oak sand dune restoration actually benefit the species. The TCP makes clear that the idea of relying on mitigation is not simply "theoretical." For example, at least one party responsible for DSL habitat loss has suggested they will plant shinnery oaks in areas mined for frac sand (Atlas Sand, LLC *public communication*, 23 January 2018) to "reclaim" the sites. But one of the best studies of the relationship between DSL demography and shinnery oak sand dune habitats (Ryberg *et al*. 2015) found:

> Specifically, significant relationships between blowout shape complexity and vital rate elasticities suggested direct links between S. arenicolus demography and amount of edge in Shinnery oak sand-dune landforms. *These landforms are irreplaceable,* based on permanent transition of disturbed areas to alternative grassland ecosystem states. *Additionally, complex feedbacks between wind, sand, and Shinnery oak maintain this landform, indicating restoration through land management practices is unlikely.* (Emphasis added)

The Texas Habitat Conservation Foundation had focused almost exclusively on mesquite removal for compensatory mitigation (Texas Comptroller of Public Accounts 2018a). As detailed in **THREATS ANALYSIS: FACTOR E**, honey mesquite is a native invasive species that

threatens the DSL's habitat. However, there is little or no data to indicate that mesquite removal results in increased DSL populations. As stated in the *Best Practices for Dunes Sagebrush Lizard in Texas* (Texas A&M 2016a):

> In the TCP (section 8.6.2), mesquite and invasive species removal are listed as conservation measures that Participants may undertake to enhance the survival of the DSL and conserve DSL habitat. Removing mesquite may indirectly benefit DSL by curbing continued mesquite invasions and improving rangelands regionally. Indeed, the presence of mesquite in DSL habitat was associated with the absence of DSL in our habitat suitability analyses (CHAPTER 6). *That said, a direct effect of brush management on DSL populations has not been observed.*
> …
> Removal techniques have been successful at eliminating nearly all mesquite without major habitat disturbances; however, habitat surveys before and after mesquite removal indicate that it is uncertain if habitat for the DSL will become suitable at these sites (Fig. A.1). *Additionally, lizard surveys before and after mesquite removal indicate that DSL populations did not, and presently do not, occupy these sites, although occupied suitable habitats exist nearby.*

Compliance Problems

The TCP cannot adequately conserve the DSL unless it complies with its conservation requirements. The plan is out of compliance for several reasons. First, the enhancement of survival permit for the plan provides the following:

> Authorization of the additional take [beyond the 2,173 acres allowed during the first three years of the TCP] is dependent on the biological monitoring showing a positive biological response in dunes sagebrush lizard from restoration actions, as accepted by the FWS…. Lack of evidence or inconclusive evidence will cap total incidental take through loss of habitat at the levels identified in Table 8-2 of the Plan until such time as a positive biological response in DSL can be documented.

But as documented in an October 2017 letter from the CPA to the Service—over three years after the TCP was finalized in 2012:

> The Service has not made a determination of whether or not monitoring shows a positive biological response in DSL from restoration activities and, consequently, the acreage of surface disturbance/incidental take allowed for the remainder of the permit term. CPA requests the Service convene the meeting required after three years to make the positive biological response determination and the amount of surface disturbance/incidental take allowable for the remaining permit term.

The Service acknowledged this problem in its January 2018 response to the October letter, stating that "[w]e are concerned the TCP may not have yet achieved the anticipated DSL conservation and protection levels" and "recommend the CPA suspend all enrollment until you complete the revisions [to the TCP] as soon as possible" (U.S. Fish and Wildlife Service 2018b).

We also believe that the procedures for determining mitigation requirements under Appendix F of the TCP were rarely complied with. The procedures involve a Qualified Third Party Contractor (which was the Texas Habitat Conservation Foundation through February 2016) evaluating potential impacts on an enrolled property to determine mitigation needs. As explained earlier, however, the Service found in 2017 that "the Standard Certificate of Inclusion (CI) used by the majority (11 of 13) of Participants to enroll in the TCP does not describe the mitigation/offset procedures contained in the TCP." We do not understand how the Appendix F procedures were complied with if the majority of certificates lacked any reference to mitigation. Further, we found no documents in the administrative record to indicate that the Appendix F procedures were followed.

Inability to Address Sand Mining

The threats from uncontrolled oil and gas development are significant, but pale in comparison to the potential habitat destruction and modification from uncontrolled frac-sand mining in the Permian Basin. As detailed in **THREATS ANALYSIS: FACTOR A**, from February 2017 to February 2018, over 1,000 acres of DSL habitat in Texas had been destroyed or disturbed because of sand mining, and over 2,000 acres across the greater landscape (Table 1). These operations have not even approached their peak buildout, and new mining operations are likely in west Texas. Based on lease boundaries for just 6 of these 12 mines, an additional 20,000 acres could be lost to sand mining. The potential may be much higher considering that "sand mining companies control between 30 and 40 percent of the DSL Habitat as classified under the Hibbitts Map," according to December 2017 estimates from the CPA (Texas Comptroller of Public Accounts 2018b). *There are currently no regulatory mechanisms, in the TCP or otherwise, to address the significant threat of sand mining to the DSL.*

The CPA has asked all the sand mining companies to voluntarily avoid or minimize their impacts on lizard habitat and has had some success. At least half a dozen companies, including Vista Sand and Black Mountain, have modified their plans to avoid lizard habitat and surrounding buffers. But some other companies have not cooperated. Hi-Crush and Atlas Sand Company, for example, own leases that cover 11 percent (6,742 acres) of the highest quality lizard habitat in Texas. As of September 2017, neither company had agreed to modify its operations. Without significant changes to the proposed footprint of these and other mines, lizard populations in Texas could be significantly harmed.

NEW MEXICO CCA/A SHORTCOMINGS

The New Mexico CCA/A were developed for the DSL and the lesser prairie chicken (*Typanuchus pallidicinctus*; U.S. Fish and Wildlife Service *et al.* 2008, U.S. Fish and Wildlife

Service and Center for Excellence for Hazardous Materials Management 2008). Unlike the TCP, the New Mexico CCA/As have strong requirements to avoid development and impacts to the DSL's preferred shinnery oak sand dunes habitat. Data indicate the CCA/As are associated with a steep decline in well approvals inside DSL habitat (Appendix A) and avoidance of undeveloped areas in the DSL range in New Mexico. However, the CCA/As fall short in three areas (Bureau of Land Management 2017; U.S. Fish and Wildlife Service 2018b, 2018c). First, the CCA/As are contingent on the BLM Roswell District RMPAs, which encourage continued habitat fragmentation in the course of stipulating avoidance of sand dune habitat. Second, the monitoring program of the CCA/As is insufficient to show that DSL populations, as opposed to habitat, respond to conservation measures. And third, the lack of publicly available data about enrollments makes it difficult to ensure compliance with the CCA/As.

Background

The CCA is an agreement between the Service, BLM, and the Center for Excellence in Hazardous Materials Management (CEHMM) for actions such as oil and gas development and livestock grazing on lands administered by the BLM (U.S. Fish and Wildlife Service *et al.* 2008). The CCAA is an agreement between the Service and CEHMM intended to provide certainty to participants that, if they implement the conservation measures in their certificate of participation, they will not be subject to additional restrictions or commitments if the DSL and/or the lesser prairie chicken become listed under the ESA (U.S. Fish and Wildlife Service and Center for Excellence for Hazardous Materials Management 2008; CEHMM 2016a). The CEHMM is the permit holder and administrator for the CCA/As. Each participating cooperator volunteers to join either of CCA/As through a certificate of participation. The signed certificates emphasize that implementation of the conservation measures is entirely voluntary by the land owner, and the specific measures listed in the certificates are contingent on available funding or good faith efforts to acquire funding.

