United States Department of the Interior

FISH AND WILDLIFE SERVICE
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Memorandum

To: Regional Director, Region 2, Albuquerque, New Mexico

Through: Assistant Regional Director, Ecological Services, Region 2, Albuquerque, New Mexico

From: Field Supervisor, Austin Ecological Services Field Office, Austin, Texas

Subject: Intra-Service Conference Opinion for the Issuance of a 10(a)(1)(A) Enhancement of Survival Permit to Canyon Environmental, LLC for *Candidate Conservation Agreement with Assurances for the Dunes Sagebrush Lizard* (*Sceloporus arenicolus*), dated November 2020 – Permit TE-89208D-0 (Consultation No. 02ETAU00-2020-F-2055)

Enclosed is the U.S. Fish and Wildlife Service's (Service) conference opinion for the issuance of a section 10(a)(1)(A) Enhancement of Survival Permit (Permit) to Canyon Environmental, LLC (Applicant) authorizing incidental take of the dunes sagebrush lizard (*Sceloporus arenicolus*; DSL). The Applicant will be responsible for implementing the proposed Candidate Conservation Agreement with Assurances for the Dunes Sagebrush Lizard *(Sceloporus arenicolus*) (CCAA). This conference opinion analyzes the effects of the proposed issuance of the Permit and implementation of the CCAA.

The information we used in the development of this conference opinion includes the CCAA, the accompanying Environmental Assessment pursuant to the National Environmental Policy Act (NEPA) of 1969, Service files, discussions with species experts, published and unpublished literature on the species and impacts, and other sources of information available to the Service. A complete administrative record of this consultation is available at the Austin Ecological Services Field Office.

If you have any questions regarding this conference opinion, please contact Adam Zerrenner at 512-490-0057, extension 248.

Attachment

Conference Opinion

This transmits the U.S. Fish and Wildlife Service's (Service) conference opinion (CO) for the issuance of a section 10(a)(1)(A) Enhancement of Survival Permit (Permit) to Canyon Environmental, LLC (Applicant) for incidental take of the dunes sagebrush lizard (*Sceloporus arenicolus*, DSL) that may result from implementation of the *Candidate Conservation Agreement with Assurances for the Dunes Sagebrush Lizard* (CCAA) in Texas, dated November 2020. This CO is provided in accordance with section 7 of the Endangered Species Act of 1973, as amended (16 U.S.C. 1531 et seq., ESA).

A CCAA is a formal agreement between the Service and the Applicant to address the conservation needs of an unlisted, candidate, or proposed species. This programmatic CCAA allows the CCAA's Administrator to enroll non-federal Participants who voluntarily agree to implement the CCAA through Certificates of Inclusion (CI). The DSL is not designated as threatened or endangered under the ESA and take of the DSL is not prohibited. In response to a petition to list the DSL, we determined that the petition presented substantial scientific or commercial information (85 FR 43203) and are reviewing the status of the DSL. We will make a decision on whether or not the species warrants listing in the near future. If the CCAA is approved and should the species become listed during the term of the CCAA, the proposed Permit will authorize incidental take of the DSL for non-federal landowners, lessees, operators, or other eligible CCAA Participants who have been issued CIs and have been in compliance with the CCAA, their individual CIs, and the Permit.

The Service has determined that two other species of fish and wildlife listed under the ESA may occur in the Action Area (defined below). Those species are the endangered northern Aplomado falcon (*Falco femoralis septentrionalis*) and threatened red knot (*Calidris canutus rufa*). These species will not be affected by implementing the CCAA and proposed Permit because they are locally extirpated, do not share suitable habitat with DSL, or differ in habitat preferences with the DSL within the Action Area. Therefore, no effects are expected; these species will not be further analyzed in this CO. The Service will initiate consultation and evaluate the effects of issuance of the Permit and implementation of the CCAA on northern Aplomado falcon and red knot if new information indicates that these species may be affected by the proposed action.

This CO is based on information provided in the CCAA, published and unpublished literature, communication with experts, and other sources of information. A complete administrative record of this consultation is on file at the Service's Austin Ecological Services Field.

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I. CONFERENCE HISTORY

In April 2020, the Applicant submitted its first draft of the DSL CCAA to the Service. The draft was a modified version of a DSL CCAA previously submitted in draft by the Texas Comptroller of Public Accounts (CPA). From April 2020 to December 2020, the Service and representatives of the Applicant have had ongoing discussions focused on increasing the conservation value of the CCAA. We made recommendations for changes to the CCAA to improve the conservation benefits that may accrue from implementation of the proposed CCAA and continued to discuss improvements with the Applicant throughout this conference. We received and reviewed subsequent drafts of the CCAA from the Applicant. On July 16, 2020, we published a Notice of Intent to prepare an environmental assessment (EA) and requested information and comments on the scope of our National Environmental Policy Act analysis (85 FR 43254). We requested that the Applicant revise the CCAA based on the public's and Service's comments. On November 20, 2020, we published a revised CCAA, dated November 2020, and a draft EA and opened a 30-day public comment period (85 FR 74370). We requested that the Applicant make revisions to the CCAA based on the public's and Service's comments. The Service's biologists met with the Applicant or their representatives eight times from December 2019 through October 2020, and provided written comments on the CCAA three times from April 2020 through November 2020.

II. DESCRIPTION OF PROPOSED ACTION

The Service proposes to issue an enhancement of survival permit under section 10(a)(1)(A) of the ESA (Permit) and approve the CCAA, which was requested by the Applicant to implement the CCAA. The Permit would authorize incidental take of the DSL, should it become listed during the term of the CCAA, for Covered Activities when those activities are conducted according to certificates of inclusion (CI) issued by the Administrator of the CCAA and in accordance with the Permit. Permits we issue for proposed, candidate, or unlisted species do not become effective unless and until those species are listed as "threatened" or "endangered" under the ESA. However, impacts to the species and conservation efforts will be tracked upon approval of the CCAA. If successful, the conservation benefits of the CCAA to the species will reduce or eliminate the threats to the species and allow its status to improve. A discussion of the purposes of CCAAs, the benefits to landowners, expected content of CCAAs, and our standards for issuing a permit are fully described in our 2016 revised CCAA policy (81 FR 95164) and 50 CFR Part 17.22(d) and 17.32(d)..

Participants operating in the Action Area (defined below) in the following industrial sectors will be eligible to enroll in the CCAA: oil and gas, sand mining, renewable energy, linear project construction, local governments, and agriculture and ranching. The Applicant will administer the CCAA. Participants who enroll are voluntarily committing to avoid and minimize impacts on DSL, as well as fund conservation measures to reduce or eliminate threats to DSLs or their habitat (see Action Area below for a description of DSL habitat types).

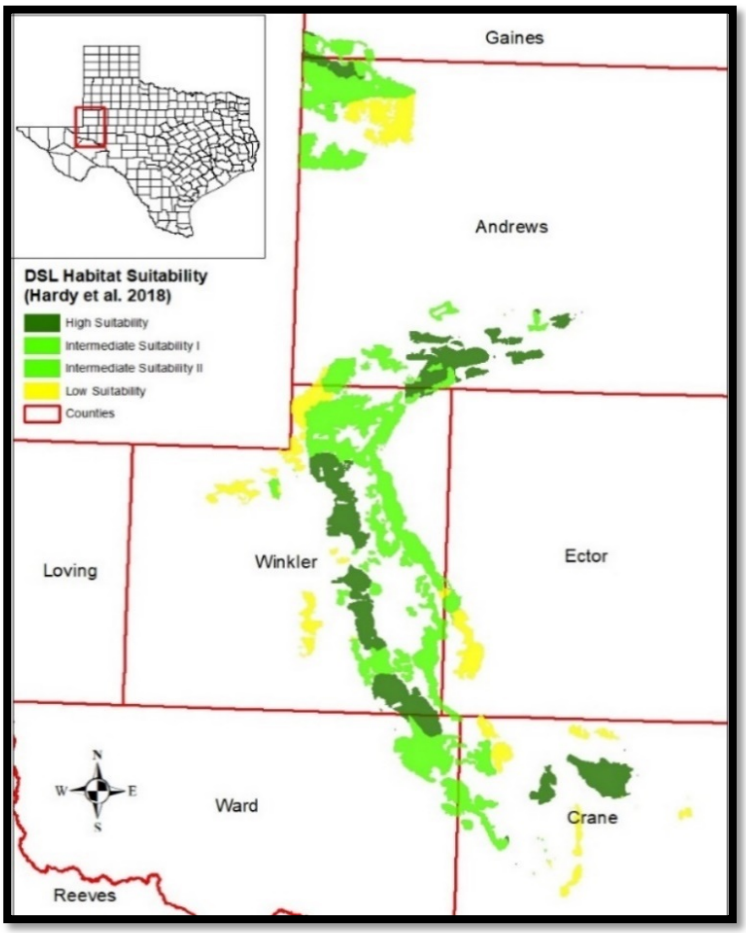
A. Action Area

The Action Area for this CO is defined as DSL habitat in Gaines, Andrews, Winkler, Ward, Ector, and Crane counties, Texas (i.e., the Covered Area for the CCAA, Figure 1). We are including Ector County where there are no documented occurrences of DSL because potential habitat is present in the county, and we are including Crane County although DSL have not been

documented from this county since the 1970's. Survey effort has been low in both counties; therefore, we cannot exclude the possibility that the species may be present or could be in the future, so we are including both in the Action Area. Dunes sagebrush lizard habitat is defined by Hardy *et al*. (2018) as:

- High Suitability – areas where DSL breed, feed, shelter, and establish home ranges, which includes shinnery oak (*Quercus havardii*) dunelands, dunes, blowouts (basically bowl-shaped depressions among sand dunes), barren sand, and shinnery oak mixed with ephemeral grasses and forbs;
- Intermediate I Suitability – areas that include shinnery oak-honey mesquite duneland with grassy or barren sandy dune areas when intermixed and where DSL breed, feed, and shelter;
- Intermediate II Suitability – areas with mesquite composing less than 25 percent and shinnery oak shrubland/flats; areas used for dispersal of both adults and juveniles; and
- Low Suitability – composed of shinnery oak-honey mesquite shrubland and grasslands; used for dispersal.

Figure 1: Hardy *et al*. (2018) DSL habitat.



The total area is approximately 278,969 acres of habitat as modelled by Hardy *et. al.* (2018). Further analysis by the Service has concluded approximately 122,516 acres in High and Intermediate I Suitability categories and 96,000 acres in Intermediate II and Low Suitability categories are undisturbed in the Action Area as discussed in the Status of the Species below.

High Suitability and Intermediate I Suitability are both dune habitat and, therefore, are considered the highest quality habitat for DSL because they support breeding, feeding, and sheltering. Acreages for each of these classifications are discussed further in the Environmental Baseline, Status of the Habitat in the Action Area section below.

B. Covered Activities

The following description of the Covered Activities are excerpted from Chapter 6 of the CCAA.

Oil and Gas Activities

Seismic and Land Surveying: Seismic activities are generally performed in the exploration phase of oil and gas development or in areas of existing development for refining knowledge of the geology and improving well siting. Seismic activities are conducted for periods of short duration (i.e., typically less than 30 days) in any given area. Activities may utilize large equipment to induce seismic pulses. Additionally, activities may include limited clearing of vegetation to allow equipment access for seismic work and consist of a small crew laying/stringing cables on foot or possibly using off-highway vehicles (OHVs). A crew removes cables when the project is complete. Land surveying is a low-impact, temporary activity and may require some truck and/or foot traffic.

Construction: Construction includes, but is not limited to, construction of facility sites and associated infrastructure and access roads, which involves the use of heavy equipment and trucking activities in clearing vegetation, contouring, compacting, stabilizing soils and installing erosion control (including silt fencing, earthen berms, etc. per Clean Water Act permitting requirements). Well site construction may include pit construction and closure, as well as temporary fencing and/or netting around pits, locations, or portions thereof, for livestock and wildlife protection. A water well, disposal well and/or injection well may be drilled near the location and possible boring and trenching related activities associated with installation of flowlines, pipelines, and utilities may occur. Associated infrastructure for compressor facilities and gathering/processing facilities may also be constructed on site or at adjacent sites. Where practical, equipment may be electrified (which greatly reduces noise and emissions from gas/diesel-driven equipment), which involves the installation of in-field electrical distribution systems (poles, transformers and overhead wires). Activities may be conducted to plug and abandon a well, which may involve workover rig mobilization, removal of facility equipment and associated infrastructure, access roads, abandonment in place of subsurface lines, and reclamation pursuant to surface use lease agreements and regulatory requirements. Construction may also include activities associated with emergency operations such as mobilization of heavy equipment, building structures, and any associated reclamation activities.

Drilling, Completion, and Workovers (Recompletion): Drilling, well completion, recompletion, and well workover activities may include rig mobilization, which involves the use of heavy equipment and frequent traffic. These activities are not expected to directly impact dune complexes because the activities are confined to locations with existing surface disturbances (e.g., existing well pads and access roads). Recompletions and workovers typically do not increase existing well pad size and typically utilize smaller rigs and equipment, require less time for onsite activities, and involve less vehicular traffic. Well site fencing may be utilized after completion of operations for security and to limit access.

Routine Production Operation and Maintenance: Routine production operation and maintenance may include, but is not limited to, stimulations; wellbore repair; daily site inspections and maintenance; testing; linear infrastructure, gathering line, and flow line repairs; right-of-way (ROW) and road maintenance; unloading of storage tanks; truck traffic for removal of product or waste; emergency response activities; workovers; recompletions; flaring; weed control; pipeline pigging activities; and regulatory inspections.

Remediation and Reclamation Activities: Remediation activities and reclamation activities include, but are not limited to, assessment, removal and reclamation of access roads, fences, well

pads, reserve pits and other facilities for the disposal of waste; tanks and storage facilities; treaters, separators, dehydrators, electric and other utility lines and pipelines (e.g., gathering lines, flow lines, distribution lines, and waterlines); and associated infrastructure for compressor facilities and gathering/processing facilities. Reclamation activities, which may be subject to requirements in surface use agreements, also may include the implementation of Conservation Measures and actions that benefit the DSL and its habitat.

Sand Mining
Excavation and processing of sand, the development of roads, processing plants and other infrastructure, drilling of water wells, and the use of roads for truck and other traffic in areas of DSL habitat are Covered Activities for sand mining companies as long as they comply with the Conservation Measures described in the CCAA.

Renewable Energy Operations
Covered Activities for solar and wind energy companies include the construction and maintenance of solar or wind energy facilities including power lines and appurtenant structures in Low Suitability areas of DSL Habitat as long as they comply with the Conservation Measures described in the CCAA. The construction of solar or wind energy facilities including power lines and appurtenant structures in High and Intermediate areas of DSL habitat are not Covered Activities.

Linear Infrastructure Construction and Operation
Linear infrastructure (i.e. midstream and gathering pipelines, electrical transmission and distribution infrastructure, and other utilities) construction and operation for industrial purposes will be a Covered Activity if conducted in accordance with applicable statutory and regulatory standards and the Conservation Measures described in the CCAA. This activity includes land surveying, construction, routine operation, maintenance and repairs, emergency response activities, reclamation activities for pipeline and appurtenant structures (e.g., pipe yards, interconnects, compressor stations), and electric utility facilities (e.g., transmission lines, distributions lines, service lines, and substations).

Pipeline rights-of-way are typically 50 feet wide, while rights-of-way for electrical transmission and distribution facilities vary in width depending upon the size of the facility. Construction of pipelines necessitates: (1) the staging and storage of equipment, materials, and vehicles; (2) clearing of rights-of-way; (3) trenching for the pipeline; and (4) constructing appurtenant facilities such as “pigging” stations, and compression and pumping stations. Such construction also requires access roads, parking lots, and fencing.

Construction of aboveground linear infrastructure necessitates: (1) land surveying which may require truck or OHV access; (2) staging and storage of equipment, materials and vehicles; (3) limited clearing of rights-of-way, particularly for tower foundations, footings, and access roads; (4) and use of heavy equipment and trucks for construction in clearing vegetation, contouring, compacting, stabilizing soils and installing erosion control (including silt fencing, earthen berms, etc. per Clean Water Act permitting requirements).

Agricultural, Ranching, and Local Government Activities
Brush management: Brush management may consist of using approved herbicide, mechanical, and prescribed burning practices to control or suppress shinnery oak in accordance with the

CCAA, and mesquite and other brush in DSL habitat if done in accordance with Conservation Measures described in the CCAA.