The New Mexico CCA/As are based on implementation of conservation measures on enrolled properties rather than the amount of adverse impacts on the DSL. The measures are intended to 1) develop, coordinate, and implement conservation actions that reduce and/or eliminate known threats to the DSL and the lesser prairie chicken in New Mexico on federal, state, and private surface and minerals; 2) support ongoing efforts to re-establish and maintain viable populations of both species in currently occupied and suitable habitats; and 3) encourage development and protection of suitable DSL and lesser prairie chicken habitat by giving participating cooperators incentives to implement specific conservation measures. The specific measures include no new development in habitat, habitat reclamation, no new pipelines in habitat, no Tebuthiuron treatment in the dunes, and mesquite removal in shinnery dunes. A series of annual and monthly reports has been issued (CEHMM 2010-2017f).

Continued Fragmentation

The CCA/As include a broad suit of activities that enrollees can undertake to contribute to DSL conservation. One of those points, "*Adhere to stipulations on surface activities required by the BLM RMPA (May 2008) on oil and gas lease developments on enrolled lands at a minimum,*"

has good intent but a bad side-effect. The BLM RMPA (Bureau of Land Management 2008) states for new leases (p. 7, emphasis added):

> Within sand dune lizard habitat (see Map 1), *new surface disturbance in dune complexes will not be authorized*. Exceptions to this requirement will be considered based on the proposed surface use and proposed mitigations indicating the proposal will not adversely affect sand dune lizard habitat.

However, the RMPA further states (p. 13 emphasis added):

> For existing leases within the sand dune lizard boundary (see Map 1), the lessee will be responsible for occupancy and habitat suitability surveys required prior to permitting surface disturbing activities. Surveys will be considered Conditions of Approval (COAs) and conducted by BLM employees or BLM approved contractors and personnel. Depending on the results of the survey, proposed well sites may not be available to be developed and directional drilling may be necessary to develop all spacing units within a lease. *Shinnery oak flats adjacent to dune complexes are the preferred location for proposed well sites.* (Emphasis added)

At the end of 2008, 36,936 acres of the DSL range in New Mexico had active oil and gas wells exceeding 13 wells/mi^2. During 2009-2017, active oil and gas wells in the DSL range surpassed this threshold for an additional 10,386 acres. Most of this increase was the result of oil and gas development within already high density (>13 wells/mi^2) areas that elevated neighboring areas to surpass the threshold. Of these increased acres, we identified approximately 140, 10-acre blocks (1,404 acres) that had one or more wells approved and operating since 2008, and those blocks now have densities >13 wells/mi^2.

Because the DSL may also be sensitive to fragmentation from additional oil and gas activities, we also estimated the acreage that exceeded 13 wells/mi^2 for all wells (dry, plugged, inactive, injection, etc.). In 2008, approximately 116,329 acres of the DSL's New Mexico range had well densities exceeding 13 wells/mi^2. Approximately 13,947 acres exceeded that threshold during 2009-2017, and 1,242 acres of this occurred because of new well development in previously low-density areas. Visual inspection of some of these wells indicated they were, in fact, sited outside of shinnery oak dunes, but in areas that may interrupt DSL dispersal. Thus, while development outside of core habitat was likely avoided, pushing oil and gas development into dispersal habitat continues to fragment DSL populations even under the CCA/As.

Monitoring the DSL, Not Only Its Habitat

Based on the information from field work included in the CEHMM annual and monthly monitoring reports (CEHMM 2011, 2012, 2013, 2014, 2015, 2016, 2017d,e) it is not possible to determine if the New Mexico CCA/As adequately protect the DSL. While our analysis indicates oil and gas well development has dramatically declined in DSL habitat in New Mexico and shows avoidance of the most undisturbed habitat (Appendices A), that is not the same as

monitoring DSL populations themselves. Until methods are developed to monitor the lizard's populations, we cannot tell how the species is faring. Key information not presented in the CEHMM reports that might help fill certain knowledge gaps include: location of the surveys, types of surveys (e.g., random, established transect, and if pitfall traps were used, including the design, how, where, amount of time set out in the field, and how often they were checked), dates and times they were conducted, and the qualifications of the biologist(s). These basic types of data simply do not exist today, but need to be a part of any monitoring program that can clearly demonstrate the DSL's status is improving.

Enrollment Transparency

The acreages for the enrolled lands where the CCA/As cover livestock grazing and oil and gas development are unclear based on information provided by the Service and the BLM (Bureau of Land Management 2017; U.S. Fish and Wildlife Service 2018c, 2018d, 2018e). The voluntary nature of each certificate of participation along with the non-specific information regarding the location, especially for oil and gas projects, make it difficult to assess the biological effectiveness of the agreements (CEHMM 2010, 2011, 2012, 2013, 2014, 2105, 2016a).

FACTOR E: OTHER NATURAL OR MANMADE FACTORS AFFECTING THE DSL'S CONTINUED EXISTENCE

INVASIVE SPECIES

Invasive species are considered one of the most widespread threats to native biodiversity in the world (Gurevitch and Padilla 2004; Wilcove *et al.* 1998). Several invasive species are threats to the DSL, adversely affecting the natural vegetative communities of the shinnery oak dunes ecosystem. The presence and intensity of human activity in and around the DSL's habitat are particularly conducive to invasions. The construction and operation of infrastructure such as oil and gas wells can facilitate the invasion and establishment of invasive species, including natives and non-natives. Disturbance and alteration of habitat adjacent to the developed areas will create favorable conditions for non-native plants and animals. Some exotic plant species are aggressively invasive and displace native vegetation, and either create unsuitable habitat for the DSL and/or its prey. Exotic animals may directly kill native fauna or eliminate them through competition or indirect effects.

Honey mesquite (*Prosopis glandulosa*), a native invasive, is likely one of the most important invasive species affecting the DSL. It is unclear why mesquite is not used by DSL, but data suggest that the lizard avoids areas where mesquite exceeds 10% of land cover (Texas A&M AgriLife 2016b). Mesquite is relatively common in parts of the American Southwest (USDA 2002), but less common in the DSL's habitat. Once introduced, however, mesquite can exhibit invasiveness that threatens existing natural communities (Brown and Archer 1989; Texas A&M AgriLife 1997). As with many invasive species, this is particularly true in areas with high disturbance regimes (Shea and Chesson 2002), such as the highly dissected landscapes of oil and gas development in the DSL's range. Research to date indicates mesquite removal benefits the DSLs only where it is encroaching on occupied habitat (CEHMM 2016; Texas A&M 2016a). As

detailed in **THREATS ANALYSIS: FACTOR D**, the "manual" on DSL management in Texas indicates mesquite removal even in unoccupied habitat adjacent to occupied habitat is ineffective (Texas A&M 2016a).

The DSL is likely being adversely affected by the Malta starthistle (*Centaurea melitensis*). This invasive weed spreads along corridors of disturbance, such as roads, pipelines, and well pads, with detrimental effects on native plants and animals (Jankowitz 2007; U.S. Forest Service 2010). Malta starthistle is highly competitive and develops dense impenetrable stands that displace native vegetation, and animals including the DSL have difficult moving through it (U.S. Forest Service 2010).

There are several other invasive exotic plant species in southeastern New Mexico and West Texas (Jankowitz 2007; Carlsbad Soil and Water Conservation District *undated*) that may adversely affect the DSL. In addition to displacing or eliminating native species and disrupting locally adapted natural processes by altering hydrologic conditions and soil characteristics, altering fire intensity and frequency, interfering with natural succession, and replacing complex communities with single species monocultures, exotic species can bring unseen impacts, such as non-native bacteria and viruses, insect pests, and chemical defense compounds with toxic or allergenic properties (Jankowitz 2007; Carlsbad Soil and Water Conservation District *undated*).

CLIMATE CHANGE

Climate change poses an additional threat to the DSL. For New Mexico and Texas, climate models project substantial changes over the next 50 to 100 years, if no measures are taken to reduce global greenhouse gas emissions (State of New Mexico 2005; Shafer *et al.* 2014). Projected climate changes by the mid- to late-21st century under the A2 emission scenario include an increase in average temperatures by 5.5-9.5° F (Garfin *et al.* 2014). Much of this increase will be the result of warmer winters and nights. In addition to increases in the average temperatures, more extreme weather events are likely, including more episodes of extreme heat, fewer cold periods, a longer frost-free season, and less snow in the winter. Currently, climate models are inconsistent about whether average precipitation will increase or decrease. However, the probability of severe drought events is predicted to increase (Ault *et al.* 2016).

The DSL is sensitive to high temperatures, is most active during the cooler spring and autumn months, inhabits the larger and cooler blowouts among the dunes, and limits its activity and ultraviolet light exposure during the hottest afternoons of summer (Ferguson et al. 2014). Additionally, the same authors found that the DSL ceased aboveground activity at sun-exposed or shaded sites in June and August when the air temperatures reached or exceeded 98°F. Despite these behaviors, no research has been conducted to determine how alterations in the climate could affect its habitat or life history. However, a recent study with a related species, *Sceloporus undulatus*, found reduced embryonic survival and hatchling size under recurrent sublethal warming of nests (Carlo et al. 2017). Using these results and a mechanistic distribution model, Carlo et al. (2017) estimated that sublethal warming of nests could result in reduced annual survival of up to 24%. This experimental study supports earlier work that hypothesized increased

temperatures from global warming will likely alter the availability of suitable thermal microhabitats for many lizard species, likely leading to decline (Huey et al. 2010; Sinervo et al. 2010). In conclusion, our knowledge of the general effects of climate change on habitats and species, knowledge about climate change and lizards in particular, and the narrow range of the DSL and its preferred habitat allow us to infer that climate change is a significant threat to the species.

CONTAMINANTS

Oil fields are the source of toxic pollutants including petroleum hydrocarbons, polycyclic aromatic hydrocarbons (PAHs), oil spills, and air pollutants (U.S. Environmental Protection Agency 1999). Research in Kuwait with a lizard of similar size and natural history as the DSL showed that PAHs were still present in both the lizard and its prey over a decade after oil spills (Al-Hashem *et al.* 2007). The exposure to oil field chemicals also impacts the body size for sand lizard species, perhaps by affecting the allocation of adipose tissues (Al-Hashem *et al.* 2007). Because much of the DSL's habitat is located in dune patches distributed within and among oil and gas fields, the potential for exposure to toxic pollutants including both oil spills and chemical leaks is high.

Hydrogen sulfide gas, a common byproduct of oil and gas extraction, is heavier than air and may poison DSLs, in particular if it accumulates at the bottom of blowouts. The New Mexico CCA/As (U.S. Fish and Wildlife Service and Center for Excellence in Hazardous Materials Management 2008) summarized the relevance of H_2S contamination on the DSL:

> The decline of [DSL] density with increasing well pad density…may be due to the presence of H_2S gas emissions and other pollutant associated with oil and gas wells. For example, H_2S is a highly toxic gas that is released during petroleum extraction and is the dominant reduced sulfur gas in oil fields (Tarver and Dasgupta 1997). During petroleum extraction H_2S is removed from the petroleum, and the emissions are released into the air where they can remain for a day or less. H_2S is denser than air and tends to sink to the ground where it remains until it is neutralized (Lusk and Kraft 2006). Lusk and Kraft (2006) measured H2S near Loco Hills, New Mexico (25 miles east of Artesia) where historically large populations of sand dune lizards were once found. They reported concentrations of H_2S as high as 33 parts per million (ppm) there for approximately 32 minutes. Most of the sulfur emitted by producing wells, tank batteries, production facilities, gas plants, sweetening plants, and pipelines may ultimately end up in the soil. Surface soil tests in active oil fields in Texas found sulfate levels to range between 20-200 ppm near active facilities (Tarver and Dasgupta 1997). This is relevant because [DSLs] dig-in just below the soil surface during hot parts of the day and at night, and thus would be in direct contact with the sulfates in the soil.

Field researchers observed a 140-meter diameter dead spot centered on a leak in an underground gas pipeline on the New Mexico/Texas border, with sick and dead animals discovered in New Mexico (Sias and Snell 1998), specifically great horned owls. There, the absence of DSLs was

noted in surrounding blowouts, which they considered prime habitat for the reptile. In contrast to the findings of Sias and Snell (1998), Weir *et al.* (2016) used laboratory studies to conclude that hydrogen sulfide gas and two herbicides (Krovar® and Quest®) did not cause significant effects on a surrogate species for the DSL, the western fence lizard (*Sceloporus occidentalis*). The authors did not conduct follow up examinations to determine if there were long term effects on the lizards caused by hydrogen sulfide gas or either of the two herbicides. Thus, even though there is some laboratory evidence of minimal effects of H_2S contamination, evidence from the field suggests the compound is a substantial threat to the DSL.

THREATS ANALYSIS CONCLUSION

The DSL is imperiled because of past, present, and future threats across their range (Figure 7). Oil and gas development and operations have been responsible for the loss of huge swaths of the lizard's habitat and continue to be a threat in significant portions. In the past year, sand mining for hydraulic fracturing has emerged as a severe threat in the heart of the lizard's habitat in Texas. Conversion of habitat for agricultural use has removed or degraded an unknown number of acres of DSL habitat. These issues have not been addressed by existing regulations, especially in the Monahans Sandhills portion of the DSL's range in Texas. And other well-known threats, including climate change, invasive species, and contaminants, are contributing to a substantially higher risk of the species' extinction.

POPULATION STATUS

Since 1982, the Service has recognized the tenuous conservation status of the DSL. In fact, the Service found the species qualified for ESA protections several times over the past two decades, most recently in 2010 (U.S. Fish and Wildlife Service 2010). We are aware of no data to indicate that the species' status has improved over the past eight years or is expected to improve. Instead, the species' status has continued to decline and is expected to continue to do so in the foreseeable future because of the threats discussed in **THREATS ANALYSIS**. The DSL's extent today is a fraction of its already narrow historic distribution. In 2010, the U.S. Fish and Wildlife Service estimated that 40% of the shinnery oak habitat had already been lost in New Mexico and Texas (U.S. Fish and Wildlife Service 2010), and that number is certainly higher today. This habitat loss is associated with documented loss of the species from formerly occupied sites, including the loss from 86% of sites in Texas (Laurencio *et al.* 2007). The species has many of the characteristics of a species at risk of extinction: it is a habitat specialist with a restricted and fragmented distribution. Based on these characteristics and habitat loss that had already occurred, scientists concluded over 20 years ago that "… the extinction of *Sceloporus arenicolus* is a real possibility" (Snell *et al*. 1997). Below, we first detail the declining status of DSL populations and habitat, then synthesize the data to show that resilience and redundancy are declining for the DSL, and it is likely to lose essential representation in the near future.

POPULATIONS AND HABITAT

There are no range-wide estimates of DSL populations: the species' low rate of occurrence on the landscape and variable detectability make such estimates very difficult to obtain (Smolensky and Fitzgerald 2010, Texas A&M 2016b). However, research has demonstrated a link between DSL occurrence or abundance and landscape- and local-scale habitat characteristics. For example, there is a relationship between DSL density and (a) the distance to oil and gas wells and (b) the density of oil wells at the landscape level (Sias and Snell 1998). Based on a series of sampling plots distributed across a gradient of oil and gas well densities, DSL density is positively associated with distance to wells (i.e., the farther away, the greater the number of lizards) and negatively associated with well density (Figure 12). Regression models indicate that DSL habitat within 600 meters of an oil or gas well supported 31% to 52% few individuals than habitat without wells (Sias and Snell 1998).