1. Grazing: Livestock grazing methods, which include approved Natural Resources Conservation Service (NRCS) prescribed grazing practices, may occur in DSL habitat.
2. Building and maintaining fences and livestock structures: Construction and maintenance of new and existing fences and livestock structures may occur in DSL habitat if done in accordance with Conservation Measures described in the CCAA.
3. Water/windmill: Water storage facilities, agricultural water pipelines, windmills and water trough construction, maintenance, and placement may occur in DSL habitat.
4. Farming and Irrigation: Farming and irrigation for agricultural purposes will be a Covered Activity if done in accordance with NRCS standards and the Conservation Measures described in the CCAA.
5. Public works and infrastructure: Local government activities to construct, maintain and repair public works and infrastructure including roads, water and sewer facilities, public buildings, facilities, parks, etc.

General Construction Activities
Including, but not limited to, enrollment in each of the industry or activities listed above, general construction activities that include, but are not limited to, construction of facility sites, infrastructure, roads, and implementation of best management practices, which involves the use of heavy equipment and trucking activities in clearing vegetation, contouring, compacting, stabilizing soils, constructing and maintaining roads and linear infrastructure, and installing erosion control (including silt fencing, earthen berms, etc.). The list of construction activities described above are not intended to be exhaustive.

Conservation, Research, and Monitoring
Conservation, research, and monitoring projects performed or approved under the CCAA include, but are not limited to, acquiring conservation easements (where feasible) and other protections to conserve DSL habitat; surveys for DSL; refinement of models of potential habitat; captive breeding and reintroduction; temporal, spatial, and geomorphological dynamics of dune systems and stability; relationships between water use, hydrogeology and dune systems; and other similar activities to study, monitor, and assess the species, and the efficacy of and compliance with the CCAA. Additionally, research projects should review the Texas A&M University (2016; TAMU) and Hardy *et al.* (2018) habitat models to contribute to the further development and refinement of DSL habitat modeling.

III. STATUS OF THE SPECIES

The DSL has been petitioned for listing to the ESA list of threatened and endangered species. Previously, on December 14, 2010, the Service proposed to list the DSL as endangered under the ESA and noted that critical habitat was prudent but not determinable at the time. After two comment period extensions, the Service extended our determination to list the DSL until June 14, 2012, due to significant scientific disagreement. On June 19, 2012, we withdrew the proposal to list the DSL, based on our conclusion that the threats to the species were no longer as significant as believed to be at the time of the proposed rule (77 FR 36871). On July 16, 2020, in response

to another petition to list the DSL, we published a 90-day petition finding and initiation of a status review (85 FR 43203). Based on our review, we found that the petition presented substantial scientific or commercial information indicating that listing the DSL may be warranted. We are currently conducting a Species Status Assessment and expect to make a listing determination in the near future.

A. Species Description and Life History

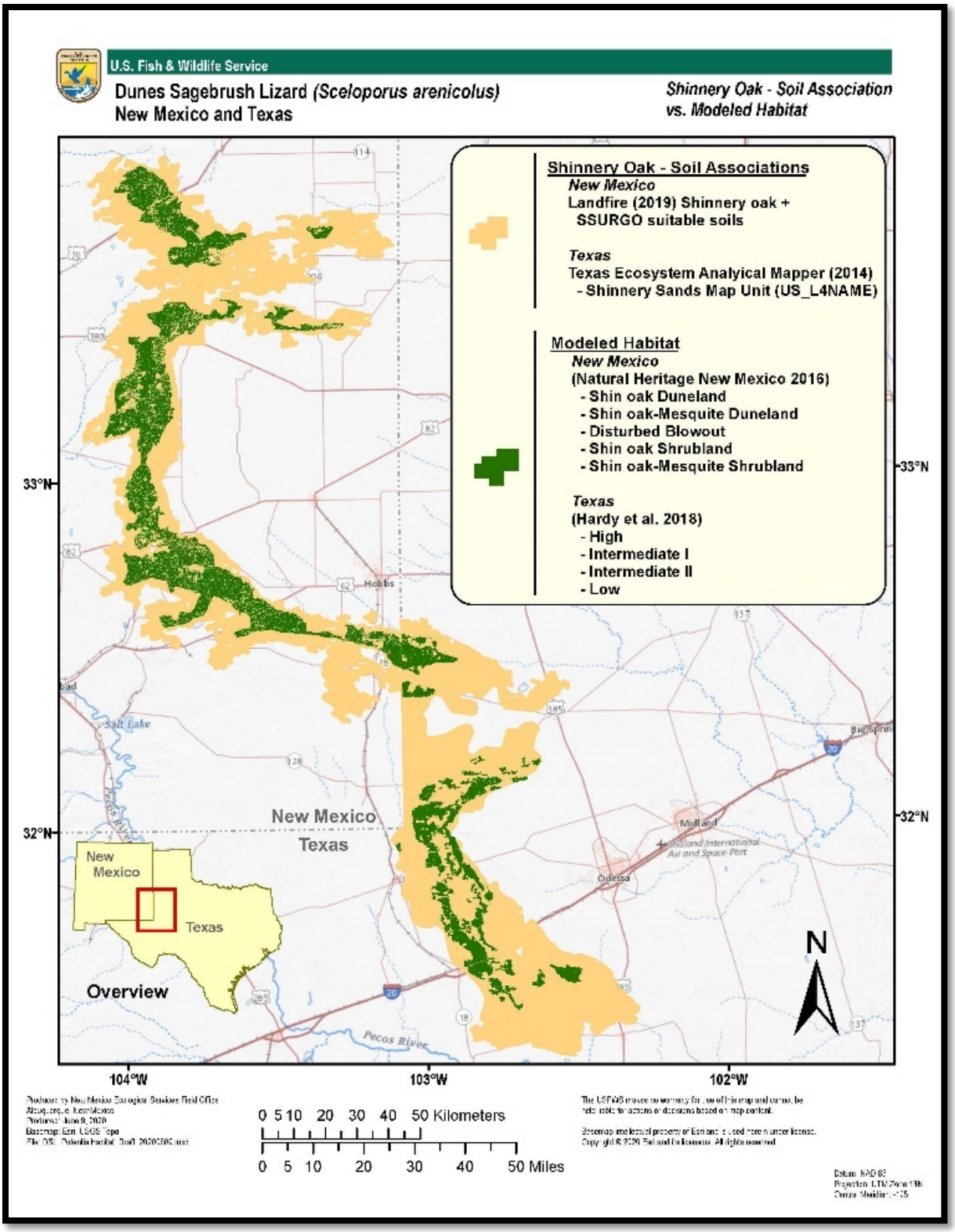
The DSL inhabits shinnery oak-dune landforms within the Mescalero-Monahans Sandhills of southeastern New Mexico and western Texas (Figure 2). The DSL is a small lizard with a maximum snout-to-vent length of 2.8 inches (Degenhardt *et al*. 2005, Hibbitts and Hibbitts 2015). Its dorsal color matches that of sand and varies from a light tan to reddish tan and has grayish stripes. During breeding, females develop patches of orange along their heads, bodies, and tails, whereas males have blue patches on their bellies (Hibbitts and Hibbitts 2015). The DSL is considered a habitat specialist due to its extremely small and restricted range and its highly specialized shinnery oak-sand dune habitat niche (Hibbitts *et al*. 2013, Hardy *et al*. 2018).

Dunes sagebrush lizards have a short lifespan, living only two to four years and have a reduced reproductive output, reproducing only once or twice annually (Snell *et al*. 1997, Ryberg *et al*. 2012, Fitzgerald and Painter 2009, Hibbitts and Hibbitts 2015). Sexually mature males emerge in April, vitellogenesis (i.e., internal egg development) in females begins in late April, and mating occurs from May to early July (Degenhardt *et al*. 2005, Fitzgerald and Painter 2009, Hibbitts and Hibbitts 2015).

Males are territorial and compete for females, whereas females are not territorial and have overlapping home ranges (Fitzgerald and Painter 2009). Females dig burrows into sand dunes and blowouts and construct nest chambers at the soil moisture horizon (Ryberg *et al*. 2012). Females lay eggs between June and August with clutches containing an average of 5 eggs (range 3-6) (Degenhardt and Jones 1972, Cole 1975, Fitzgerald and Painter 2009, Hibbitts and Hibbitts 2015, Hill and Fitzgerald 2007). Hatchlings emerge about 30 days after the eggs are laid, between July and September (Snell *et al*. 1997, Fitzgerald and Painter 2009).

The DSL dives into sand to escape predators, can move several feet underneath sand, and sleeps buried in sand (Fitzgerald and Painter 2009). Dunes sagebrush lizards also bury themselves in sand as a thermoregulatory tactic to minimize heat loads and to avoid lethal and physically damaging surface temperatures (Snell *et al*. 1997, Fitzgerald and Painter 2009, Ferguson *et al*. 2014). Desert sand usually has a high albedo (reflecting a high amount of solar radiation) due to

Figure 2: New Mexico and Texas distribution of DSL habitat.



its lighter coloration, such that high temperatures are ameliorated a few inches below the surface (Cooke and Warren 1973, Ashkenazy and Shilo 2018).

Machenberg 1984, Fitzgerald *et al*. 1997, Sartorius *et al*. 2002, Ferguson *et al*. 2014). Predators include snakes (e.g., *Arizona spp*., *Masticophis spp.*, etc.) and birds, such as loggerhead shrikes (*Lanius ludovicianus*), American kestrels (*Falco sparverius*), and greater roadrunners (*Geococcyx californianus*) (Hughes 1996, Yosef 1996, Smallwood and Bird 2002, Alderfer 2006, Hill and Fitzgerald 2007, Young *et al*. 2018).

Many species of insects utilize shinnery oak as a food source and can inhabit the shrub in high abundances (Peterson and Boyd 1998, Gucker 2006). Within shinnery oak vegetation DSLs forage for insects and take refuge from predators (Peterson and Boyd 1998, Axtell 1988, Snell *et al*. (1997) suggest that coarse sand may have properties that allow for adequate exchange of gas and water between eggs and the surrounding substrate, and DSLs appear to be more abundant in areas where sand particles are larger (Fitzgerald *et al*. 1997). Soils with fine-grained particles may interfere with breathing (e.g., inhaling sand) and prevent gas exchange while buried (Snell *et al*. 1997, Ryberg and Fitzgerald 2014). Fine-grained sand may also be too compact for the DSL to bury itself or may be inadequate for nest excavation and egg incubation (Ryberg and Fitzgerald 2014).

The dune fields of the Mescalero-Monahans Sandhills consist of windblown sand that began accumulating several thousand years ago in the late Pleistocene (>10,000 years before present) to early Holocene (dating 4,000 years before present, and mostly before 1,500 years before present) periods (Machenberg 1984, Muhs and Holliday 2001). The sandy source material for these landforms was originally derived from erosion of igneous and sedimentary rocks in the southern Rocky Mountains and transported to the Pecos River Valley via ancestral streams and waterways (Machenberg 1984). As the climate dried at the end of the Pleistocene, streams that once flowed permanently became ephemeral, leaving sand and silt unconsolidated in floodplains and exposed to the elements (Machenberg 1984). Eolian (wind driven) processes then concentrated this sand along the western escarpment of the Southern High Plains, creating the dune fields and sand sheets present today (Machenberg 1984, Holliday 2001, Muhs and Holliday 2001). At a regional level, dune field activity increases, and dune vegetation cover decreases, from north to south in the Mescalero-Monahans Sandhills. The Monahans Sandhills, for example, represent the most southerly dune fields, and are thus the most active and least vegetated dune system (Holliday 2001). This geographic variability in dune activity and vegetation is the result of a latitudinal gradient in climate, which becomes warmer and drier from north to south within the Southern High Plains (Holliday 2001).

The Mescalero-Monahans Sandhills region is located along the semiarid margins of the Chihuahuan Desert and characterized by low precipitation, high evaporation rates, large variations in daily temperature, and high winds (Breckle *et al*. 2008, Cornett 2013, Machenberg 1984, Boghici 1998, Holliday 2001). Rainfall averages approximately 15.7 inches per year, mostly falling during the spring and summer, but is highly variable from year to year and the region is subject to severe droughts (Machenberg 1984, Leavitt 2019, Holliday 2001). In any 10-year period, it is common for the region to experience 2 or 3 years with less than 75 percent of the average annual precipitation (Peterson and Boyd 1998). Most precipitation occurs as scattered thunderstorms resulting from the convection of air masses off the heated land surface during July, August, and September (Anaya and Jones 2009). Tropical disturbances from the Gulf of Mexico also occasionally move through the Action Area during summer months (Anaya and Jones 2009). Winter months are relatively dry, and snowfall is infrequent.

Shinnery oak is slow growing and long-lived with both a shallow root system for uptake of precipitation and a taproot (15-20 feet) that extends deeper below the surface for absorption of groundwater (Peterson and Boyd 1998, Gucker 2006). Shinnery oak regeneration primarily occurs via rhizatomous (underground stem and roots) growth, rather than by sexual reproduction from acorns (Gucker 2006, Carroll *et al*. 2019). That is, the original plant produces many individual clones vegetatively and then multiplies by fracture (Peterson and Boyd 1998). The root and rhizome system of mature shinnery oak is extensive and is concentrated in the top 20 inches of soil; however, roots can penetrate up to 30 feet deep (Gucker 2006). Shinnery oak does not readily colonize open sites and if removed from a site, reinvasion is slow (Gucker 2006). In one study, reestablishment of a disturbed open space by adjacent clones was measured at just 30 feet in 50 years. Ninety percent or more of shinnery oak biomass occurs underground where its root and rhizome system is typically 10 to 16 times greater than aboveground stems (Gucker 2006).

Shinnery oak acts as a soil stabilizer in sandy areas and influences dune formation (Machenberg 1984, Gucker 2006, Dhillion and Mills 2009). Aboveground stems and leaves trap windblown sand, while the extensive root and rhizome system holds subsurface sand in place and prevents wind erosion. The upward growth of shinnery oak continues during sand deposition as the size of the sand dune grows (Machenberg 1984, Gucker 2006, Dhillion and Mills 2009). Peterson and Boyd (1998) report that the stem system of shinnery oak may grow to 30 feet or more during sand deposition and dune formation.

Shinnery oak-sand dune communities are some of the most poorly studied in the southwestern United States (Dhillion and Mills 2009). The restoration of shinnery oak is hindered by a lack of basic information on shinnery oak biology and ecology (Dhillion *et al*. 1994, Carroll *et al*. 2019). Most of the research available on shinnery oak has focused on its eradication and control, rather than its restoration (Pettit 1979, Dhillion *et al*. 1994).

An important component of the shinnery oak-sand dune landforms are the underlying aquifers (Garza and Wesselman 1959). Rainwater percolating downward is captured and retained within the sand dune landforms by capillary forces to create a soil water reservoir within the dune fields (Garza and Wesselman 1959, Machenberg 1984, Newton and Allen 2014, Mace 2019). Interbedded layers of less permeable sediment (e.g., clay, silt, caliche) deposited within the sand dunes by alluvial and eolian processes also function to slow the infiltration of rainwater to underlying formations and retain soil water in the dune fields (Garza and Wesselman 1959, Machenberg 1984, Newton and Allen 2014). Machenberg (1984) describes localized areas where precipitation infiltrates through the sand dunes and sand sheets of the Monahans Sandhills and collects in large volumes near the surface, above less permeable soil layers, as perched aquifers. Rainwater (2020) calls into question the presence of perched aquifers based on core samples taken at several sand mine facilities and an inability by Mace (2019) to rediscover the areas of perched aquifers described by Machenberg (1984).

Water present within the dune fields and underlying groundwater table directly affects dune processes and plays an important role in dune dynamics (Machenberg 1984, Kocurek and Havholm 1993). Groundwater from underlying aquifers that intersects with sand formations at the surface, or that is pulled up from the underlying water table by capillary potential, stabilizes the dune fields through cohesiveness as capillary forces hold intergranular water and sand grains in place and provide resistance to wind erosion (Machenberg 1984, Kocurek and Havholm 1993,

Newton and Allen 2014). Both surficial soil water and groundwater enable the growth of vegetation on the dunes, which in turn, reduces wind velocity and further stabilizes and protects these landforms from erosion (Machenberg 1984, Newton and Allen 2014).