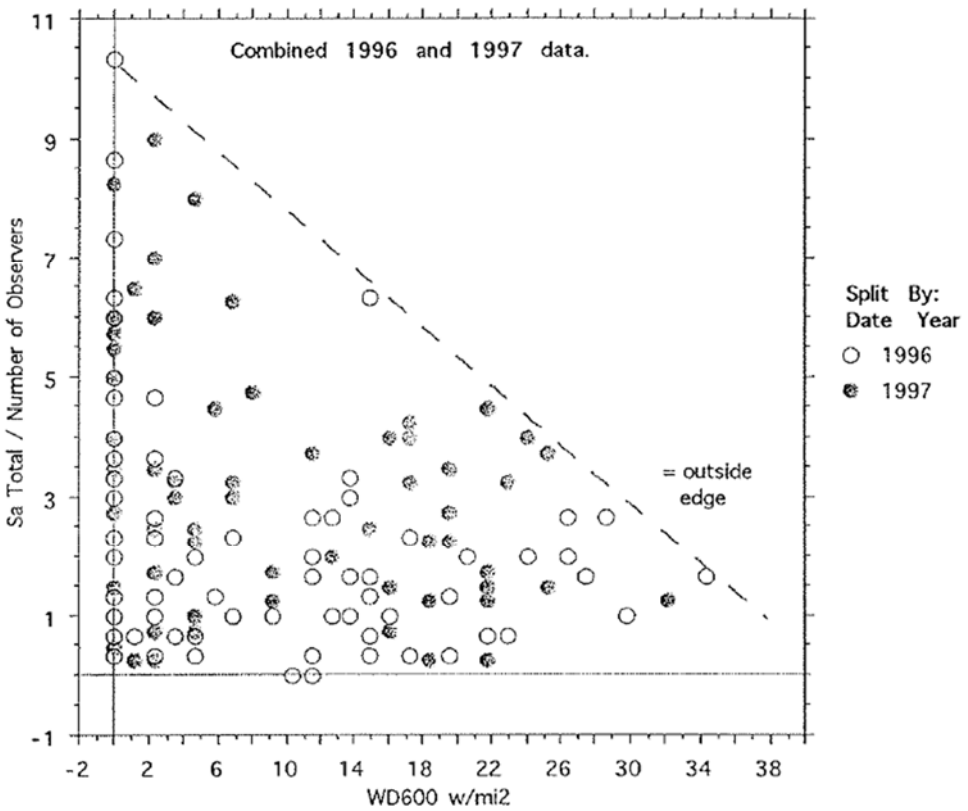

Figure 12. The number of dunes sagebrush lizards detected declines with increasing well density*. A regression on the data suggest a 25% decline of lizard density at well densities greater than approximately 13.6 wells per square mile. From Sias and Snell (1998, page 32).*

At the local scale, systematic surveys have shown the species has disappeared from areas where the shinnery oak has been removed (Fitzgerald and Painter 2009; Degenhardt et al. 1996). During 2008 and 2010, 77 sites in New Mexico known to be occupied by the DSL in 1997 (Fitzgerald *et al*. 1997) were surveyed by qualified individuals (Stevenson 2011), and the lizard was not detected at 28% of these sites. The vegetation at three of these sites (14% of missing

sites) appeared to have been sprayed with herbicides since the study by Fitzgerald *et al*. (1997), was significantly degraded, and did not appear suitable for the DSL.

Together, the landscape- and local-scale research establishes links between DSL populations and habitat status. Because habitat status can be measured in a variety of ways, we focus on habitat status as a proxy of the species' status[4]. We note, however, that outstanding questions of DSL-habitat relationships remain unanswered, such as whether the DSL responds to habitat restoration (Texas A&M 2016b).

There has been significant loss or degradation of DSL habitat throughout all parts of its range: the shinnery oak habitat of the DSL declined by 40% between 1982 and 2010 (U.S. Fish and Wildlife Service 2010). This includes wholesale loss of the species' dunes-shinnery oak habitat to oil, gas, and other infrastructure development. Using oil and gas well data from both states, we estimate over 47,322 acres in New Mexico and 30,591 acres in Texas have active oil and gas well densities exceeding 13 wells/mile^2 (Figure 13). If we include all oil and gas wells (inactive, dry, plugged, injection, etc.), this number jumps to 130,276 acres in New Mexico and 65,198 acres in Texas. We do not have estimates of current vegetation (i.e., shinnery oak) losses to Tebuthiuron treatment for agricultural development, but note that these changes in the past have been extensive (U.S. Fish and Wildlife Service 2010).

[4] This is consistent with the Service's policy on using habitat proxies for implementing the ESA in the context of incidental take permits (U.S. Fish and Wildlife Service and NOAA 2015).

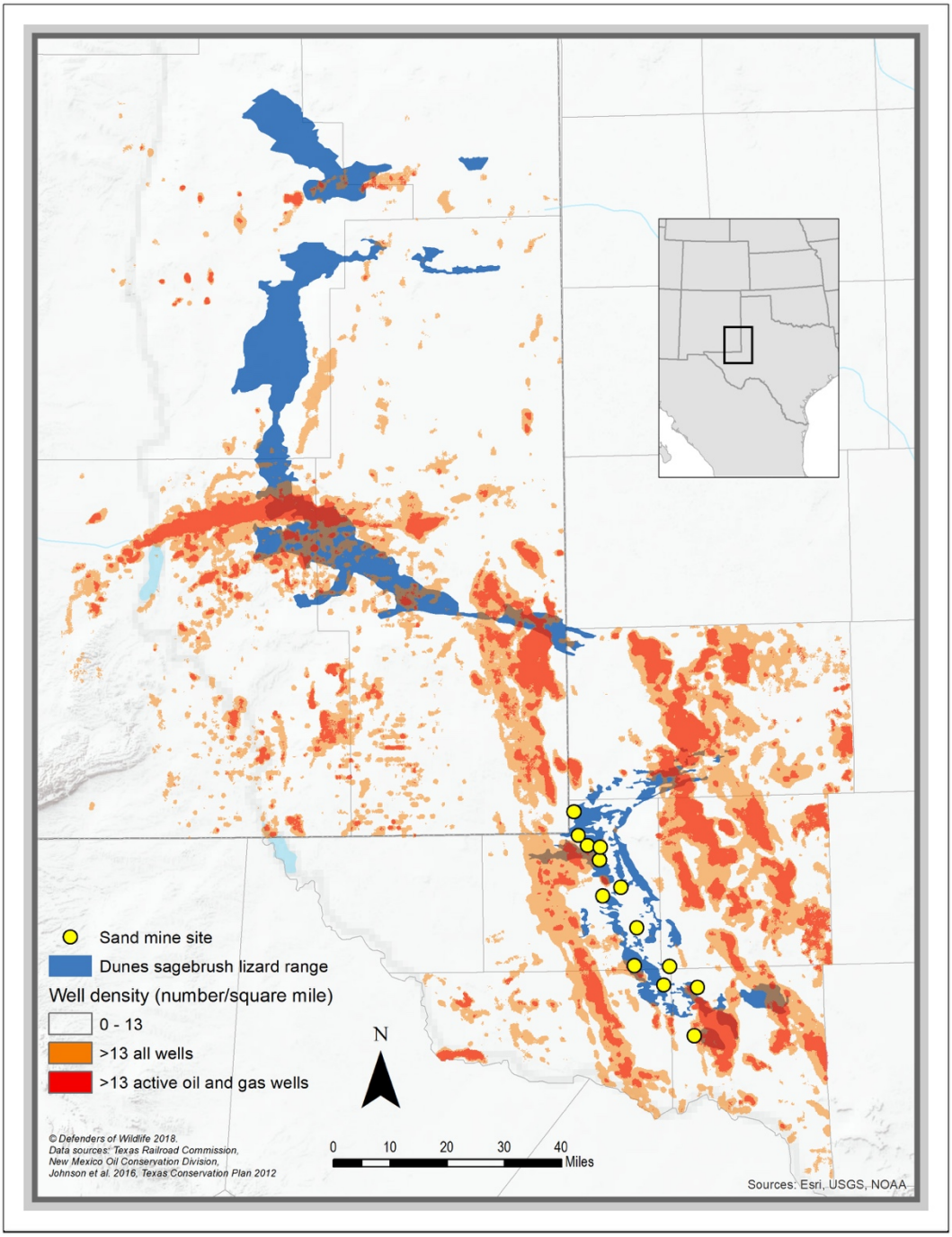

Figure 13. Between 77,913 and 195,474 acres of the dunes sagebrush lizard's range in New Mexico and Texas exceed the 13 wells per square mile threshold that has been shown to depress the species' populations. *Well densities are based on approved wells reported in the New Mexico and Texas oil and gas well databases as of April 2018. Density was calculated in half-mile radius areas on a 1/8th-mile grid using the PointDensity function of ArcMap. Sand mine locations are shown for reference.*

The DSL does not exist as a single, panmictic population, but instead as a metapopulation[5] (Verboom and Apeldom 1990; Verboom *et al*. 1991), which is important for understanding the species' status. While considerable attention is paid to direct destruction of the species' preferred habitat—shinnery oak dune blowouts—destruction of general habitat in the interstitial areas, such as shinnery oak flats, is a significant problem because it likely inhibits connectivity among preferred habitat patches (see, e.g., Painter 2004). We are not aware of any current estimates of the destruction or modification of interstitial habitats that enable connectivity, but reviews of aerial imagery in the DSL's range in New Mexico and Texas illustrate a significant challenge (Figure 14). The details of the threat of habitat fragmentation and impacts on DSL connectivity are discussed in **THREATS ANALYSIS: FACTOR A**.

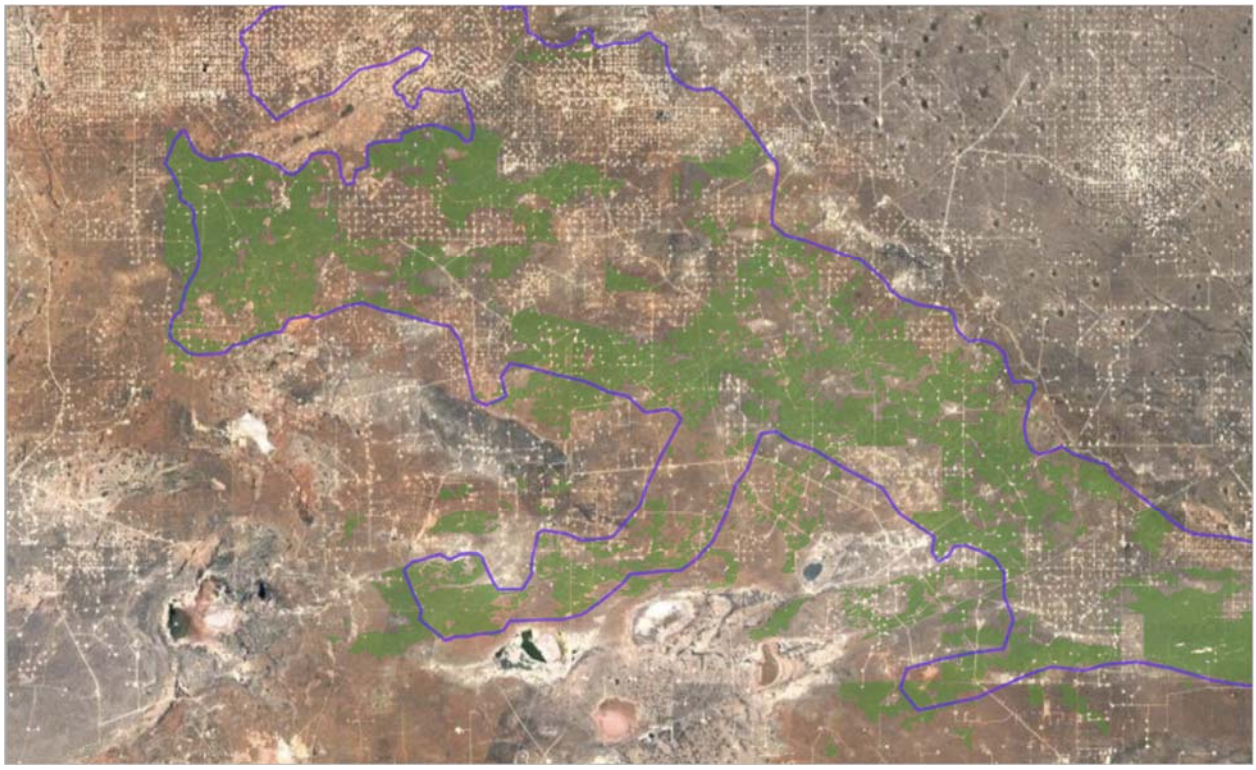

Figure 14. Connectivity among the dunes sagebrush lizard's preferred habitats (shinnery oak dunes, green) is reduced or lost when habitat between patches is modified or destroyed, as seen here with oil and gas wells and associated roads in the southern portion of the species' range in New Mexico. *Habitats separating preferred shinnery oak dune blowout patches need to be conserved to allow dispersal of dunes sagebrush lizards among the*

[5] A metapopulation is a collection of spatially discrete subpopulations that are connected to each other by the dispersal movements of individual animals (Levins 1970; Hanski 1991). Subpopulations in patches with all necessary resources are more likely to persist because these sites are more likely to have population growth rates ≥ 1. Larger subpopulations have a lower probability of extinction from stochastic events (Gilpin and Soule 1986). Similarly, patches with insufficient resources to meet the needs of the species cause an increased possibility of extinction. Patches that are near occupied patches are more likely to be recolonized after their resident subpopulation goes extinct (Hanski 1982; Gotelli 1991; Fahrig and Merriam 1985). Isolated subpopulations are at greater risk from inbreeding, genetic drift, and founder effects. The movement of individuals between occupied patches and unoccupied patches is important for maintaining the overall persistence of the metapopulation through colonization-extinction dynamics and ensuring gene flow among subpopulations. For a metapopulation to persist, the rate of patches being colonized must exceed the rate of subpopulations going extinct (Levins 1970).

patches, which is essential for resilience and redundancy of the species. The purple outline shows the lizard's range as of 2008, when the CCA/As were established in New Mexico.

Significant DSL habitat loss is likely to continue in the immediate and foreseeable future, especially in Texas. Assuming a conservative advance of 585 acres per year of oil and gas wells above 13 wells/mi^2, plus the expansion of 15 sand mines at 12.2 acres/month/mine in prime habitat, the direct losses of DSL habitat may top 2,781 acres annually. If existing and new sand mines were to expand as quickly as the Fairmount-Santrol mine (36.7 acres/month) then the estimate may be closer to 7,191 acres annually in the highest quality habitat. And if the oil and gas industry were to return to higher development rates seen prior to 2009, the negative effects on the lizard and its habitat would be even worse. Because fragmentation is such a significant threat to the DSL, these direct habitat losses are magnified by the indirect effects of disconnecting populations and increased edge effects (see **Habitat requirements, THREATS ANALYSIS: Factor A**). When combined with the threats posed by invasive species, climate change, and contaminants associated with oil and gas operations, there is substantial evidence that the DSL in the Monahans Sandhills of Texas are in danger of extinction or are likely to become endangered in the foreseeable future.

Direct habitat loss in parts of the lizard's range in New Mexico appears to be substantially reduced because of the CCA/As (see Figure 7). However, losses that are in compliance with the CCA/As in connecting habitats (e.g., shinnery oak flats) will likely continue fragmenting DSL habitat in the southern portion of the Mescalero Sandhills, further imperiling the species. In the northern portion of the New Mexico range, the threats of invasive species, climate change, and contaminants all constitute unchecked threats to the DSL's habitat and the lizards themselves. The time horizon to extinction in New Mexico is clearly longer than in Texas, but extinction is a foreseeable outcome if threats are not controlled.

Together, Factors A, D, and E have and will continue to imperil the DSL across its range in New Mexico and Texas, individually and in combination. Further, these factors have and will continue to cause the conservation status of the DSL to decline as the resilience, redundancy, and representation are reduced or lost.

THREE RS: RESILIENCE, REDUNDANCY, AND REPRESENTATION

The Service has adopted the conservation framework in which a species' conservation status is evaluated in terms of its resilience, redundancy, and representation ("three Rs"; Shaffer and Stein 2000). Listing and delisting decisions are informed by an analysis of whether a species has or will have sufficient:

- Resilience to withstand and recover from systemic shocks that threaten populations;
- Redundancy to ensure that "backup" populations exist so that local population losses or declines are not catastrophic to the species; and
- Representation of intrinsic (e.g., genetic diversity) and extrinsic characteristics (e.g., across ecosystems).