B. Historical and Current Distribution

The DSL is endemic to the Mescalero-Monahans Sandhills of southeastern New Mexico and adjacent western Texas and occurs in disjunct populations throughout this region (Panter *et al*. 1999). The Mescalero Sands extend in a north-south trending arc from Roosevelt and Chaves counties southward through Eddy and Lea counties in New Mexico and end in Gaines and northern Andrews counties in Texas (Painter *et al*. 1999). The Monahans Sandhills extend in a north-south trending arc from southern Andrews County southward through Winkler, Ward, and Crane counties (Painter *et al*. 1999, Fitzgerald *et al*. 2011). While Ector County is sometimes included because it has the proper habitat, a DSL has never been documented in this county. As such, the range of the DSL in Texas may not yet be comprehensively defined, since DSL surveys in Texas have been constrained by site access to private lands and areas of potential DSL habitat (e.g., in Cochran and Yoakum counties) may have been inappropriately identified as unoccupied by DSLs based on insufficient survey effort (Hardy *et al*. 2018).

Using a combination of Landfire and NRCS's SSURGO soils data, the Service estimates that historically there was approximately 1,179,980 acres of DSL habitat in New Mexico. Dzialak *et al*. (2013) estimated 494,927 acres of DSL habitat in Texas, while the Service, using Texas Parks and Wildlife Department's (TPWD) Ecological Systems classifications (downloadable GIS vegetation layers), estimates approximately 984,921 acres in Texas. There are a few reasons these acreages are different, the main one being that the TPWD landcovers incorporate more vegetation types than Dzialak *et al*. (2013) who also then corrected for (removed) areas that were clearly not habitat (for example, agricultural lands).

The range of the DSL is narrow in terms of its planar width. For example, the Mescalero Sands ecosystem is only 10 to 16 miles at its widest point and less than 1 mile wide at its narrowest point (Painter *et al*. 1999). Whereas, the Monahans Sandhills are approximately 5 miles wide (Meyer *et al*. 2012).

The range of the DSL is severely fragmented by anthropogenic development and by natural, geological landscape barriers, which together have rendered large areas of habitat unsuitable for DSLs (Painter *et al*. 1999, Chan *et al.* 2009). Consequently, the DSL exhibits a patchy distribution throughout its range in the Mescalero-Monahans Sandhills (Hammerson 2007, Lorencio *et al*. 2007, Laurencio and Fitzgerald 2010). Based on these mostly anthropogenic effects, DSL habitat in New Mexico decreased from the Service's historical estimate (1,179,980 acres) to 346,319 acres (a 71 percent decrease) and in Texas from a range of 494,927 to 984,921 acres to 287,327 acres (a 42 to 71 percent decrease) (Hardy *et al*. 2018; Johnson *et al.* 2016, 2016, Dzialak *et al*. 2013). Not all these habitats are suitable because these estimates include disturbed extirpated and otherwise unuseable habitat for DSL.

The majority (approximately 70 percent) of DSL habitat in New Mexico occurs on public lands that are managed by the state and federal government (i.e., Bureau of Land Management) (Painter *et al*. 1999). In contrast, virtually all DSL habitat in Texas occurs on private lands, except for habitat at Monahans Sandhills State Park (3,840 acres) in Winkler and Ward counties, which is managed by TPWD.

Within shinnery oak-sand dune habitat, adult DSL have small home ranges (the area used for feeding, breeding, and sheltering) (Young *et al*. 2018). Hill and Fitzgerald (2007) reported an average home range of 0.11 acre, with the largest home range documented of 0.69 acre, and Young *et al*. (2018) documented a home range of 0.25 acre for males and 0.15 acre for females. Data on DSL dispersal is limited, especially for juveniles. Females may or may not leave their normal home range to nest (Fitzgerald *et al*. 2005). One gravid female tracked with radio telemetry moved approximately 656 feet through shinnery oak habitat and then returned to the original capture site while another moved approximately 492 feet (Fitzgerald *et al*. 2005).

Ryberg *et al.* (2013) found that insular DSL populations distributed throughout a contiguous patch of habitat and separated by distances ranging from 0.37 to 2.2 miles, were part of a single metapopulation maintained by dispersal and diffusion of individual DSL. Additionally, genetics studies in New Mexico detected measurable gene flow (i.e., genetic exchange) among DSL populations separated by at least 8.7 miles (Chan *et al*. 2009, Ryberg *et al.* 2013, Johnson *et al.* 2016). These findings suggest that gene flow among DSL populations is maintained by cumulative short distance movements of individual DSL across many generations and by occasional long-distance dispersal of individuals (Chan *et al*. 2009, Ryberg *et al*. 2013, Johnson *et al*. 2016). This underscores the need to consider the spatial context of suitable DSL habitat and potential dispersal corridors that maintain spatial connections between habitat by protecting shinnery oak shrublands (flats) and other potential dispersal habitats (Hardy *et al*. 2018). There is a general lack of information on juvenile dispersal, activity of juveniles, and habitat preferences of juveniles (Painter *et al*. 1999).

Recent studies have delineated patterns of genetic differentiation of the DSL across its range (Chan *et al.* 2009; Chan *et al*. 2013, Chan *et al*. 2020). The summary of these studies, based on mitochondrial DNA, present a geographic distribution of 10 different phylogroups, suggesting limited migration (Chan *et al*. 2020). These groups are composed of 7 Mescalaro Sands units, including Gaines County and northern Andrews County in Texas, and 3 Monahans Sandhills groups[1]. These phylogroups reflect historical population differentiation based on reduced connectivity that first occurred thousands of years ago and are early divergences that have persisted to present day (Chan *et al*. 2020). This study also found that DSL colonized the northern Mescalero Sands over 34,000 years ago and then divergence between the Mescalero Sands and the Monahans Sandhills phylogroups occurred at least 16,000 years ago.

C. Threats and Reasons for Decline

Shinnery oak has been subjected to degradation and eradication from livestock grazing, herbicide treatments, conversion to cropland and grassland, oil and gas development, and other large-scale disturbances, for example the recent development of sand mines (Dhillion and Mills 2009, Johnson *et al*. 2016). Because shinnery oak primarily reproduces from rhizomes, it spreads incredibly slowly (Peterson and Boyd 1998).

Significant reductions in DSL population abundance are associated with the removal of shinnery oak vegetation (Snell *et al*. 1997). Dunes sagebrush lizard populations are prone to decline at relatively low levels of habitat loss and fragmentation (Sias and Snell 1998, Hibbitts *et al*. 2013,

[1] The southern portion of mapped DSL habitat (southern Ward County and Crane County) is not assigned to a group because there was no genetic material. However, for purposes of discussing the range of suitable habitat, the Service grouped the southern section into a unit (see Environmental Baseline for further discussion).

Leavitt and Fitzgerald 2013, Ryberg *et al*. 2015, Johnson *et al*. 2016, Walkup *et al*. 2017). For example, Sias and Snell (1998) identified local reductions in DSL abundance around individual oil well pads up to 262 feet. The authors suggest that DSLs declined in abundance due to removal of habitat and loss of resources (e.g., shelter, food, and mates) resulting from well pad construction, but also in response to alteration of the physical environment and the introduction of human activity and other stressors around the well pad.

Increases in the use of heavy equipment and OHVs in the sand dune ecosystem, and grading and paving roads with caliche (soil with high amounts of calcium carbonate), results in sand dune compaction. Because DSL are psammophilic (sand-dwelling), they are not readily found in areas with compact soils (Ryberg and Fitzgerald 2014, Fitzgerald *et al.* 1997). Extensive OHV use may result in soil compaction, reduced plant cover, and tire ruts that exacerbate erosional processes in the dune complexes (Van Pelt *et al.* 2013). Furthermore, shinnery oak requires permeable sand in order to establish and grow and cannot grow through areas compacted with caliche or through permanently paved areas (Peterson and Boyd 1998).

Herbicide application by agricultural and ranching interests, particularly tebuthiuron, can kill shinnery oak. The effectiveness of tebuthiuron applications varies, but a 95 percent reduction in oak cover has been documented with as little as a 0.88 pounds/2.5 acres application rates (Jones and Pettit 1984). Over 100,000 acres of shinnery oak in New Mexico and 1,000,000 acres of shinnery oak in Texas have been lost due to the spraying of tebuthiuron and other herbicides (Peterson and Boyd 1998). Extirpation of DSL was repeatedly confirmed by Snell *et al.* (1997) from areas that were treated with herbicides to remove shinnery oak. Dunes sagebrush lizard numbers dropped 70 to 94 percent in areas that were chemically treated, compared to adjacent untreated plots, and some plots experienced 100 percent population loss in treated areas. One 5-year study on the effects of tebuthiuron application on DSLs documented that DSL were absent at 50 percent of previously occupied sites after spraying had occurred (Painter *et al.* 1999). Additionally, buffering an individual dune from shinnery oak spraying is not sufficient to keep the habitat intact because the majority of the shinnery oak plant is underground and acts to stabilize the dunes, thus its removal in the vicinity of the dune will cause the dune to collapse (Muhs and Holliday 2001).

While tebuthiuron demonstrates low toxicity to fish and wildlife, it persists in the environment in soils and vegetation. Its half-life ranges between 11 and 61 months (Emmerich 1985). In the arid southwestern United States, decomposition in the natural environment was estimated to occur between three and seven years. In Texas, tebuthiuron persisted in the Claypan Resource Area for more than two years (Bovey *et al.* 1982). Furthermore, chemical recycling via absorbing and decaying vegetation may prolong the presence of tebuthiuron in the environment. One study detected the herbicide in the environment via contaminated plant tissues over 11 years after initial application (Johnsen and Morton 1991).

Dunes sagebrush lizards in fragmented habitats may also experience increased competition with sympatric species that are not as affected by habitat loss or alteration (i.e., habitat generalist) (Sias and Snell 1998, Hibbitts *et al*. 2013). Interspecific competition may also lead to declines in DSL population abundance in fragmented areas (Hibbitts *et al*. 2013, Leavitt and Fitzgerald 2013, Young *et al*. 2018). Habitat patch size and population size can influence probability of extinction. That is, smaller populations tend to go extinct more frequently than large populations because of stochastic environmental events and chance fluctuations in demographics and

genetics (Hokit and Branch 2003, Henle *et al*. 2004). Walkup *et al*. (2017) demonstrated that habitat loss and fragmentation can decrease abundance and disrupt the demographics of DSL populations by impairing the survival and breeding behaviors of lizards in developed areas and increasing the likelihood of extirpation in such areas. For example, DSL consistently declined over five years of trapping in fragmented habitat until no DSL were captured. Also, Walkup *et al.* (2017) noted that at least one demographic life stage (adult males, adult females, or juveniles) was missing each month overall, noting that juveniles were not captured during expected periods of presence, indicating they emigrated or died. The results support the conclusion that DSL are highly susceptible to local extirpation following fragmentation and such fragmentation reduces the demographic structure such that self-sustaining populations are no longer present (Walkup *et al*. 2017).

Habitat destruction and fragmentation isolate DSL populations in smaller and lower quality habitat remnants and disrupt source-sink diffusion-dispersal dynamics that maintain populations (Young *et al*. 2018). Movements of individual DSL between populations are hindered or precluded by fragmentation and do not occur at rates sufficient to sustain population size (i.e., growth rates) and demographics necessary to prevent localized extirpations (Leavitt and Fitzgerald 2013, Ryberg *et al*. 2015, Walkup *et al*. 2017, Young *et al*. 2018). This in turn can lead to inbreeding depression and genetic drift, which can reduce population viability (Hokit and Branch 2003, Chan *et al*. 2009). Thus, overtime, fragmentation isolates DSL populations and results in a progressive decline in population abundance until ultimately the species becomes extirpated (Leavitt and Fitzgerald 2013).

One of the primary causes of fragmentation in DSL habitat is well pads, roads, and highways. Densities of well pads and their associated roads have been found to have a negative relationship with numbers of DSL (Sias and Snell 1998, Leavitt and Fitzgerald 2013, Ryberg *et al.* 2015, Johnson *et al*. 2016, Walkup *et al*. 2017). One study found a marked decrease in abundance at 8 well pads/square mile; nevertheless, the researchers suggested the development of up to 13 well pads/square mile because this was a generally accepted standard (Johnson *et al*. 2016). Considering a density of 13 well pads/square mile, studies have reported a 25 percent decline in DSL abundance and designated this level of disturbance as degraded habitat (Sias and Snell 1998, Johnson *et al*. 2016). The results of this level of fragmentation are an increase in susceptibility to local extirpation events because of smaller, fewer, and more dispersed blowouts (Leavitt and Fitzgerald 2013, Walkup *et al*. 2017). Hibbitts *et al*. (2017) found that 82 percent of DSLs completely avoided a 16-foot flat caliche road with habitat on both sides. The study road was blocked from traffic to eliminate road noise as a possible avoidance variable. Another Hibbitts *et al*. (2013) study found DSL prefer the steepest sandy slopes within their habitat, compared to the shallower slopes, which are associated with more vegetation structure. Therefore, abandoning caliche roads and well pads, which are placed within a caliche pad site, will be insufficient for long-term preservation of an area for DSLs. Additionally, under normal circumstances traffic noise will be a compounding factor that may increase the negative effect of roads and pad sites on DSLs (Hibbitts *et al.* 2017). Similarly, the larger caliche roads and paved highways are expected to have a stronger negative effect on movements of DSL.

Fragmentation also impacts the overall suitability of the shinnery-oak sand dunes. Hibbitts *et al.* (2013) found fragmented sites had shallower slopes, higher soil compaction, less leaf litter and grass, and more caliche than unfragmented sites. Oil pads and roads are a significant contributor to fragmentation. These changes in slopes and soil could also potentially change the wind

patterns across fragmented sites, which is necessary for the creation and maintenance of the sand dunes (Rich and Stokes 2011).

The removal of a portion (or portions) of a larger dune landform, such as from sand mining, can affect the soil moisture and thermal properties of adjoining and proximate intact segments of the dune. As rainwater infiltrates downward through sand dunes into underlying aquifers, the geomorphology and topography of the dunes also delivers water to proximate dune and sand sheet formations (i.e., via a process called lateral seepage) (Newton and Allen 2014). That is, sand dunes within a dune-field are connected hydrologically, contributing water to, and receiving water from adjoining dunes. The removal of a portion of a larger dune landform alters its geomorphology and topography and in turn has the potential to alter its drainage characteristics, affecting the delivery of water to adjoining and proximate segments of intact dunes (Mossa and James 2013, Pye and Haim 2009, Mace 2019).

Groundwater pumping can affect shinnery oak vegetation and shinnery oak-sand dune habitats used by all life stages of the DSL. For example, Ryberg *et al.* (2012) found that nesting females prefer sandy soils with high moisture content where they burrow through the sand to the soil moisture horizon to lay eggs. Lowering the underlying water table can affect the groundwater resources and water table depth, which can deplete soil moisture; reduce the cohesiveness of sand grains; leave dune plants susceptible to water stress, desiccation, and death; and cause wind erosion and deflation of the dune landforms (Laity 2003, Forstner *et al*. 2018, Machenberg, 1984, Stromberg *et al*. 1992, Stromberg *et al*. 1993, Campbell *et al*. 2017). Regionally, if the amount of water pumped from multiple water wells exceeds the amount of water that effectively recharges the aquifer, then water-level declines may be seen across the aquifer year after year, as water is removed from storage.

D. Range-wide Survival and Protection Needs

Viability is the ability of a species to maintain populations in the wild over time. To assess viability, we use the conservation biology principles of resiliency, redundancy, and representation (Shaffer and Stein 2000). To sustain populations over time, a species must have the capacity to withstand: 1) environmental and demographic stochasticity and disturbances (resiliency), 2) catastrophes (redundancy), and 3) novel changes in its biological and physical environment (representation). More specifically, resiliency is the ability of a species to withstand environmental stochasticity (normal, year-to-year variations in environmental conditions such as temperature and rainfall); periodic disturbances within the normal range of variation (fire, floods, storms); and demographic stochasticity (normal variation in demographic rates such as mortality and fecundity) (Redford *et al.* 2011). Simply stated, resiliency is the ability to sustain populations through the natural range of favorable and unfavorable conditions. Redundancy is the ability of a species to withstand catastrophes, which are stochastic events that are expected to lead to population collapse regardless of population heath and for which adaptation is unlikely (Mangal and Tier 1993). Finally, representation is the ability of a species to adapt to both near-term and long-term changes in its physical (climate conditions, habitat conditions, habitat structure, etc.) and biological (pathogens, competitors, predators, etc.) environments. This ability to adapt to new environments--referred to as adaptive capacity--is essential for viability, as species need to continually adapt to their continuously changing environments (Nicotra *et al*. 2015).