If an ESA-listed species lacks resilience, redundancy, or representation then it cannot be considered conserved and therefore must remain listed. Conversely, if a non-listed species lacks one of the three Rs or is likely to lose one element in the imminent or foreseeable future, then it must be listed. In a recent Species Status Assessment that underpins the proposed threatened listing of Panama City Crayfish (US Fish and Wildlife Service 2018a), the Service characterized the importance of the three Rs (US Fish and Wildlife Service 2017):

> Together…the 3Rs comprise the key characteristics that contribute to a species' ability to sustain multiple distinct populations in the wild over time (i.e., viability). Using the principles of the 3Rs, we characterized both the species' current viability and forecasted its future viability over a range of plausible future scenarios.

The conservation status of DSL has been declining over the past 30 years in terms of the three Rs, and is likely to further deteriorate in coming decades. Most importantly, in Texas the sand mining in the DSL's core habitat and the extensive oil and gas development could cause the loss of the species from the Monahans Sandhills in the near future. This will constitute the complete loss of representation of populations with a unique evolutionary history and unique genetic content, as well as the loss of representation of the species from a key geological feature and geographic area.

RESILIENCE

The High Plains of eastern New Mexico and West Texas are known for their extremes, with temperatures and precipitation that vary widely within and between years (see, e.g., habitat descriptions in Degenhart et al. 1996). Species like the DSL evolved to cope with this variation: populations possess an emergent property of resilience to allow persistence when, for example, a year of very low precipitation results in a year of very low or no reproductive output. Greater resiliency is related to factors such as a greater number of populations (lower risk of any single loss affecting the whole species; e.g., Hanksi 1998); broader geographic extent of populations (lower risk that all populations will be affected by any single event; e.g., Purvis *et al.* 2000); and certain life history characteristics (e.g., sufficiently long lifespan to bridge poor periods or harmful events). Critically, the loss of resilience has a feed-forward non-linearity: smaller and fewer, less-connected populations accentuate the losses that arise from these characters.

The DSL was resilient over the thousands of years since the Mescalero and Monahans sandhills formed, but human activity in recent decades across its range has degraded the natural resiliency of the species. The loss of each additional subpopulation through direct destruction, and the widespread isolation of subpopulations as connectivity is lost through interstitial habitat destruction, systematically reduces resiliency (Hanski 1998, Minor and Urban 2008). Under a "range of plausible future scenarios," losses are likely to continue across the DSL's range because of continued habitat destruction, invasive species, climate change and other factors. Because of the inadequacies of the TCP (see **THREATS ANALYSIS: FACTOR D**, below), the loss of resilience will be faster, and the consequence more immediate, in Texas.

REDUNDANCY

Most of the same factors that affect resilience—the number and spatial extent of populations, and the connectivity among populations—are also directly related to redundancy. With fewer subpopulations, there are simply fewer sources for colonists to recover other subpopulations that are lost. When the spatial extent of subpopulations is reduced, colonists are more likely to have to travel farther to recover other lost subpopulations. And when connectivity among subpopulations is reduced, colonists are less likely to arrive at patches that have lost populations. For the same reasons discussed for resilience, each of these characteristics is likely to decline across the range of the DSL, under a range of plausible future scenarios.

REPRESENTATION

The DSL exists as a metapopulation in shinnery oak sand dunes patches spread across two states and two geologic formations. For the species to be conserved it must be represented across this range, with representation in *both* the Mescalero Sandhills of New Mexico *and* the Monahans Sandhills of Texas (Figure 2). Losing the lizard from either of these formations would constitute a fundamental loss of representation for the species and for these ecosystems. As detailed above (see Population structure / genetics), the DSL populations in the Mescalero and Monahans sandhills have different evolutionary histories. The Mescalero DSLs in particular harbor a set of unique and widely diverged alleles that will be lost if the Texas populations are not protected. The accelerating habitat loss in Texas, as detailed in **THREATS ANALYSIS**, indicates that the likelihood of losing essential representation is high. Under a range of plausible future scenarios, the risk of reducing the DSL to a small and incomplete portion—and failing conservation of the species—is very high unless there is intervention.

The importance of the Texas populations to the three Rs and, hence to conserving the species, is further evident from internal Service documents. One of the most telling evidence comes from a January 4-6, 2012 meeting of the Service's New Mexico Ecological Services Field Office (U.S. Fish and Wildlife Service 2012c). Relevant notes from the meeting include the following:

> If we lose all of the TX populations would the species go extinct? Group (off the cuff) says not. But in contrast, on the recovery side of the decision, we can't let 30+% of acreage go.
>
> …
>
> Distribution of the landscape- disjunct nature is negative element because of gene flow etc., but on the other hand, it may be really important to keep two areas that are disjunct. Also, Manahan [*sic*] State Park is relatively protected area in TX. The habitat between the TX and NM populations is good enough to warrant surveys but as far as we know it's not occupied. From the recovery perspective, we wouldn't write off TX. If lost we lost the TX population, and reduce the threats in NM, someone could make the argument that we delist the species. We want appropriate representation from both states but we have to be able to articulate why.
>
> …

> SQ: Why does TX matter, or does it, now since it didn't matter 3 years ago? There was so little information that we dismissed TX. From a restoration approach we would forget TX.
> There's information now that wasn't available at the time of writing the proposed rule that says there are lizards in TX so it matters to the discussion.
> AA: TX is important because it exists. Four populations are better than three plus TX is geographically distinct, there are positive and negative aspects to its being disjunct, and there's genetic diversity produced in its patchiness.
> …
> The TX population contributes to the 3Rs in some way and the loss of this population increases the risk of extinction of the whole species.
> …
> TX Plan: It's legally defensible to say that we need TX because of conservation biology principles. We need some portion of the range in TX with conservation measures to feel comfortable.

These and other remarks from the Service make clear that the New Mexico populations alone are not enough to adequately conserve the species because the Texas populations contribute meaningfully to the species' resilience, redundancy, and representation.

REQUEST FOR CRITICAL HABITAT DESIGNATION

The petitioners request the designation of critical habitat for the DSL concurrent with its listing. Habitat loss across the species' range, but especially across many parts of the Monahans Sandhills in Texas, has been the single biggest cause of the species decline. It is closely associated with a dynamic feature of the landscape—shinnery dunes blowouts—that moves over time, and therefore, all areas within its range are potential habitat and important for its long-term survival. Special attention should be given to areas that may be unoccupied but are either sand sources or corridors for lizard dispersal. Because of the imperiled status of the DSL, its small range, and specific habitat requirements, the Service should designate all potential, suitable, and occupied habitat, including suitable sources of sand and corridors for the movement of wind-blown sand, as critical habitat.

CONCLUSION

The DSL is threatened or endangered by the past and continuing effects of habitat destruction, inadequate laws and regulations, invasive plants and animals, climate change, and contaminants. The effects of these threats were, in fact, exacerbated as a result of the withdrawal of the proposed rule to list this imperiled species. Despite the Service's analysis in its 2012 withdrawal finding, the TCP did not eliminate or adequately reduce the threats or improve the status of the DSL. In fact, sand mining is now occurring in the species' habitat and is not covered or even described in the TCP. Despite the efforts described in the TCP and the New Mexico CCA/As,

habitat fragmentation and destruction is ongoing and, in combination with the threats from invasive species and climate change, imperils the species. The Center for Biological Diversity and Defenders of Wildlife petition the Service to list the DSL as a threatened or endangered species to ensure its long-term persistence and designate critical habitat.

Sincerely,

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NOTE: To improve the readability of the main text of the petition, we have placed the key page numbers, when applicable, in the lines following the references below. These are indented 0.5" and italicized. If a reference does not include such a note, then the entire reference is of relevance as cited in the petition.

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Appendix A. Effect of the New Mexico dunes sagebrush lizard (and Lesser Prairie Chicken) CCA/A on oil and gas well approvals

Jacob Malcom and Matthew Moskwik, Defenders of Wildlife
06 April 2018

The dunes sagebrush lizard (*Sceloporus arenicolus*) is an imperiled species that is restricted to shinnery oak sand dune habitats in southeastern New Mexico and West Texas. This region is also a hotspot of oil and gas development, which is a major threat to the species. Here we evaluate the effectiveness of voluntary conservation agreements for the lizard in New Mexico and Texas. We show that the Candidate Conservation Agreement and CCA with Assurances (hereafter, CCA/As) in New Mexico, which contain strong avoidance mechanisms, are associated with a steep decline in oil and gas well approval in the lizard's New Mexico range. In contrast, the Texas Conservation Plan (TCP), which does not include avoidance, is not associated with any decline of oil and gas well approval in the lizard's Texas range. These results show that the voluntary agreements alone are insufficient to conserve the lizard in both states to ensure genetic and geographic representation.