The resiliency of DSL populations (e.g., abundance, growth rate, survivorship, fecundity, etc.) is linked to various characteristics of its shinnery oak-sand dune habitat (TAMU 2016). The size of localized DSL populations (i.e, neighborhoods) is associated with the contiguity of habitat, with larger populations occurring in habitats with greater dune blowout contiguity (Ryberg *et al*. 2013 and 2015). Population growth is sensitive to proportional changes in fecundity and juvenile survival in irregular shaped blowouts with more edge, but more sensitive to proportional changes in adult survival in blowouts that are regularly shaped and with less edge (Ryberg *et al*. 2013 and 2015). Lizard populations, like all wildlife populations, will fluctuate over time and space with varying environmental conditions, such as periods of drought, which reduce the abundance of food resources (Fitzgerald *et al*. 2011). However, because populations of insects and the quality and quantity of habitat vary across the landscape, DSL populations do not fluctuate at the same rate and time across broad landscapes. Rather, there is variation in population size from one place to another for multiple reasons. Additionally, the extent to which immigration and emigration are necessary for long-term resiliency and persistence of DSL populations is not currently known (Fitzgerald *et al*. 2011).

Observational data are available across the range in New Mexico, providing us with limited distribution information. However, these data have not been analyzed such that they can inform our understanding of population numbers or the species ability to withstand catastrophes. Additionally, local population collapses are being observed in high quality habitat for unknown reasons (pers. comm. Jennifer Davis, Service, 2020). In Texas, there is a lack of access to private lands, so there is a significant lack of DSL observational data available. Based on these various factors, we are unable to estimate a population size or fully understand the distribution of DSL throughout the range. The result is an inability to assess the ability of DSL to withstand local population collapses due to catastrophes (redundancy).

Chan *et al.* (2020) conducted a genetic study of the phylogeography (the study of the historical processes that may be responsible for the contemporary geographic distributions of individuals) of the DSL across its range using tissue samples from individuals captured in the field and tissue from museum specimens. Their results indicate multiple genetic groups of DSLs having distinguishable geologic histories. The data analysis suggests limited migration between groups, divergence occurring 34,000 years ago (Chan *et al.* 2020), and that the southern Mescalero DSLs are more closely related to the Monahans Sandhills populations than to the northern Mescalero populations. This indicates a historical connection that is no longer present, and that the Mescalero Sands were colonized by the Monahans Sandhills populations. Chan *et al.* (2020) suggests that the divergences detected indicate that extensive habitat may be necessary to support adequate gene flow and that corridors should be identified to maintain connectivity.

Other studies also support that DSL exhibit a metapopulation dynamic structure, wherein a series of insular populations are patchily distributed throughout areas of contiguous habitat (Ryberg *et al.* 2013). Populations are maintained by dispersal and diffusion of individual DSL, with larger populations acting as net exporters of individuals (sources) and smaller populations as net importers (sinks) (Ryberg *et al.* 2013). Larger populations exhibit higher recruitment and population diffusion rates, acting as sources for smaller population sinks with negligible recruitment. Thus, population persistence depends on diffusion-dispersal throughout interconnected habitat patches (Young *et al*. 2018).

This diffusion-dispersal, source-sink dynamic of DSL populations results in a pattern of natural extirpation and re-colonization of habitat over time and produces a patchwork of occupied and unoccupied areas across a landscape of otherwise suitable habitat (Fitzgerald *et al*. 1997, Fitzgerald *et al*. 2005). That is, DSL may not occur in all areas of suitable habitat due to natural extirpation-colonization dynamics (Fitzgerald *et al*. 1997, Painter *et al*. 1999, Fitzgerald *et al*. 2005) and the current state of occupancy may not necessarily reflect the future state at a site (Walkup *et al*. 2018). Therefore, to maintain adequate representation, unoccupied, suitable habitat within the range of the DSL should be considered potential habitat, especially since dispersal rates and their mechanisms are not well-understood (Painter *et al*. 1999, Hardy *et al*. 2018).

Until we understand the resiliency, redundancy, and representation of DSL across their range, we need to take a conservative approach to conservation. Preservation of large tracts of shinnery-oak habitat with blowouts are necessary to "maintain historical levels of connectivity, prevent local extirpation, and avoid the loss of genetic diversity due to genetic drift in reduced populations" (Chan *et al*. 2009). Because patch isolation has implications on DSL dispersal mechanisms, protection of dispersal habitats is also important especially when considering increasing patch isolation (Dzialak *et al*. 2013, Hardy *et al*. 2018). Additionally, it is imperative that we not exclude certain habitat types (for example, large, seemingly barren, dune fields) because DSL are not often found there (Hardy *et al.* 2018), but rather be more inclusive until we fully understand how the DSL uses the various habitat types throughout its range.

IV. ENVIRONMENTAL BASELINE

Regulations implementing the ESA (50 CFR 402.02) define the environmental baseline as the condition of the species or its designated critical habitat in the Action Area, without the consequences to the species or designated critical habitat caused by the proposed action. The environmental baseline includes the past and present impacts of all federal, State, or private actions and other human activities in the Action Area, the anticipated impacts of all proposed federal projects in the Action Area that have already undergone formal or early section 7 consultation, and the impact of State or private actions which are contemporaneous with the consultation in process. The consequences to listed species or designated critical habitat from ongoing agency activities or existing agency facilities that are not within the agency's discretion to modify are part of the environmental baseline. While the DSL is not a listed species, we are analyzing it as if it is, so that we can adequately analyze the effects of the Covered Activities on the species.

In accordance with Service regulations at 50 CFR 402.14, this opinion is using habitat as a surrogate for quantifying the amount and extent of incidental take. This is necessary because DSL individuals are difficult to detect and there are very few sightings in Texas. Therefore, this opinion will describe what we know about documented DSL in Texas but will primarily focus on the status of the habitat in the Action Area.

A. Status of the Species within the Action Area

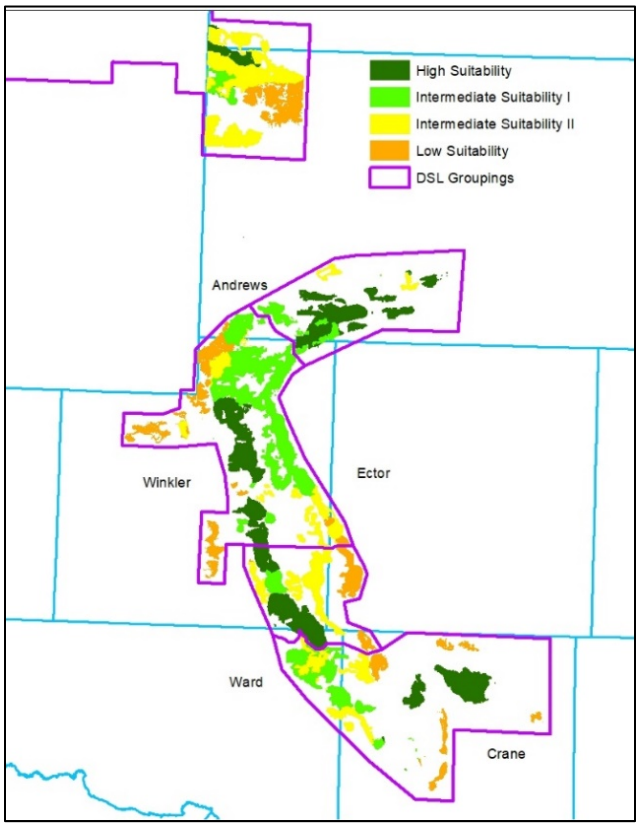
In Texas, there have been few DSL surveys because the vast majority of DSL habitat is on private lands. Two recent attempts to survey across a wide spectrum of DSL habitat in Texas both only found DSL in Andrews, Ward and Winkler counties (Lorencio *et al.* 2007, Fitzgerald *et al*. 2011). Because of a lack of data in Texas, there is no population estimate. Below is a brief

summary of surveys that have been done in each Texas county, listed geographically from north to south.

Gaines – The DSL habitat in this county is within the Mescalero sands that extend into northwestern Andrews County (Painter and Sias 1998, Lorencio *et al.* 2007).
Andrews – The DSL are thought to occur throughout the shinnery oak dunes in Andrews County with numerous positive detections (Lorencio *et al.* 2007, Fitzgerald *et al*. 2011).
Winkler – Has more low quality, patchy habitat with fewer detections, but it has not been thoroughly surveyed (Lorencio *et al.* 2007, Fitzgerald *et al.* 2011).
Ector – The DSL is not known from this county. The habitat is patchy with mixed grasses and mesquite and was classified as low and very low quality (Fitzgerald *et al.* 2011).
Ward – The DSL is known only from the northeastern corner of Ward County near Monahans Sandhills State Park, which is known to support DSL.
Crane – The DSL is only known from one historical record (1970) and recent attempts have not found them despite the presence of shinnery dune habitat (Lorencio *et al.* 2007, Fitzgerald *et al.* 2011).

In Texas, Chan *et al*. (2020) found four phylogeographic groups, one in the Mescalero Sands and three in Monahans Sands. Because of the lack of DSL specimens, habitat in southern Ward County and all of Crane County did not get assigned to a group; however, to represent the range of the habitat in Texas, the Service grouped southern Ward County and Crane County together (Figure 3). Divergences detected amongst phylogroups indicate that extensive habitat may be necessary to support gene flow among and between the phylogroups, including dispersal corridors (Chan *et al*. 2020).

Figure 3: DSL habitat groupings.



Additionally, continued fragmentation increases the likelihood diversity within populations will decrease and evolutionary lineages may be lost (Chan *et al*. 2020). These phylogroups can be useful when considering conservation efforts. For example, if impacts occur in one phylogroup, we can direct conservation within the same phylogroup. Unfortunately, with so few DSL observations available, we are currently unable to determine the status of DSL within each of these groups. Additionally, because there has not been an analysis of habitat patch size and distribution in Texas, we are unable to determine the viability of DSL habitat within each of these units.

The TPWD describes the status of the DSL in the Action Area as critically imperiled and at high risk of extirpation due to its extreme rarity, very restricted range, very few populations, and steep decline. These factors

have led TPWD to designate the DSL as a Species of Greatest Conservation Need (SGCN) in Texas. According to TPWD's website, "native animals or plants designated as a SGCN are generally those that are declining or rare and in need of attention to recover or to prevent the need to list under state or federal regulation." This designation, however, does not afford the species any legal protection, but does guide TPWD's nongame conservation efforts, including regional efforts to conserve these species. In August 21, 2019, TPWD biologists recommended listing DSL as a threatened species, which is any species that TPWD has determined is likely to become endangered in the future, but did not finalize that designation.

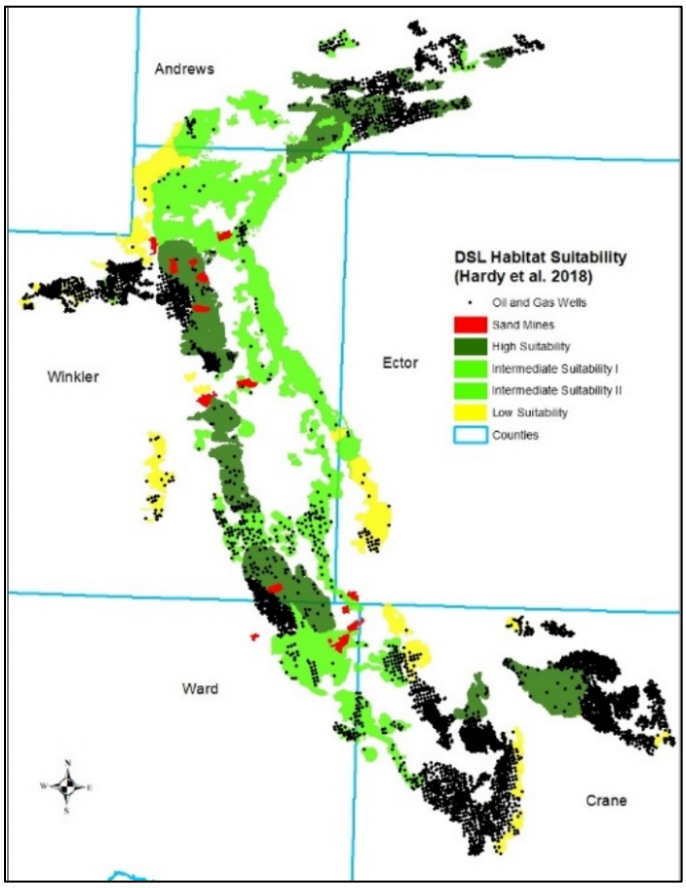
B. Status of the Habitat in the Action Area

The following analysis considers Hardy *et al*. (2018), as well as additional analyses conducted by the Service, in consultation with Hardy and other experts. This analysis may differ from the EA, Findings, and other documents supporting the CCAA in order to demonstrate the likely range of impacts supported by the best available science. Of note, even at these lower remaining habitat levels, our jeopardy conclusion remains consistent throughout scenarios.

Hardy *et al*. (2018) estimated there are approximately 287,327 acres of DSL habitat remaining in Texas. These acres represent varying landscape features that are classified into suitability categories (described in more detail above under Action Area). These categories show landscape feature characteristics are either High, Intermediate I, Intermediate II, or Low Suitability habitat and are 31 percent (90,308 acres), 23 percent (64,790 acres), 22 percent (63,081) and 24 percent (69,148 acres), respectively (Hardy *et al.* 2018). High and Intermediate I Suitability encompass the dune structure and together are the highest quality areas of DSL habitat. This is where DSL breeding, feeding, and sheltering occurs. Intermediate II and Low Suitability are important for dispersal and need to be adjacent or near High and Intermediate I to be used for dispersal. Estimates for adjacency are wide ranging from 656 feet to over 1.2 miles typically associated with egg laying (where the female subsequently returns to her territory) and dispersal and have documented DSL traversing all habitat types including the occasional caliche road (Fitzgerald *et al*. 2005, Johnson *et al*. 2016).

Oil and gas production have been historically the primary industry in West Texas. The Permian Basin, a geologic formation, is made up of three sedimentary basins: the Delaware Basin, which stretches from New Mexico into far west Texas and Mexico; the Central Basin Platform, which stretches from eastern New Mexico south, encompassing all DSL habitat; and the Midland Basin, which makes up the eastern portion of the Permian Basin stretching from the Panhandle to south Texas (Ruppel 2009). The first well was drilled in the Permian Basin in July of 1920. Since then, over 30 billion barrels of crude and 75 trillion cubic feet of natural gas have been extracted, and there are at least 50 billion barrels and 300 trillion cubic feet of natural gas remaining (Enverus 2020). The Central Basin Platform is an area of low-cost wells and consistent returns (Enverus 2020); therefore, we expect that continuation and expansion of this industry is inevitable based on the available supply and the relatively low cost of extraction.

Figure 4: Oil and gas wells and sand mines in Texas.



As of 2017, there were 17 sand mining companies with leases encompassing over 20,000 acres in the Permian Basin, 7,400 acres of which were in high quality DSL habitat (CPA 2018). By the end of 2017, sand mining operations had impacted approximately 1,070 acres of DSL habitat (CPA 2018). As of 2020, there has been a loss of over 3,240 acres of suitable DSL habitat disturbed by sand mines.

Habitat is affected by other energy industries to varying degrees. Wind and solar energy are produced in West Texas and the growth in development of these renewable energy sources is likely to continue expanding. In 2005, the Texas state legislature enacted a law requiring an increase in the use of renewable energy, including 2,300 miles of new electrical transmission lines in just five years (75 SB 20). This law also mandated 5,880 megawatts be generated from renewable sources by 2015 and 10,000 megawatts by 2025. According to the Electric Reliability Council of Texas (ERCOT), these goals were well surpassed by 2017 with 2,400 miles of transmission lines being built carrying over 19,000 megawatts of wind production (equal to coal), and surpassing hydropower in 2016 for the first time in the state's history. West Texas and the Texas Panhandle are some of the windiest areas of the state, and currently Texas is leading the nation in wind energy generation and is ranked fourth in the world (Brody 2018). Additionally, according to ERCOT, solar was expected to produce over 5,000 megawatts in 2020, a 150 percent increase over previous production, and is expected to be producing over 13,000 megawatts, another 130 percent increase, in 2021 (Nusser 2020, Brody 2018).

While grazing and ranching are known to occur in the Action Area, it is not clear how much occurs in DSL habitat. Dhillion and Mills (2009) state that dune habitat is poor for ranching and is inadequate for long-term grazing. Smythe and Haukos (2010) believe tebuthiuron use has been reduced since 2000, particularly in sand dunes. It was used to limit the extent of sand shinnery oak expansion through root sprouts, which can outcompete grass, with the goal of allowing for a return to a balance of grasses and shinnery oak. There is evidence of treatment in Texas from aerial photos (approximately 12,000 acres), the majority of which is in Andrews County (pers. comm. Mark Horner, Service, 2020). However, many of these areas appear the same over a 15-year time period, indicating a lack of retreatment, but also showing very limited regrowth, indicating long-lasting damage.

While Hardy *et al*. (2018) excluded the majority of destroyed habitat in their model, they did not remove from habitat suitability classifications all indications of anthropogenic effects, such as

well pads, associated roads, and sand mines; therefore, the Service is currently updating the model, in coordination with the authors, to reflect these effects in the model output. The first step was removing destroyed habitat (sand mines, well pads, and their associated roads) from any habitat classification, which resulted in 203,240 modeled habitat acres, a 30 percent decline from Hardy *et al*. (2018). With the remaining habitat, the next step was distinguishing between disturbed habitat and undisturbed habitat (Table 1). Disturbed habitat is intact habitat that exists between non-habitat that may still support DSL. For example, DSL habitat between well pads and roads. The total number of acres of disturbed habitat and undisturbed habitat in each of the four categories resulted in the following initial estimates:

Table 1. Amount of Hardy *et al*. (2018) disturbed versus undisturbed habitat.

Habitat Classification	Acres Undisturbed	Habitat Classification	Acres Disturbed
High Suitability	63,441 acres	High Disturbed	24,439 acres
Intermediate I Suitability	66,608 acres	Intermediate I Disturbed	5,133 acres
Intermediate II Suitability	27,297 acres	Intermediate II Disturbed	3,114 acres
Low Suitability	5,311 acres	Low Disturbed	7,896 acres
Total Undisturbed	**162,657 acres**	**Total Disturbed**	**40,582 acres**

As discussed above under Status of the Species, DSL populations are prone to decline at relatively low levels of habitat loss and fragmentation (Sias and Snell 1998, Hibbitts *et al*. 2013, Leavitt and Fitzgerald 2013, Ryberg *et al*. 2015, Johnson *et al*. 2016, Walkup *et al*. 2017). Literature indicates that disturbed habitat classes likely do not support sustainable DSL populations, so we will discuss only undisturbed habitat classes moving forward. The sum of undisturbed High and Intermediate I Suitability habitat is 130,049 acres where DSL breed, feed, and shelter distributed across the range in Texas. While the undisturbed Intermediate II Suitability and Low Suitability acreages are over 32,608 acres combined, without the source populations provided by the High and Intermediate I habitats, these adjacent dispersal areas are unlikely to support DSL in the long-term. Quantifying the highest quality habitat in each of the phylogeographic group boundaries (Chan *et al*. 2020), which are distinct genetic groups, including the southernmost Monahans Sands counties that did not contribute genetic material, results in the following representation of DSL dune habitat within Texas:

Table 2. Amount of habitat in DSL habitat groupings

Group Location	High Suitability	Intermediate I Suitability	Total	% of Total
Mescalaro Sands	4,079.80	2,926.40	7,006.20	5.39
Northern Monahans Sand	16,616.34	11,685.70	28,302.04	21.76
North/Central Monahans Sand	12,423.17	30,983.99	43,407.16	33.38
South/Central Monahans Sand	19,383.9	11,176.7	30,560.69	23.5
Southern Monahans Sand	10,938.0	9,834.9	20,772.96	15.97
Total	**63,441.28**	**66,607.77**	**130,049.05**	**100**

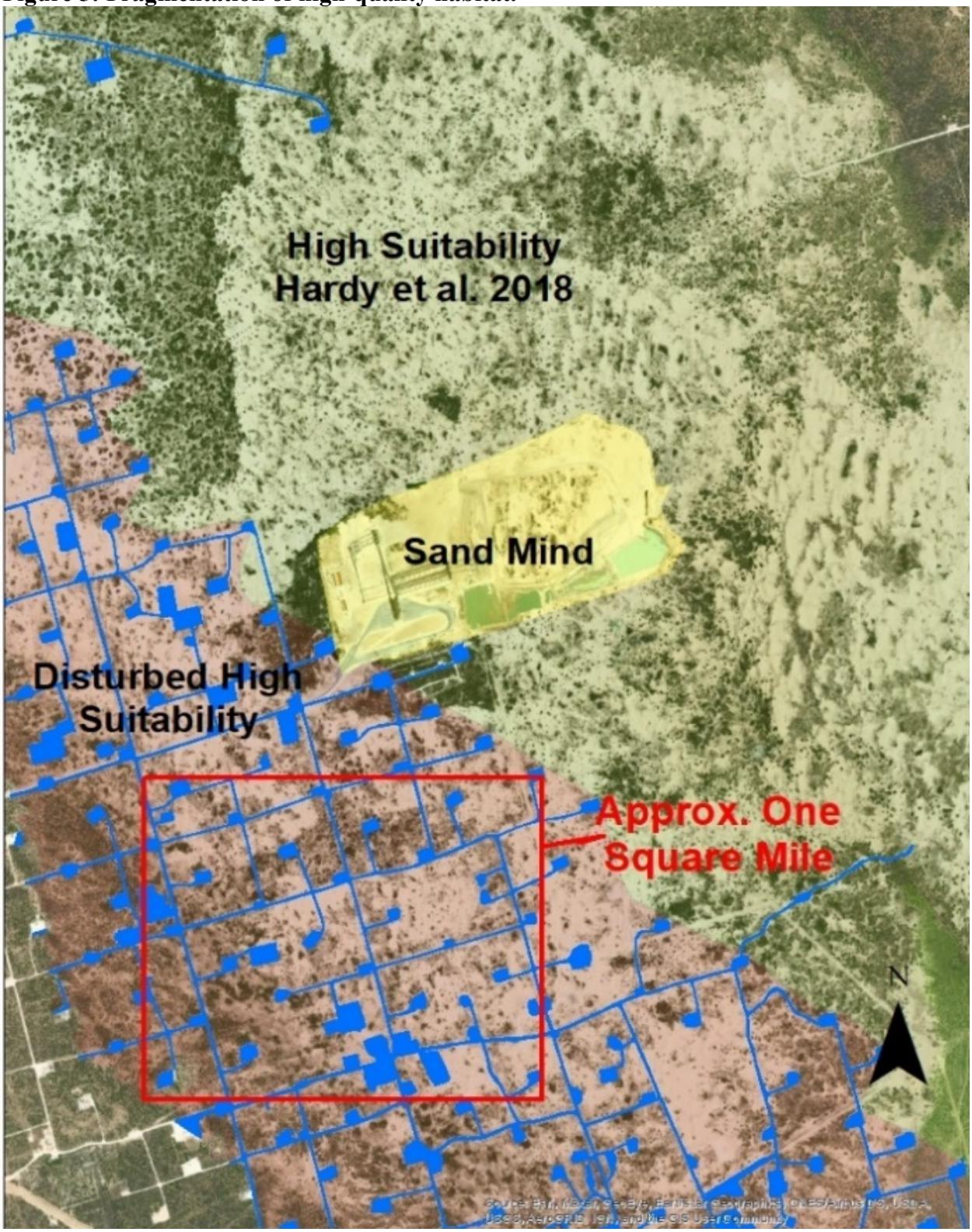
We expect that numerous isolated patches of DSL habitat across the range may no longer serve as feeding, breeding, sheltering, or dispersal habitat, due to increased destruction, modification, and fragmentation. For example, there has never been a DSL recorded from Ector County and the only record of a DSL in Crane County is from the 1970's, despite what appears to be a fair amount of shinnery oak-duneland in both counties (Chan *et al.* 2020, Hardy *et al*. 2018).

Altogether the southern Monahans Sand group (most of Ward and Crane counties) may not support any DSL; thereby reducing likely occupied DSL habitat by another 16 percent.

Until fragmentation metrics can be applied to the mapped habitat (for example with the computer software program FRAGSTATS), we will not understand the potential viability of the remaining patches of DSL habitat. Once this step is completed, and if these counties, isolated remnants, and classified disturbed habitats throughout the range do not support DSL or their dispersal, this will result in even less available suitable habitat for the DSL.

The Texas Railroad Commission (TRC) regulations (16 Texas Administrative Code, Part 1 §3.37) require a statewide standard of 1 well per 40 acres, equivalent to 16 wells per square mile, which is what the CCAA uses as a basis for determining their take request for the oil and gas industry. However, a variance can be requested of the TRC to allow for additional wells per square mile. As shown in Figure 5, and across all High and Intermediate I disturbed habitat, TRC frequently grants this variance.

Figure 5: Fragmentation of high-quality habitat.



C. Status of the Groundwater Aquifers in the Action Area

The Pecos Valley and Dockum Aquifers underlie the majority of the Action Area. The Pecos Valley Aquifer is unconfined, meaning it is bound by a confining layer at its bottom but not at its top and consists of alluvial and windblown sediments from the Pecos River Valley (Garza and Wesselman 1959, Mace 2019). The Dockum Aquifer underlies the Pecos Valley Aquifer and is

a confined system, meaning it is bound by a confining layer at its bottom and at its top (Mace 2019). Additionally, it is believed that there are perched aquifers where localized groundwater seeps above ground (Machenberg 1984, Mace 2019).

Total water use in the Permian Basin ranges from 1,400 to 5,500 acre-feet per year for conventional oil and gas drilling practices and 8,000 acre-feet of water per year for unconventional drilling practices (e.g., fracking) (Mace 2019). Sand mining facilities use water for mining, transport, sand processing, dust control, and on-site potable needs. Recycling is commonly practiced with water used to wash mined sand, resulting in a generally high efficiency process (Mace 2019, Rainwater 2020). One review of two sand mining companies found they used 10.8 to 24.5 gallons of water per ton of sand and mines used both the Pecos and Dockum aquifers to meet their water needs (Rainwater 2020). This review also determined that because of the amount of water recycling compared to a range of recharge rates occurring within the mining lease boundaries, these mines were currently well under withdrawal rates to impact aquifer levels (Rainwater 2020). Estimates for sand mine extractions average 3.6 million tons of sand per year per mine (Mace 2019), which the Service estimates would consume 43.9 to 88.2 million gallons of water per year per mine. Multiply by the 17 mines and that is 746 million to 1.5 billion gallons of water per year. The number of wells at individual facilities ranges from 4 to 30, suggesting the aquifers in this area are not highly productive, which is supported by the thin saturated thickness of the Pecos Valley Aquifer and the low hydraulic conductivity of the Dockum Aquifer (Mace 2019).

D. Climate Change

Climate change impacts on DSL populations have not been studied, and therefore, are not well understood. However, because lizards are ectothermic, ambient temperatures affect their physiological performance and influence their daily activities (Sartorius *et al*. 2002). Daily DSL activity, for instance, declines as air and substrate temperatures increase due to thermoregulatory constraints (Sartorius *et al*. 2002, Fitzgerald *et al*. 2011). On average, surface air temperatures across Texas are predicted to increase by 3°C (5.4°F) by 2099 (Jiang and Yang 2012). In the southwest United States, temperature increases will be concentrated in the summer months, which coincides with the DSL breeding period. In Texas, the number of days exceeding 95°F may double by 2050 (Intergovernmental Panel on Climate Change 2013, Kinniburgh *et al*. 2015). According to climate change predictions, West Texas will experience greater variability in seasonal precipitation patterns with the greatest net loss experienced in winter (Jiang and Yang 2012).

Climate (e.g., moisture) also exerts control over the mobility of dunes in the Southern High Plains, through its effects on the susceptibility of sand grains to wind transport (Muhs and Holliday 2001). The Monahans Sandhills represent the warmest, driest part of the Southern High Plains region and are near the climatic limits of dune stability. Only a small shift in moisture balance, wind strength, or intensity of land use might be enough to activate dune fields in this region (Muhs and Holliday 2001). Thus, it is possible that alteration of climatic conditions, such as temperature and precipitation in the Permian Basin may have corresponding impacts on the DSL and its habitat. An increase in drought frequency and intensity has been shown to be occurring throughout the range of the DSL habitat (Kinniburgh *et al*. 2015). While shinnery oak is highly adapted for arid conditions, prolonged periods of drought may inhibit growth and reproduction.

Shinnery oak clones may reach 50 feet in diameter, making large areas of dune habitat vulnerable in the event of climate-induced oak mortality (Gucker 2006). Historically, natural groundwater discharge from the Cenozoic Alluvium aquifer characterized the Monahans dune system as "wet eolian," where a shallow water table stabilized sand beneath the dune deposits (Garza and Wesselman 1959, Newton and Allen 2014, Kocurek and Havholm 1993). Any disruption to this system that lowers the water table may destabilize the dunes such that the system experiences a net loss in sand (Newton and Allen 2014). Lowering of the water table and its capillary fringe due to drought (Machenberg 1984) can destabilize the dune structures and sand sheets characteristic of areas of DSL habitat, and thus, degrade these essential features. Drought and climate change can exacerbate this potential impact and may affect regional groundwater availability. While industrial sector pumping (particularly sand mining) may increase as a direct result of climate change, limited recharge due to altered hydrologic conditions may increase competition for groundwater resources.

In summary, sand mining facilities join other industries with long histories of groundwater extraction in the Permian Basin, including hydraulic fracturing, growing populations, declining surface-water reservoirs, a lack of water-supply alternatives, climate change, and new demands for water. All of these water uses are stressing the Pecos Valley and Dockum aquifers, which are experiencing an increase in drilling and pumping due to expansion of oil and gas and associated industries.

E. Texas Conservation Plan (TCP)

In 2010, the proposed listing of the DSL prompted the Texas CPA to facilitate development of a conservation plan for the DSL among the oil and gas industry and farming and ranching landowners in the Permian Basin. The CPA, together with a group of potentially impacted stakeholders, developed the Texas Conservation Plan (TCP) for the DSL, a CCAA with an associated Enhancement of Survival permit, issued to the CPA by the Service in February 2012. By 2017, it was clear to the CPA that they were not achieving the anticipated DSL conservation levels, so they requested to revise the TCP. Despite efforts to update the TCP to rectify various issues and include sand mines, the CPA offered to relinquish the permit back to the Service, halting any additional participation in the plan. The Service transferred the permit to a new Administrator in 2020, covering existing Participants but restricting any new companies from enrolling. The maximum amount of take that the existing Participants are covered for is 1,749.54 acres over the life of the 22-year permit (the time remaining from the original 2012 permit). This available amount of take does not include the acres already authorized under the previous permit.

Participants in the TCP agree to avoidance and minimization measures, including building new or relocating existing fencing to avoid DSL habitat, using currently disturbed locations for future drilling projects, managing livestock in accordance with NRCS Prescribed Grazing Standards, constructing new well sites outside of DSL habitat, restricting unnecessary off-road vehicle access, and avoiding new disturbances. The TCP uses the 2011 map developed by TAMU (2016) to classify habitat into categories (as opposed to the updated Hardy *et al*. [2018] map). These categories of habitat and the associated TCP take are divided into: Very High = 531.12 acres, High = 350 acres, Low = 304.89 acres, and Very Low = 563.53 acres. Additionally, the TCP estimated participating lands would encompass 70 percent of all DSL habitat (approximately 197,604 acres).

Because sand mining is not expressly included as a Covered Activity, the TCP could not cover mining activities in DSL habitat. They could, however, cover those activities outside of DSL habitat. During TCP implementation, the CPA worked closely with eight separate sand mining companies to avoid excavations in DSL habitat; follow avoidance, minimization, and enhancement measures; and provide conservation protections. According to a CPA (2018) annual report, 4 conservation areas were established by sand mining interests placing 5,844.6 acres of DSL habitat, 1,551.8 acres of 200-meter buffer, and 23 acres of unclassified habitat under conservation protection.