Objective, hypothesis, and predictions

Our objective was to test whether voluntary conservation agreements for the dunes sagebrush lizard (DSL) in New Mexico and Texas have been effective at reducing oil and gas activity in the species' habitat. We hypothesized that the New Mexico CCA/As, which have strong avoidance requirements, produced a noticeable reduction of new oil and gas wells in DSL habitat, but that the TCP did not produce such a reduction because it lacks avoidance requirements. Our predictions were:

1. The rate of new well approval through time is approximately the same inside and outside of DSL habitat *before* the CCA/As (2009) and *before* the TCP (2012);
2. The rate of new well approval in New Mexico is lower inside of DSL habitat than outside of DSL habitat *after* the CCA/As were adopted; and
3. The rate of new well approval in Texas is not different inside and outside of DSL habitat *after* the TCP was adopted.

Methods

Well approval data for both New Mexico and Texas are the respective states' oil and gas well records, which we downloaded from Texas Driling.com and the New Mexico Oil Conservation Division on 03 April 2018. We defined the DSL's range in New Mexico as the boundaries recognized in 2008 at the time of CCA/A development and adoption. We defined the DSL's range in Texas as the boundaries of the 'Hibbetts map' of suitable habitat (from low to very high quality) produced by researchers at Texas A&M in 2011. 'Outside' the DSL's range in Texas comprised a five-county region where the lizard is found, but outside the 'Hibbetts map' suitable habitat regions. In New Mexico, 'outside' is defined as within the Permian basin, but outside the delineated species range. We then tallied the number of wells approved each year since 1990 inside and outside of DSL habitat. We fit separate linear models to estimate trends in/out of habitat and before/after well approvals.

Results

The well data supported our predictions. We observed the rate of new well approval rate declined rapidly within DSL habitat but remain unchanged outside of DSL habitat after the adoption of the CCA/As in New Mexico (Figure A1):

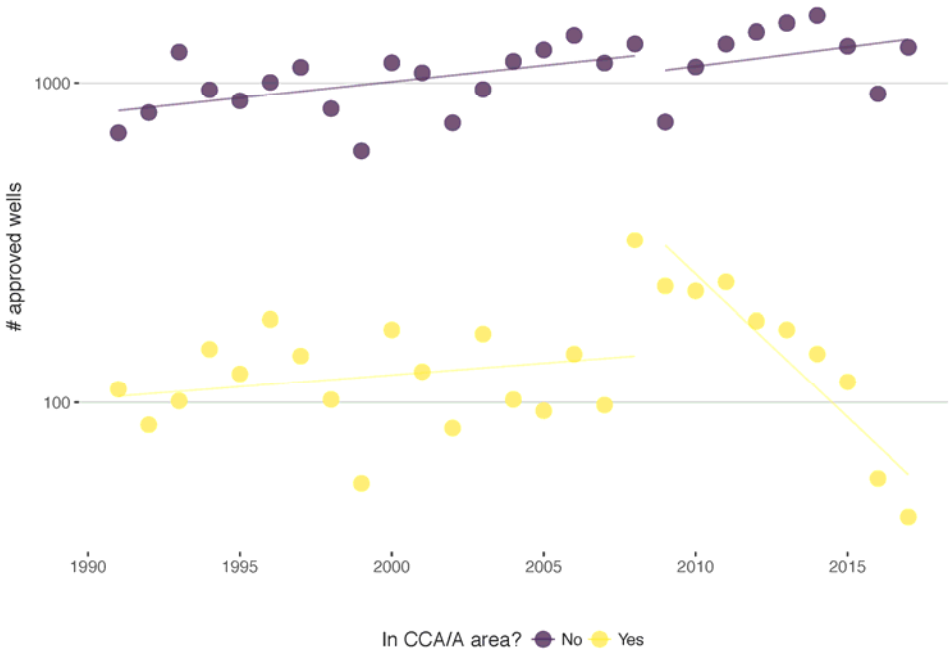

Figure A1. The New Mexcio CCA/As, which have strong avoidance requirements, result in a rapid decline of new well approvals in dunes sagebrush lizard habitat after their adoption in 2008.

In contrast, the rate of new well approval rate was no different inside versus outside of DSL habitat after the adoption of the TCP in Texas (Figure A2):

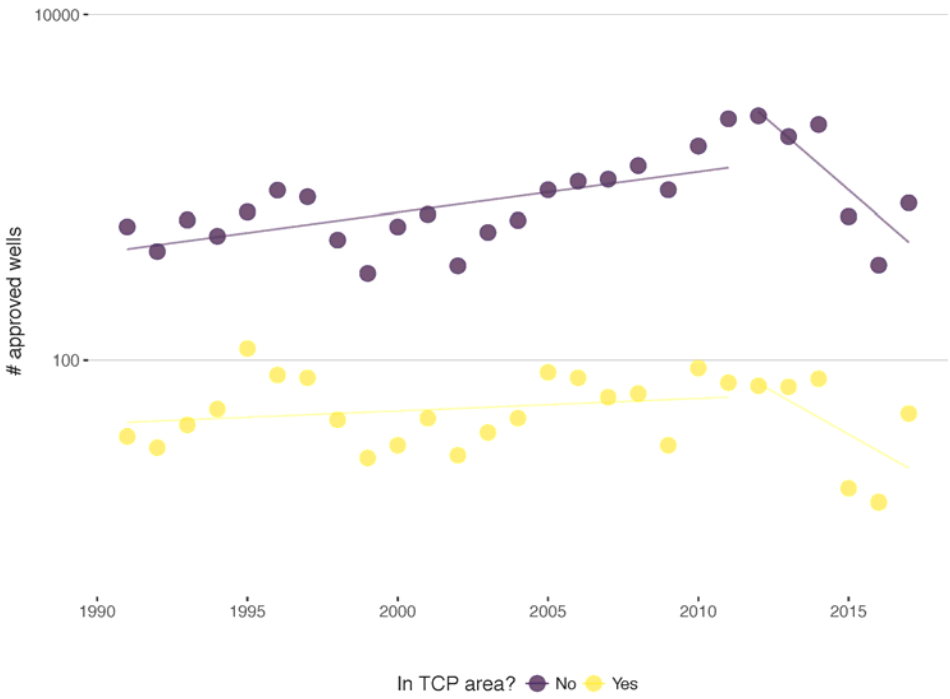

Figure A2. The TCP, which lacks strong avoidance requirements, has no apparent effect on new well approvals in dunes sagebrush lizard habitat after in 2012.

Discussion

The DSL's conservation requires protecting its remaining habitat in both New Mexico and Texas: if the species is lost from either state than fundamental representation—both in terms of unique genetic contributions and geographical distribution—will be lost. Our analyses indicate that the CCA/As in New Mexico have reduced one of the most significant threats to the species and its habitat, oil and gas development. The number of new well approvals in New Mexico is not zero since the CCA/As, but it is feasible that those new approvals are primarily occurring outside of suitable DSL habitat, despite occurring within the its range.

In contrast to New Mexico, our results show that the TCP has had no effect on the rate of new well approval inside of DSL habitat in Texas. This is expected because the TCP does not require avoidance of DSL habitat loss. Had the State of Texas incorporated strong avoidance requirements into the TCP, then our analysis may have shown that voluntary conservation efforts were sufficient to protect the DSL.