Due to the layering (stratification) of geologic minerals in the Permian Basin, there can be up to 10 stacked reservoirs, or strata, of oil and gas minerals beneath the surface (Mace 2019). Typically, the surface estate is severed from the subsurface estate allowing different ownership or control of the underlying minerals. It is common for a surface landowner to lease the right to access minerals at different depths, lease grazing rights on the surface, and sell easements across their properties to pipeline and utility companies (CPA 2018). The result is all entities having independent access rights via the same surface acreage.

Stratification is an issue for the TCP in reaching a net conservation benefit for DSL. For example, between 2012 and 2017, 291 wells were developed on enrolled properties; however, only 236 were Participant wells, leaving 55 wells (19 percent) developed without restrictions or conservation. Based on reporting from the TCP, after six years (2012-2018) of implementation, approximately 4,564 acres of DSL habitat were disturbed in the TCP Plan Area. Of those acres, only 423 acres (9 percent) were disturbed by TCP Participants, while non-Participants disturbed 4,141 acres of DSL habitat. Non-Participant disturbance was from sand mining operations (1,692 acres) and oil and gas activity (2,449 acres). Additionally, TCP Participants offset only 26 of the impacted 423 acres of DSL habitat with on-the-ground mitigation (a 16:1 ratio of acres disturbed to acres of conservation).

Because the issue of stratification was not addressed in the TCP, enrollment of multiple entities drilling different strata via the same surface acreage lead to double counting of DSL habitat acres enrolled in the plan. Enrollment of a property in the TCP by a Participant did not necessarily preclude disturbance of DSL habitat by a non-Participant who was not bound by the conservation measures of the plan. According to the last annual report received (CPA 2018), 24 Participants enrolled 115,167.31 acres in the TCP, including the 8 sand mining companies. This number accounts for stratification by excluding areas that are redundant by overlapping Participants and represents 58 percent of TCP defined habitat, well short of the 70 percent goal. On-the-ground conservation was primarily funded through sand mine Participants with additional funds restoring 39 acres of abandoned well pads and roads. Unfortunately, likely due to confidentiality constraints, the Service is unaware of where the restoration work was done; how, or if, the land is still conserved; where the conservation lands are located; or if they are being managed for the species. Stratification, among other implementation issues, was more problematic than initially anticipated with the original Permit. The 2020 Permit attempted to address some of these issues, but stratification will likely remain the primary obstacle to conservation.

F. Summary of Environmental Baseline

As noted above, this summary considers Hardy *et al*. (2018), as well as additional analyses conducted by the Service, in consultation with Hardy and other experts, in order to show the likely range of available habitat. When starting with all suitable habitat (287,327 acres) from

Hardy *et al*. (2018) and then removing sand mines, well pads, and roads, there remains 203,239 acres of DSL habitat. This acreage includes those areas between well pads and roads where DSL habitat exists but where DSL occupancy is reduced or extirpated (previously defined as disturbed). Comparing this acreage to historical estimates of habitat in Texas (494,927 to 984,921 acres) results in a 42 to 71 percent decline in DSL habitat (Dzialak *et al*. 2013, Hardy *et al*. 2018 refined by the Service). When you remove disturbed habitat (40,582 acres, Table 1) from the equation, because of its potential lack of viability in the long-term, this results in 162,657 acres of undisturbed DSL habitat remaining (a 66 to 83 percent decline from historical estimates). This acreage represents all four Hardy *et al.* (2018) classes – High, Intermediate I, Intermediate II, and Low Suitability. As discussed above, without High and Intermediate I Suitability habitat (130,049 acres) where DSL breed, feed, and shelter, there is no source population to maintain DSL in Intermediate II and Low Suitability habitat. Therefore, the remaining High and Intermediate I Suitability habitat are of utmost importance for conservation of DSL. While subtracting the acreage authorized under the TCP does not substantially change the percentage of decline, it is still additional habitat removal and fragmentation that is occurring in the Action Area. If the southern Monahans Sands habitat in Ward and Crane counties are found not to support DSL, that is another 16 percent reduction in DSL habitat. What is not available to us are the habitat patch metrics, for example, what is a patch, how many patches of habitat remain, what size are the patches, are the patches occupied, what is a minimum viable patch size, etc. While potentially 130,049 acres of the highest quality, undisturbed habitat remains on the landscape, it is highly likely not all of this is occupied or, if occupied, is not viable in the long-term. Until more data are gathered on DSL habitat and population status, we will not be able to make a viability determination.

V. EFFECTS OF THE ACTION

In accordance with 50 CFR § 402.02 effects of the action are all consequences to listed species or critical habitat that are caused by the proposed action (permit issuance), including the consequences of all other activities that are caused by the proposed action. A consequence is caused by the proposed action if it would not occur but for the proposed action and it is reasonably certain to occur. Effects of the action may occur later in time and may include consequences occurring outside the immediate area involved in the action (see 50 CFR § 402.17).

As noted above in the Environmental Baseline, we are using habitat as a surrogate for quantifying the amount of incidental take; thus, take will be described and measured by the amount of DSL habitat that is disturbed and destroyed by the Covered Activities from both Participants and non-Participants. The Applicant formulated the projected maximum impacts (34,940 acres) based on a variety of factors. See Section 18 of the CCAA. The Applicant then allocated each industry with a maximum amount of incidental take; and, for those that participate, each has different requirements for avoiding, minimizing, and mitigating the effects of their actions. These are discussed further in this section.

It is important to note that the Applicant only has three habitat categories (High, Intermediate, and Low) because they combined Hardy *et al.* (2018) Intermediate I and II Suitability into a single Intermediate category. Intermediate I Suitability is dune habitat that provides the DSL with areas for breeding, feeding, and sheltering (with slightly lower abundance due to the presence of mesquite). Intermediate II Suitability is used as dispersal habitat, which is important

for metapopulation dynamics, conservation, and the continued existence of the species. If grouping was necessary, Intermediate I Suitability should have been grouped with High Suitability. The merging of the two Intermediate habitat categories in the CCAA effectively underestimates the high biological value of Intermediate I Suitability to the survival of the DSL. The Applicant's plan assesses the highest mitigation fees on the High Suitability habitat and lower fees for "Intermediate Suitability Habitat," some of which will be high quality Intermediate I Suitability. As a result of lower fees assessed on Intermediate I Suitability, less conservation will occur when high-quality habitat will be impacted. For example, if an oil and gas operation expands into Intermediate I Suitability habitat, they will pay half the fees ($28,000 per well pad) compared to if it was categorized more appropriately as higher quality dune habitat ($56,000 per well pad).

A. Effects of the Conservation Measures

The CCAA is a plan that intends to provide conservation to DSL through assessing fees based on industry type and level of impact. The plan Administrator will use the revenue generated by participation to fund studies and provide conservation, where feasible and affordable. The CCAA does not include an estimate of expected income or explain how it established the pricing structure for Participants or impact types. An estimate of expected costs of conservation, as well as funding for conservation is tabulated within the Finding document. The Applicant did provide the Service separately with a draft annual budget based on scenarios of differing levels of participation, for the first six years of implementation, but it is not clear what all of the dollar amounts represent. For example, under Conservation Contracts, it is not clear what Easements ($75/acre), Contracts ($50/acre), Cost Share ($35/acre), or Company Directed ($35/acre) and the associated funds represent or what each of these is paying for, yet in total these costs are $1.2 and $3 million every year under a low and moderate enrollment scenario, respectively. The underlying calculation is acres of industry impacts multiplied by cost per acre (above) multiplied by 30. Without understanding what the cost per acre represents or what the multipliers are based on, among other items in the spreadsheet, it is difficult for us to analyze the functionality of the proposed funding program or how much conservation is reasonably expected to occur.

Chapter 8.1 of the CCAA describes the goals and objectives of the CCAA conservation strategy. As defined in the HCP Handbook (Service and National Marine Fisheries Service [NMFS] 2016), goals are broad, guiding principles that describe the desired condition. Objectives should follow the SMART framework – specific, measurable, achievable, result-oriented, and time fixed. The CCAA does not follow the SMART framework; therefore, it is difficult to understand how each goal will be achieved and what measures will be used to monitor the effectiveness of each goal. The CCAA does have one overarching goal: contribute, directly or indirectly, to the conservation of the DSL by reducing or eliminating threats on enrolled properties. This overarching goal is then followed by a list of objectives that emphasize conserving DSL habitat, restoring and reclaiming impacted areas, reducing habitat fragmentation, and others. Below we connect the objectives with the conservation measures (Chapter 8.4) and proposed effectiveness monitoring (Chapter 8.2)), as best we can, to understand the CCAAs overall goals and objectives for the purpose of determining what achievable DSL conservation is certain or likely to occur, so we can include any beneficial effects in this opinion.

1. Avoid, Minimize, and Conserve DSL and its Habitat.

The CCAA has objectives to avoid, minimize, and conserve DSL habitat. Avoidance and minimization are expected to occur by encouraging well pad construction in areas where well density is 4 to 13 well pads per square mile; charging higher fees for disturbance of higher

quality habitat; implementing on-the-ground actions to eliminate or reduce threats of habitat loss and fragmentation; and implementing various industry specific minimization measures, subject to exemptions detailed under each industry below. Initial conservation efforts will be to: identify efficient patterns of infrastructure use, encourage voluntary reductions in vehicle traffic, and develop a conservation strategy in year one that emphasizes reducing or eliminating threats and establishing priorities for conservation easements and other protections (not defined). The conservation strategy will be developed in consultation with the Adaptive Management Committee (AMC) and the Service. The CCAA states the priorities will likely include implementing on-the-ground actions to eliminate or reduce threats; where "warranted and feasible," acquire conservation easements and other protections, both permanent and limited in duration, in high priority areas; require Participants to pay fees; and where an easement of 25 or more years is appropriate, the easement must continue past the expiration of the permit or be replaced for reissuance of the CCAA to maintain a net conservation benefit.

One objective of the CCAA is to develop a conservation strategy by the end of the first year of implementation. As this strategy is not yet developed, it is not possible for us to analyze the expected effectiveness of the proposed conservation strategy or the potential benefits that might result from it. We know only that it will be developed in a manner that preserves the Covered Activities and conservation measures as included in the plan. Additionally, because most, if not all, of the industries that will participate in the CCAA are leasees of surface estates (sand mines, renewables, and linear infrastructure) or have restricted surface access to mineral estates (oil and gas), we do not expect conservation easements to be permanent. We question whether the draft funding projections provided by the Applicant are sufficient, since the CCAA is allocating $75 per acre per year for the cost of easements. According to NRCS, easements are valued at 50 to 75 percent of the full value per acre (www.nrcs.usda.gov). Cost per acre of land, according to TAMU rural land data (available at: https://www.recenter.tamu.edu/data/rural-land), is $700/acre in Crane, Ward and Winkler counties, and $926/acre in Andrews, Ector, and Gaines counties.

To determine the effectiveness of the objectives, the Administrator will: report annually on implementation; compare acres of High and Intermediate Suitability DSL habitat protected through conservation easements and other measures with the acres of disturbances; conduct annual vegetation surveys, and using Participant's surveys, evaluate changes over time where minimization measures have and have not been used and where the conservation strategy has been implemented; evaluate overall acreage of surface disturbances on enrolled and unenrolled properties in DSL habitat by industry sector; and coordinate with the Center of Excellence and the Service to develop a protocol for and conduct range-wide DSL surveys every five years to evaluate the efficacy of conservation actions and measures.

In total effectiveness monitoring is the reporting, comparing, coordinating, evaluating, and studying of data on the effectiveness of the CCAA or its measures (Chapter 8.2). The CCAA process for effectiveness monitoring does not indicate whether the Administrator must take any action as a result of effectiveness monitoring data if that data indicates deficiencies, it only states they will receive the recommendations of the AMC. We are concerned with the functionality of the CCAA with little to no explanation of next steps regarding several of the effectiveness monitoring items. For example, it is not clear what remedies the Administrator will take if more DSL habitat is being destroyed on enrolled versus unenrolled properties, if densities of well pads and roads on enrolled properties increase compared to the same area prior to the CCAA, if more High and Intermediate Suitability DSL habitat is disturbed by Participants than is reclaimed or

conserved, or if removing oil pads and caliche roads is not cost effective. The CCAA states the AMC will make recommendations on these items, but the Administrator is not obligated to take action on these recommendations.

The governance of the CCAA consists of two committees and one Administrator. One of these committees, the AMC (Chapter 2.2), is described as the scientific advisor to the Administrator. The AMC's responsibilities include reviewing new science, vegetation and species surveys, the effectiveness of the conservation program, and making recommendations, including on high priority conservation areas. The AMC is composed of one TPWD and one Service representative, one representative each from two academic institutions, and three representatives from the Participant Committee (Chapter 2.3). Therefore, three of seven committee members will not be scientists (unless a Participant happens to be a scientist in a relevant field). The role of the Participant's representatives, approximately 40 percent of the committee, is undefined. The second committee, the Participant Committee, also is tasked with reviewing new science, the effectiveness of the conservation measures, and recommending high priority areas for conservation, and is not required to include scientists among its members.

The CCAA relies on fees to incentivize the conservation. Participants are expected to be motivated to minimize their own participation costs by avoiding the highest quality DSL habitat. The financial incentive is weak because the CCAA allows for ways to reduce the costs of participation. Unfortunately, the lack of a conservation strategy, exceptions allowed for each industry, potential conflicts of interests on committees, and the likelihood that any conservation easements will be temporary and subject to stratification impacts, are unlikely to result in long-term conservation of DSL habitat. We do expect, however, that some avoidance, minimization, and conservation may occur as a consequence of the proposed action, but it is difficult to project these metrics with the information provided in the CCAA.

2. Reclaim or Restore DSL Habitat.

The CCAA has objectives that focus on identifying well pads and roads in high priority conservation areas, obtaining access and permission, and initiating removal and restoration. Remediation would begin with removal of caliche or pavement, because shinnery oak requires loose, permeable sand to establish and grow (Peterson and Boyd 1998, Boyd and Bidwell 2002). Removal of caliche well pads and roads where the sand substrate is recovered may restore connectivity among habitat patches that were previously fragmented by that infrastructure (Johnson *et al.* 2016). Recolonization of shinnery oak, however, is slow because the species is slow-growing and recolonizes disturbed and open spaces at an extremely slow rate. Growth rates, as measured by tree ring size, averages one millimeter per year, and one study observed during drought years no significant regeneration over a two-year period (Gucker 2006, Cox and Davis 2013). One two-year study had some success growing rhizomes in the lab, but very little success establishing rhizomes in the wild (Cox and Davis 2013). A lack of shinnery oak establishment and regeneration could allow for significant erosion, loss of topography, and possible invasion by other species that prefer that condition (Cox and Davis 2013). Ryberg *et al.* (2015) found that restoration of shinnery oak-dunelands is unlikely, and it is "far from certain that artificial dune blowouts could support populations of [DSL]." These dune landform features have also been described as "irreplaceable and nonrenewing" by Ryberg *et al.* (2015).

The CCAA recognizes there are problems with reclamation and restoration. The approach is to focus on first researching the efficacy and feasibility of removing abandoned or decommissioned

well pads and roads, and secondarily studying establishment of shinnery oak in areas of DSL habitat. It is not clear how long this research would take. Even after years of study, there is no assurance that reclamation and restoration or shinnery oak reestablishment measures would be biologically feasible. If, however, they are proven biologically efficacious and feasible, the Administrator will then consider implementation, but only if economically feasible. There is no discussion in the CCAA what the next steps would be if the Administrator determines that the measures are not economically feasible. However, because the CCAA relies heavily on restoration and remediation, which is a costly measure, we believe these efforts would not occur without the proposed action. Additionally, as a member of the AMC the Service could work with the AMC to prioritize areas to begin removal; encourage immediate restoration efforts begin, rather than spending time studying the efficacy and feasibility; and then study the shinnery oak-sand dune response.

3. Stratification

Stratification, or the separation of property into multiple layers with different ownership, is a substantial obstacle for the conservation of the DSL habitat. The rights of underlying mineral estate owners to access their subsurface property from the surface means any effort to conserve habitat can be undone by owners of the underlying strata when they exercise their right to access their minerals. Access can include roads and well pads and other infrastructure. The surface property owner cannot deny access to the subsurface owners. One objective in the CCAA is to address stratification issues by encouraging participation of non-enrolled entities sharing access to the same surface estate in the CCAA through outreach and education. The CCAA also requires Participants to agree to work with the non-surface estate and the Administrator to identify approaches to development that avoid, minimize, or offset impacts from development.

The AMC responsibilities regarding stratification include making recommendations to the Administrator and Participant Committee regarding: 1) a methodology to evaluate the extent of stratification and to identify any trends in the amount of stratification, 2) actions to minimize surface impacts where mineral estates are stratified, and 3) development of a written report on items 1 and 2. Using this information, the Administrator will encourage participation in the CCAA and will work with the Participants to develop approaches that conform with the requirements of the CCAA, including "where feasible and appropriate," a surface use agreement or mineral management plan. Participants agree to work with the non-Participant estate-holder and the Administrator to identify approaches to development that avoid, minimize or offset impacts from development, taking into consideration statutory and legal rights of the mineral estate (it is not clear what this last statement means, or how it would impact the feasibility of reducing stratification).

Evaluating the effectiveness of addressing stratification includes conducting a change detection analysis to monitor the acres disturbed by Participants and non-Participants and reporting the findings annually. There is also a changed circumstance (Chapter 16.1.1) addressing stratification stating if there is "an observable trend in the amount of stratification," the Administrator will develop and implement an education and outreach program. The Administrator would meet with stratified owners and attempt to develop surface use plans and discuss measures to minimize adverse impacts to the surface estate. The CCAA proposes to allow owners of different strata to split the fees amongst themselves to encourage participation.

Neither the TCP nor the CCAA provide any measurable solutions for addressing stratification as a barrier to conservation. The TCP has reported an inability to reduce impacts from non-Participants where stratification is resulting in an ongoing threat to implementation of conservation. Unfortunately, stratification undermines both on-the-ground permanent conservation (because of the rights of mineral estate owners) and successful implementation of the CCAA (because conserving habitat is an objective of the CCAA), diminishing both aspects. Therefore, with no specific strategy to address stratification problems, we believe that permanent conservation will be difficult to achieve, but we also recognize that stratification would not be addressed at all but for the proposed action.

4. Outreach and Research

The CCAA has objectives to develop and implement an outreach program to enhance enrollment, and to conduct research to enhance knowledge of the DSL. The CCAA states enhancement will be improved by providing the All Activities option, which will make it easier to transfer leases; increase awareness of the importance of participation within the oil and gas industry, including if the species is listed; and focus this outreach on non-enrolled mineral rights holders with access to lands of Participants. The AMC will consider, develop, and prioritize recommendations for research. The CCAA contemplates these will include studying threats posed by high densities of well pads to DSL occupancy and dune structure; threats posed by roads, or certain types of roads, including but not limited to, whether and to what degree, roads serve as a barrier or limitation to DSL crossing; potential consequences to dune stability and integrity in a highly dynamic dune system; efficacy of DSL translocation; and water management across industry sectors and the potential consequences to DSL habitat.

The effectiveness of the outreach program will be measured through monitoring the percent of DSL habitat that is enrolled versus unenrolled and by considering whether or not enrollment increases. It is not clear how either of these will verify the effectiveness of the outreach program. Additionally, many of the proposed research objectives have already been thoroughly studied. Therefore, we do not believe the outreach and research programs will result in measurable reductions in habitat destruction or fragmentation, or significantly increase conservation, but as a member of the AMC we will be involved in prioritizing research needs, which would not occur without the proposed action.

In summary, there are no assurances that there will be significant avoidance or minimization of impacts from participating Covered Activities because of the various exceptions allowed for each industry (detailed in the next section). Additionally, as detailed above, without a measurable conservation strategy, no clear steps on how the results of effectiveness monitoring will be addressed, and possible conflicts of interest of the AMC committee members, it is not possible for us to determine the effectiveness of the CCAA's avoidance, minimization, conservation, or monitoring program. Many details are yet to be determined and the actions of the Permittee and the Participants will affect the quality and quantity of conservation. Additionally, while temporary easements or protections (which is not defined) in DSL habitat could help in the short-term, it is not an adequate offset for permanent impacts. As currently proposed, reclamation and remediation will occur only after studies of efficacy and efficiency, which could take years. With the TCP as an example of the challenges with stratification, it exemplifies the inability to have all mineral estate owners of one parcel participate and has no real strategy for addressing successfully conserving all mineral estates. Therefore, stratification remains the largest obstacle to long-term conservation of DSL habitat. While remediation, stratification, and permanent

conservation are uncertain, these attempts along with the proposed outreach would not occur but for the proposed action.

B. Industry Specific Effects and Avoidance and Minimization Measures

1. Oil and Gas

Oil and gas industry Participants are discouraged from developing facilities and infrastructure in High and Intermediate Suitability habitat, but there are several exceptions in the CCAA that could allow a Participant to develop in these habitat types. For example, Participants may be permitted to develop in High and Intermediate Suitability habitat if, as determined by the plan's Administrator: 1) avoidance by the Participant is not "legally, technically, and economically feasible;" 2) where well density is 4 to 13 well pads per square mile; and 3) when conducting seismic activity by walk-in geophonic or other smaller seismic survey equipment, rather than large mobile trucks, or by limiting the activity to periods of DSL inactivity (October through March). All of these exceptions to the avoidance proposed in the CCAA demonstrate the ease by which CCAA Participants may impact High and Intermediate Suitability habitat. For example, oil and gas industry Participants do not need to avoid areas where well pads are less than four per square mile. It is not clear where this number 4 came from and why avoidance is restricted to between 4 and 13 well pads/square mile. Additionally, the exception for seismic testing suggests if DSL are inactive, large equipment conducting seismic pulses can be used in High and Intermediate Suitability habitat. Therefore, impacts (for example, hibernation disruption or avoidance of areas where activities are occurring) to DSL are still expected from seismic activity, but no fees are assessed for this activity, unless the Administrator determines that habitat was disturbed when the activity was conducted. Additionally, use of existing roads, pads, or easements is encouraged but not strictly prohibited. If considered infeasible by the Administrator, then avoidance will not be required, which will result in more habitat destruction and fragmentation than contemplated by the CCAA. Finally, oil and gas industry Participants have two ways of accessing High and Intermediate Suitability habitat: 1) conduct a habitat survey where they propose to construct facilities, and if they believe the Hardy *et al*. (2018) map is incorrect, they can submit their survey results and analysis to the Administrator to negotiate lower fees or no fees and proceed with covered activities; or 2) demonstrate that the only access to a Participant's mineral estate is through High and Intermediate Suitability habitat. These exceptions will result in more habitat destruction and fragmentation of DSL than contemplated by the CCAA.

The CCAA allows Participants to alter the definitions of habitat by reducing the sand dune habitat into discrete, potentially isolated, habitat patches, and then exclude the matrix between the patches, thus making access to the intervening matrix available for development through the plan. This approach fails to recognize that the location, size, and configuration of the sand dunes and DSL habitat across the landscape is dynamic. Separating and delineating areas within the greater dune ecosystem (for example, grassland dunes and barren dunes) and claiming such areas are not habitat is inappropriate because the sand dunes are emerging and receding as part of dynamic landscape scale processes (Dzialak *et al.* 2013). Chan *et al*. (2020) found genetic support for the separation and convergence of habitat patches across time, which results in repeated local extirpations, population divergence, and later recolonization. Painter (2004) specifically stated that because sand dunes are a "dynamic feature moving across the landscape through time, it would be imprudent to consider any currently unoccupied patches of suitable habitat within the overall range or along the edge of the range as being useless to *S. arenicolus*." Using localized vegetation surveys to determine whether some smaller part of the larger dune

system is or is not DSL habitat will likely result in more impacts through the destruction and fragmentation of DSL habitat than the CCAA will document.

While the CCAA indicates that the Administrator will consult with the Service on requests for altering the definitions of habitat, it later states that the Service may request to review the documentation submitted within 10 calendar days of the submission, or 20 days if the Service requests it. The CCAA further states the Service may seek to have the Administrator "require the Participant to address any deficiency." There are several issues with this process, which could result in high-quality DSL habitat being impacted and not being offset, if in fact the Service is not provided a true opportunity to review and comment on requests to alter habitat definitions and reviewing the submitted documentation:

a. There is no time commitment when the Administrator would consult with the Service which could shorten review time.
b. Ten calendar days commits the Service to reviewing and responding to applications in a short amount of time (possibly as little as five working days, assuming the Administrator shared the application the day it was submitted). While an extra 10 days is offered, the Service would still not know when an application package was submitted, so it is not clear how the Service would know to make a "request to review the documentation submitted."
c. The CCAA does not provide a process for settling disagreement about habitat delineations between the Service, Participants, and the Administrator, but the CCAA states that the Administrator evaluates and makes decisions on the information and recommendations provided by Adaptive Management and Participant committees, and will inform the Committees and the Service of its final decisions.

It is currently the Service's intention to continue updating the Hardy *et al.* (2018) habitat suitability map with expert input and to continually update this model as new information becomes available. The most current version of the map available at the time of participation would be the recommended basis for all habitat evaluations, until such time the species experts agree that another model or approach is more accurate. Using a map that more conservatively determines what is DSL habitat is preferred, rather than parsing out small areas within the larger duneland system. We are concerned that to do so will result in an underestimation of impacts to DSL from the Covered Activities, which would result in greater negative effects to DSL through habitat destruction and fragmentation than is currently contemplated by the CCAA.

2. Oil and Gas Minimization/Conservation

In addition to payment of fees, minimization measures that oil and gas industry Participants must implement, as a requirement of being a Participant, include the following.

a. Maximize use of existing developed areas and ROW for infrastructure supporting the development of the wells (roads, power lines, pipelines, flowlines, etc.) "where feasible."
b. Avoid aerially sprayed application of approved herbicide for weed control (e.g., utilize pellets, hand applicators, or manual removal).
c. Avoid introduction of non-native vegetation by using habitat appropriate native vegetation and best management practices, such as cleaning vehicles coming into the area to remove mud and seeds. If an activity is identified that introduces new nonnative

vegetation, the activity or source will be controlled to manage or remove the invasive vegetation.

d. Take appropriate measures to mitigate risk that DSL become trapped in any trenches left open for more than eight hours.
e. Remove mesquite from flowback pits, "where feasible."
f. Minimize spills through inspection, monitoring, maintenance and employee training in spill response procedures.
g. Minimize OHV activity in DSL habitat "as practicable."
h. Restore disturbances from emergency operations.

The CCAA lacks certainty and commitment to implement minimization measures. We cannot quantify or qualitatively evaluate to what extent these minimization measures will be implemented to determine the extent that they meaningfully reduce negative effects of the Covered Activities. While there is a measure to mitigate risks for trapped DSL in trenches, it is not specific like under Linear Infrastructure and Renewable Energy. For example, under Linear Infrastructure and Renewable Energy earthen ramps will be built at intervals to allow for DSL to escape and biological monitors will be employed when trenching or constructing to ensure DSL are not trapped or injured. It is unclear why the wording would be different for different industries, unless something less would be committed to by oil and gas. There is also no information provided on minimizing the frequency of contaminant spills or how they will be addressed when they occur. It is also not clear how compliance monitoring of these measures will be conducted or verified. The uncertainty prevents us from evaluating if these measures will be implemented or beneficial in reducing impacts from oil and gas activities; therefore, the effects from these activities could negatively affect DSL and its habitat more than is contemplated in the CCAA.

The oil and gas incidental take request is 15,424 acres of DSL habitat, which is a total of expected impacts from Participants and non-Participants. The CCAA presumes the oil and gas industry intends to focus development in already disturbed areas (detailed in Table 1 above and Section 8.3.1 of the CCAA). However, because of the availability of exceptions provided in the CCAA, we evaluate in this opinion all of the take occurring in High and Intermediate I Suitability DSL habitat as a possible consequence of implementing the Covered Activities, which would cause an 11.8 percent decline in remaining undisturbed DSL high quality habitat (162,657 acres). These declines do not include any assessment of fragmentation; therefore, additional fragmentation and habitat degradation caused by the oil and gas industry will likely result in a greater loss of DSL habitat than is contemplated in the CCAA.

3. Sand Mining

Sand mining is the activity of digging and processing sand for industrial and commercial uses (Benson and Wilson 2015), which can destroy DSL habitat and harm individuals during mining activities (Forstner *et al.* 2018). Habitat is destroyed by the removal of a portion (or portions) of a sand dune either for sand processing or construction of associated processing facilities, which can be as large as 100 to 200 acres (Forstner *et al.* 2018). Degradation of the surrounding dune ecosystem occurs when the large, deep pits (sometimes as deep as 80 feet) created by mines (Forstner *et al.* 2018) receive surrounding sand, permanently removing it from the dune ecosystem. Wind is a primary force of change in these dynamic dune complexes (Rich and Stokes 2011), but it is unlikely that sand that blows into a mine pit will subsequently blow out of these pits. This sand loss undermines the stability of the adjacent dunes through erosion, which can result in dune deflation resulting in greater destruction of surrounding DSL habitat than is

contemplated by the CCAA. Sand mining involves mechanized equipment used to clear, grade, excavate, transport, and process sand (Wisconsin Department of Natural Resources 2012), which could entrain, crush, injure, and kill DSL (including nests and eggs). There is no measure, similar to those under Linear Infrastructure and Renewable Energy, where earthen ramps and monitors will be employed when trenching or constructing. Therefore, we expect DSL to become trapped and killed during these activities.

Sand mine operations also create high volumes of vehicular traffic (350 trucks per day) on local and regional roadways as trucks delivering sand to processing plants, and then hauling away processed sand from plants to regional well fields (Wisconsin Department of Natural Resources 2012, Maslowski 2012, Forstner *et al.* 2018). Traffic density has been positively correlated with reptile strikes on roads; therefore, increased vehicular traffic on roadways that traverse DSL habitat are expected to contribute to DSL mortalities (Ouren *et al.* 2007). The location of a sand mine can also result in negative behavioral modifications associated with avoidance of the mine and mining activities by DSL (Hibbitts *et al.* 2013), which could also separate individuals from portions of their territory. Additionally, once mines are excavated, they are not filled in or restored. Forstner *et al.* (2018) reported a general lack of reclamation strategies at sand mines operating in the Monahans Sandhills, and backfilling, if done at all, results in 25 percent or less of the original grade or elevation. Currently, there is no effort or method to reclaim or level mined areas once the mining operation is completed; therefore, sand mines are a permanent impact on DSL habitat at the excavation site, introduce permanent fragmentation, and cause adjacent impacts from overall reduction in dune stability from increased erosion. We know of no effort to successfully reclaim a defunct sand mine in the Action Area.

Sand mine Participants are not discouraged from impacting High and Intermediate I Suitability habitat when enrolling in the CCAA. Mining Participants must submit to the Administrator the results of a presence/absence survey and a vegetation survey with their application delineating the property to be enrolled, including if it is categorized as habitat and if any habitat is considered to be occupied. As we noted previously, sand dune habitat is heterogeneous and DSL are difficult to detect; therefore, both the methods and uses of surveys that Participants can use to enroll in the CCAA will result in greater habitat fragmentation, and will fail to detect individuals causing them to be harmed or killed. According to the CCAA, the presence/absence survey protocol (Appendix D) is:

> "…designed to be used within the 2020 DSL CCAA, for the limited purpose of informing a Participant (or potential Participant) on whether DSL is present or absent on a specific discrete parcel. The results can be used to confirm or alter the parcel's DSL Habitat Suitability classification, as well as to inform the implementation of Conservation Measures such as barrier fencing to protect DSL Habitat and individuals."

Proving absence of DSL through surveys is not practical, because: 1) DSL may not occur in all suitable habitat areas all of the time because of cycles of extirpation and colonization through time; 2) this species burrows under the sand for protection and to lay eggs, and when burrowing, individuals and nests are not be detectable by surveyors; and 3) shinnery oak stands are dense and can obscure detection of individuals (Fitzgerald *et al.* 2011, Smolensky and Fitzgerald 2010, Kiehne 2019). After a one-year study, Fitzgerald *et al.* (2011) recommended conducting multiple surveys over many years to fully understand if DSL are undergoing temporary, local extirpations, which are then recolonized later in time. One study that focused the majority of its

survey effort in areas classified as high-quality habitat, the probability of detection rate was only 52 percent (Walkup *et al.* 2018). Another study that conducted surveys equally across a gradient of habitat types had only a 13 to 19 percent probability of detection with a total of only 12 DSL over the 2-year study period (Kiehne 2019). Therefore, it can be expected that more DSL habitat and individuals will likely be negatively affected than is contemplated in the CCAA with the use of surveys.