Appendix B: Stratification in the dunes sagebrush lizard's range in Texas

Matthew Moskwik and Jacob Malcom, Defenders of Wildlife
03 May 2018

The dunes sagebrush lizard (*Sceloporus arenicolus*; DSL) is an imperiled species that is restricted to shinnery oak sand dune habitats in southeastern New Mexico and West Texas. This region is also a hotspot for oil and gas development, which is a primary threat to the species and its habitat. In 2012, a voluntary conservation agreement, the Texas Conservation Plan (TCP), was created to avoid listing the DSL under the Endangered Species Act. Unfortunately, the TCP does not account for multiple owners with rights that overlap the same surface acre, such that owners of subsurface rights (e.g., mineral rights) can still harm habitat on the surface even if the surface owner has enrolled in the TCP. This problem is termed 'stratification'. Here we illustrate a generic approach to estimate the area possibly subject to stratification around the DSL's range in Texas. Oil and gas well data suggest that over 50% of the DSL's range in Texas could be compromised by stratification. This amount is similar, but lower than an estimate from the Texas Comptroller of Public Accounts.

Objective and challenges

Our objective was to estimate the area affected by oil and gas well stratification in DSL habitat in Texas. There are two challenges to achieving this objective. First, TCP enrollment data are protected by Texas law, so we cannot determine the enrollees. Second, parcel ownership and leasing data are unavailable for most of the area, so we cannot match well owners to land owners/lessees.

To obtain an estimate of the rate of single- versus multi-owner lands we make two simplifying assumptions. First, we assume that oil and gas well data should only show a single well owner for unstratified parcels. Second, we assume that overlaying a 1-mile grid on the landscape is sufficient for an initial estimate of stratification, because ownership and leases often follow section boundaries. If stratification is not an issue, then we should see very few cases of multiple well owners within a single block.

Methods

We downloaded Texas Railroad Commission oil and gas well data from www.texas-drilling.com on 03 April 2018. Using a random starting point, we created a 1-mile grid across the five counties of the DSL's range in Texas using ArcGIS, then assigned each oil and gas well to a single grid cell (i.e., parcel). We used R to count the number of unique well operators in each grid cell, and then counted the number of single- and multi-operator cells across the area. We then mapped the single- and multiple-operator grid cells using ArcGIS and clipped it to the DSL habitat polygons to obtain a more precise estimate of within-habitat stratification.

Results

The oil and gas well data indicate that stratification across the DSL's range is likely extensive (Figure 1). Based on well ownership data and the random $1mi^2$ grid, 79% of blocks in this part of Texas

have >1 well operator and may be stratified; 76% of blocks with >1 operator overlap DSL habitat. Clipping the DSL habitat polygon to the stratified blocks provides a refined estimate of 51% stratification of the lizard's range (Table 1).

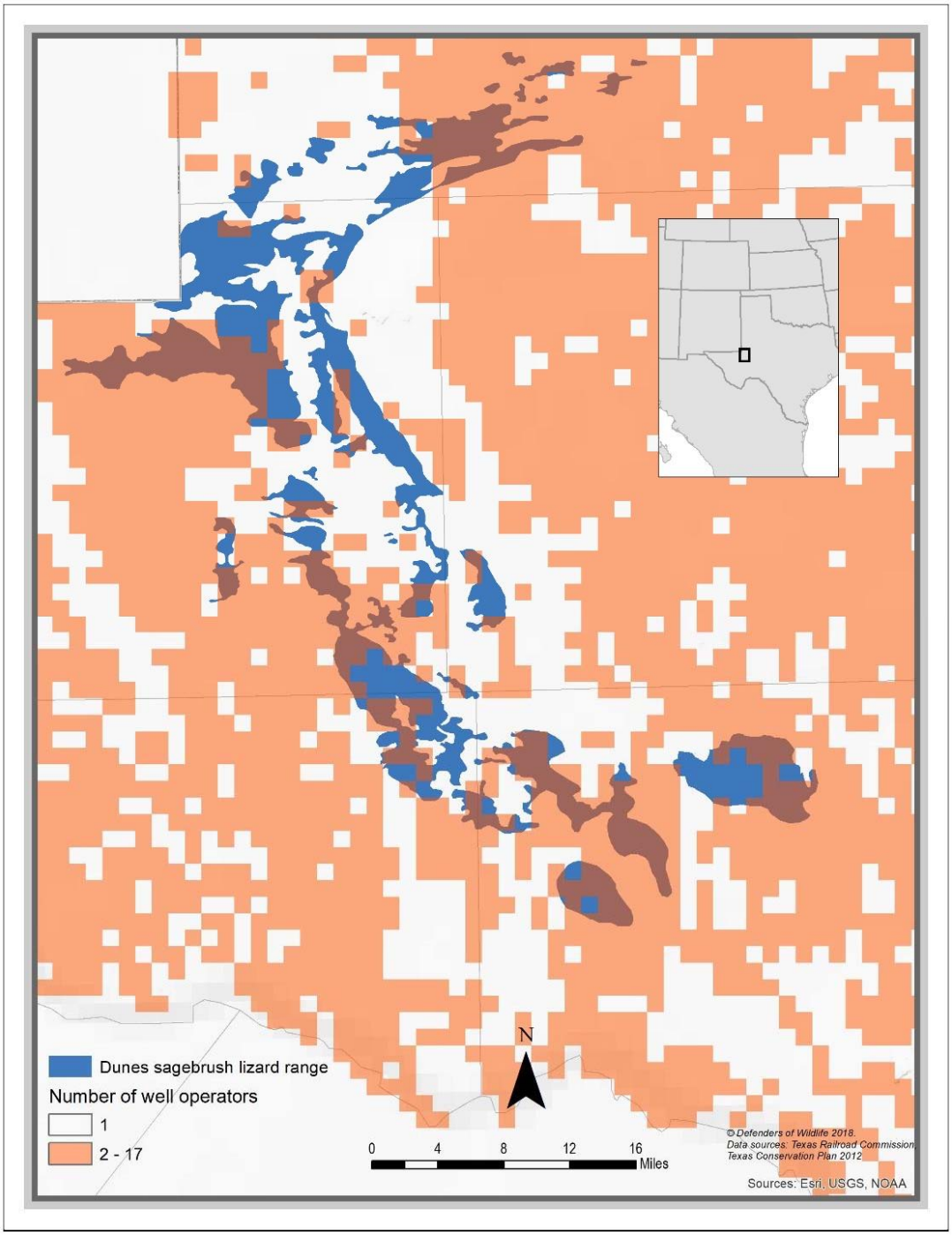

Figure 1. Over half of the DSL's range in Texas are likely to have stratified ownership (salmon cells). 76% of cells that intersect the DSL's range have multiple well operators; 79% of cells overall have multiple operators.

Table 1. The frequency of number of well owners per pseudo-parcel (1mi^2) across the five counties of the DSL's range in Texas.

# owners	Outside DSL habitat	Inside DSL habitat		Total
1	789	53		842
2	831	50		881
3	667	45		712
4	503	22		525
5	361	17		378
6	248	15		263
7	157	9		166
8	101	3		104
9	59	5		64
10	32	2		34
11	13	0		13
12	8	0		8
13	8	0		8
14	4	0		4
15	1	0		1
16	3	0		3
17	1	0		1
Strat. rate	0.792	0.760		0.790

Discussion

The TCP does not account for the stratification of ownership of surface vs. subsurface rights. This means that even if 100% of surface owners in the range of the DSL enroll in the TCP, subsurface owners can still modify or destroy the species' habitat on the surface. The full extent of the stratification problem is not known and cannot be derived by outside parties because of data availability restrictions. Here we estimated the extent of stratification using available oil and gas well data and two simplifying assumptions. Our results indicate that over half of DSL habitat in Texas may be susceptible to stratification and therefore are not fully protected under the TCP.

These results are an approximation, and we are aware of certain shortcomings in the data and assumptions. First, the results indicate limited stratification in some of the DSL core habitat in Texas. This may be an artifact of few wells being drilled on large sand dune blowouts, which are associated with DSL habitat. If no wells were present, we could not infer ownership and stratification. Second, detailed enrollment and parcel data could change this estimate of stratification. We assumed 1 mi^2 parcels for our analysis but if the average parcel is larger, than stratification may increase substantially. Conversely, if the average parcel is smaller, than the stratification estimate should drop. Absent access to the necessary parcel and lease data, we believe these are the best available estimates of stratification in Texas.