Rather than using the Hardy *et al*. (2018) habitat suitability map, or a revision of that model, sand mining Participants will delineate enrollment areas based on the following land cover categories (defined in more detail in Appendix A of the CCAA): 1) Shinnery Oak Dune I, 2) Shinnery Oak Dune II, 3) Shinnery Oak Flats or Co-Dominate Shinnery Oak Mesquite Flats, 4) Grass Dunes, 5) Open Sand Dunes, and 6) Mesquite Shrub. Covered Activities related to sand mining may proceed in all of these land cover types with different fees. The consequence of using different habitat mapping approaches on the DSL is that habitat previously classified as High and Intermediate I Suitability (grass dunes, open sand dunes, and mesquite shrub) where it is intermixed with the other habitats on a landscape is no longer being considered habitat, despite DSLs having been found in these habitats. The result will be impacts to DSL breeding, feeding, and sheltering habitat that is not accounted for or offset in the CCAA. Additionally, the loss, degradation, and fragmentation of these habitats, particularly when embedded in the larger dune ecosystem, reduces the capacity for individuals to survive and reproduce in an already limited, fragmented, and shrinking sand dune ecosystem. This exclusion will result in higher quality DSL habitat being impacted, but not accounted for in the CCAA, and this higher quality habitat type being offset by lesser fees, which will result in less conservation for the species.

As discussed under oil and gas, requests for reclassification of habitat types are in consultation with the Service, but there are several issues with the process that may result in high quality DSL habitat being reclassified, not being accounted for in the take assessment, and not being offset appropriately.

Alternatively, a sand mining Participant may purchase or otherwise contribute acres of similar habitat to be acquired or placed into long-term conservation through a conservation easement at a 1:1 ratio (one acre of conservation for each acre of impact) rather than paying fees for conservation into the CCAA. A 1:1 ratio will not result in a net mitigation benefit offset to the species because the same number of acres being impacted are being conserved. To provide a net mitigation benefit offset to the species' status, more habitat needs to be protected than is impacted. Additionally, the CCAA lacks financial resources to fund permanent habitat conservation at a meaningful scale, is not a goal of the CCAA, nor is it likely to be achievable due to stratification (as discussed above). Thus, any habitat that may be temporarily protected, even with a long-term easement, will eventually no longer protect the DSL from impacts, since temporary conservation easements do not contribute to conservation beyond the term of the easement and are thus limited in their conservation value.

4. Sand Mining Groundwater Impacts

Irrigation-related consumption of groundwater accounts for a majority (75 to 87 percent) of water withdrawals from the Pecos Valley and Dockum aquifers, while consumption of groundwater by the oil and gas industry, ranchers, and municipalities account for the remaining (13 to 25 percent) (Boghici 1998, Jones 2004, Meyer *et al.* 2012). Sand mines have recently become established throughout the region and extract large volumes of water from the Pecos

Valley and Dockum aquifers (Mace 2019, Rainwater 2020). Groundwater pumping, particularly from the shallow Pecos Valley Aquifer, could lower the water table (and its capillary fringe), reducing its contribution to intradunal soil water. This water loss could destabilize sand dunes by reducing blowout stability and cohesion, or preclude dune formation altogether, by reducing sand grain cohesiveness, making dunes susceptible to wind erosion and deflation (Machenberg 1984, Kocurek and Havholm 1993, Pye 2009, Newton and Allen 2014).

Groundwater pumping and subsequent declines in water tables have been shown to adversely affect phreatophyte (i.e., shinnery oak) communities in arid climates (Campbell *et al.* 2017). Groundwater depletion can stress phreatophytes through reduced photosynthesis and growth, which can lead to their deterioration (senescence) and death (Machenberg 1984, Stromberg *et al.* 1992 and 1993, Laity 2003). As depth to the water table increases, phreatophytes become scattered and less vigorous, and gradually diminish in size until they cease to exist altogether (Robinson 1958). Death or deterioration of dune-anchoring phreatophytes, such as shinnery oak, can lead to the erosion and deflation of dune landforms by strong winds (Machenberg 1984, Kocurek and Havholm 1993, Muhs and Holliday 2001, Laity 2003). Reduced growth rates can hinder plant growth, sand accumulation, dune formation, and prevent young plants (e.g., seedlings and saplings), which have limited rooting depths, from becoming established, further precluding dune formation and stabilization (Machenberg 1984, Gucker 2006, Laity 2003, Campbell *et al.* 2017). It is not clear what amount of groundwater pumping from the Pecos Valley Aquifer could affect shinnery oak, but one report states currently observed water use is not sufficient to cause declines in the groundwater table (Rainwater 2020).

According to the CCAA, sand mining Participants must submit the most recent year's Water Use Survey, as defined by the Texas Water Development Board; all groundwater drawn by aquifer; and a description of how water is drawn and used in processing, including all measures implemented to capture water used for re-use. Additionally, in cooperation with the Administrator, each sand mining Participant must create a water use minimization plan that will include targets on water use reduction, and they must monitor and annually report performance relative to those targets. There is no discussion in the CCAA: 1) regarding how much water sand mining companies currently use; 2) any indication of what the targets may be; 3) what measures would be implemented to reduce groundwater use; 4) how water is captured, reused, or disposed of; 5) or what additives, if any, are in the water that is disposed of. Without detailed information on sand mining and groundwater use, it is difficult to analyze what impacts on groundwater depletion sand mining companies could or will have and subsequently what the sustainability of shinnery oak-dune habitat will be.

5. Sand Mining Minimization/Conservation

In addition to payment of fees, minimization measures that sand mining industry Participants must implement, as a requirement of being a Participant, include the following.

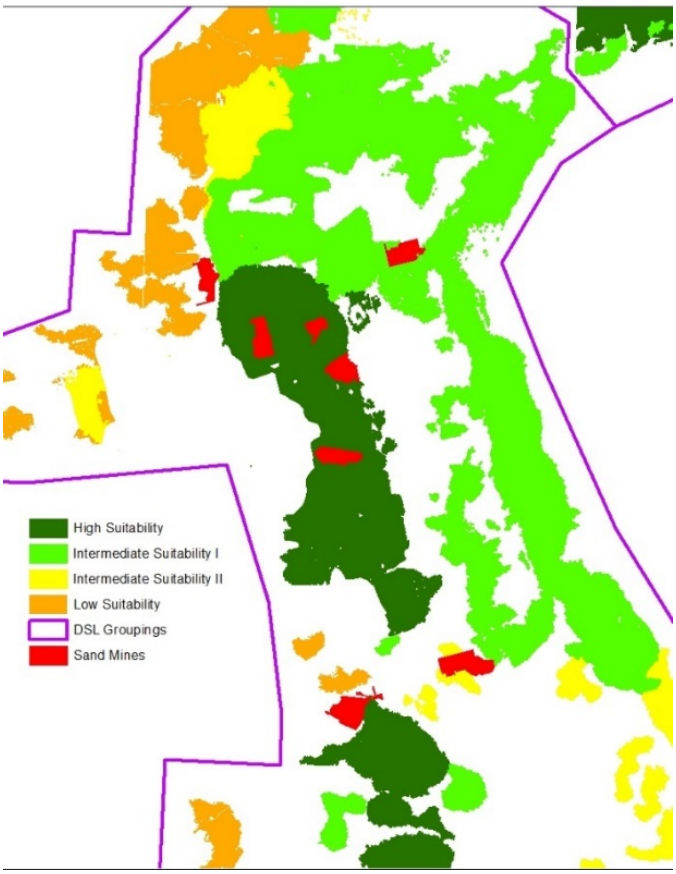
a. Maximize use of existing developed areas and Low Suitability DSL habitat in siting excavation activities and ROWs for infrastructure supporting the excavation activities.
b. Re-grade areas of mining disturbance consistent with any applicable contractual requirements and avoid or minimize additional surface disturbance or pay fees.
c. Restrict traffic to existing roads "to the maximum extent practicable" and minimize new road development or pay fees. Measures (e.g., signage and fencing) will be implemented

to ensure that traffic does not impinge on High or Intermediate Suitability areas of DSL habitat.

d. Avoid aerially sprayed application of approved herbicide for weed control (e.g., utilize pellets, hand applicators, or manual removal).
e. Avoid introduction of non-native vegetation by using habitat appropriate native vegetation and best management practices, such as cleaning vehicles coming into the area to remove mud and seeds. If an activity is identified that introduces new nonnative vegetation, the activity or source will be controlled to manage or remove the invasive vegetation.
f. Control dust from road traffic and other activities including restricting unnecessary off-road vehicle access.
g. Minimize OHV activity "to the extent practicable."
h. Implement best management practices, such as barrier fencing, to protect DSL habitat and individual DSL.

As previously noted with oil and gas, it is unclear how compliance monitoring of many of these minimization measures will be conducted and verified or how much minimization of impacts and use of existing infrastructure will actually be implemented. There is also no discussion of how contaminant spills will be minimized or addressed, if they occur. Therefore, we expect greater negative consequences on DSL through habitat destruction and fragmentation than is contemplated by the CCAA.

Of the 14 known mines (many owned by the same companies), as seen on aerial photos, 5 are in High Suitability habitat, 1.5 are in Intermediate I, 0.5 of 1 is in Intermediate II, 1 is in Low, and 6 are outside of DSL habitat. Of the six mines located outside of DSL habitat, only one is not adjacent to any DSL habitat. Therefore, the growth of all but one sand mine currently will or could impact DSL habitat. According to recent calculations, since 2015-2016 when sand mining began in the Monahans Sandhills, there have been over 3,240 acres of potential DSL habitat disturbed by sand mines (NRS 2021). The requested incidental take is 60 acres per year per mine with a maximum of 1,380 acres per mine over the life of the permit



and a total maximum of 16,560 acres[2]. Considering the 13 mines in or adjacent to DSL habitat and assuming they will continue to impact the habitat type they are currently in or adjacent to, that results in a loss of 780 acres a year, 540 of which will be in the High and Intermediate I Suitability habitat where DSLs breed, feed, and shelter. If those mines in or adjacent to High and Intermediate I Suitability habitat use all incidental take available to them, over 12,400 acres of this highest quality habitat will be permanently destroyed and will fragment those few remaining large blocks of habitat.

Figure 6: Sand mines in north-central grouping.
Significantly, 8 of the 14 sand mines are in one phylogeographic unit as designated by Chan *et al.* (2020). As seen in Figure 6, the large central patch of High Suitability DSL habitat is approximately 11,900 acres. Growth of the 4 mines (red polygons) currently located in the patch could result in destruction of 240 acres per year and over 5,500 acres over the life of the permit. This would be a 46 percent decline in remaining habitat in one of the few large blocks of habitat remaining in this phylogeographic unit. Destruction of 12,400 acres (the estimated loss of high and intermediate I habitat) would be a 9.5 percent habitat reduction in the Action Area in remaining undisturbed High and Intermediate I Suitability habitat (130,049 acres) from just 9 mines. If, however, additional sand mines develop in High and Intermediate I Suitability habitat, such that all 16,560 acres of incidental take are in these areas, that would result in a 12.7 percent reduction in the highest quality habitat just from sand mines. It is important to note that this does not include any assessment of fragmentation; therefore, the percent of habitat impacted will likely be much higher than is contemplated in the CCAA.

6. Renewable Energy

Currently, wind farm development is east of DSL habitat seemingly confined to a topographic ridge. The Applicant believes that the low topography of DSL habitat will likely discourage wind development in this area. Solar companies have previously planned activities in DSL habitat, but then reconsidered siting those facilities to other locations upon learning about the DSL. While this downward trend for renewable energy development in DSL habitat may continue, the CCAA requests 767 acres of incidental take. And, while High and Intermediate habitat impacts are discouraged, renewable energy development companies may survey to negotiate whether the area to be impacted is DSL habitat. As previously discussed under oil and gas, this is not an appropriate approach in DSL habitat and will likely result in higher quality habitat being impacted with little to no fees to offset that impact, resulting in greater negative effects to DSL from habitat destruction and fragmentation than is contemplated by the CCAA.

7. Renewable Energy Minimization/Conservation

In addition to payment of fees, minimization measures that renewable industry Participants must implement, as a requirement of being a Participant, include the following.

a. Maximize use of existing developed areas and rights-of-way for infrastructure supporting the development of the power lines and appurtenances (roads and associated infrastructure).
b. Minimize footprint for development (i.e., width of pipeline right-of-way, centralized facilities and interim reclamation).

[2] The CCAA states the 16,560 acres is intended to include all potential surface disturbance of DSL habitat from both sand mine Participants and non-Participants.

c. Trenches left open for 8 hours or more must have earthen ramps (built at no more than a 30-degree slope and placed no more than 500 feet apart). At the end of each day, a monitor approved by the Administrator (in consultation with the FWS, as appropriate), shall walk the entire length of open trench and remove all trapped DSL and release them at least 100 yards from the trench.
d. Avoid introduction of non-native vegetation by using habitat appropriate native vegetation and best management practices, such as cleaning vehicle coming into the area to remove mud and seeds. If an activity is identified that introduces new nonnative vegetation, the activity or source will be controlled to manage or remove the invasive vegetation.
e. Use SCADA (Supervisory Control and Data Acquisition System) or remote sensing, where appropriate, to monitor remotely to reduce traffic and need to clear right-of-way for line-of-sight inspection and monitoring.
f. Restore rights-of-way promptly with native vegetation.
g. Restrict traffic to existing roads.
h. Minimize OHV activity "to the extent practicable."

As previously noted with oil and gas and sand mines, it is unclear how compliance monitoring of many of these minimization measures will be conducted and verified or how much minimization of impacts and use of existing infrastructure will actually be implemented. There is also no discussion of how contaminant spills will be minimized or addressed, if they occur. Therefore, we expect greater negative consequences on DSL through habitat destruction and fragmentation than is contemplated by the CCAA.

It is also difficult to determine where incidental take will occur; however, if it were all to occur in undisturbed High and Intermediate I Suitability, it would be a 0.6 percent decrease in remaining habitat. It is important to note that this does not include any assessment of fragmentation; therefore, the percent of habitat impacted will likely be greater than is contemplated in the CCAA.

8. Linear Infrastructure

Avoidance of High and Intermediate Suitability DSL habitat is required unless the buried linear infrastructure Participant demonstrates that the criteria below are met:

a. Contractual fulfillment of surface use agreements or leases existing at least six months prior to the planned activity and that cannot be achieved by an alternative development plan;
b. No feasible technological routing diversions are available;
c. Horizontal or directional boring is not feasible; and
d. Areas in Low Suitability Habitat or areas with existing disturbance in habitat are not available.

Avoidance of High and Intermediate Suitability DSL habitat is required unless the above ground linear infrastructure Participant demonstrates that the criteria below are met:

a. No feasible technological routing diversions are available
b. Spanning High and Intermediate Suitability DSL Habitat is not possible; and

c. Areas in Low Suitability Habitat or areas with existing disturbance in habitat are not available.

These exceptions reduce the intended beneficial effects to the DSL by allowing Participants a six-month waiting period before construction and then constructing as they otherwise would; not requiring facilities be routed around High and Intermediate suitability habitat; applying minimization measures inconsistently; allowing companies to claim rerouting would not be technologically feasible when the technology already exists; and not requiring horizontal or directional boring when the oil and gas, pipeline, and electric industries frequently employ this technology. Participants may also survey the habitat and negotiate whether it is or is not DSL habitat as delineated in Hardy *et al.* (2018) to reduce impact fees. As previously described with other industries, this is not an appropriate use of surveys and may result in less fees and, consequently, less conservation. Combined, all of the exceptions will likely result in greater impacts to DSL through habitat destruction and fragmentation than is currently contemplated in the CCAA.

9. Linear Infrastructure Minimization/Conservation

In addition to payment of fees, minimization measures that linear infrastructure industry Participants must implement, as a requirement of being a Participant, include the following.

a. Maximize use of existing developed areas and ROWs for infrastructure supporting the development of linear infrastructure and appurtenances (roads, power lines, associated infrastructure);
b. Conduct routine monitoring and inspection for oil, gas, and produced water pipelines and facilities to prevent accidental pollution events;
c. Trenches left open for eight hours or more must have earthen ramps (built at no more than a 30-degree slope and placed no more than 500 feet apart). At the end of each day, a monitor approved by the Administrator (in consultation with the FWS, as appropriate), shall walk the entire length of open trench and remove all trapped DSL and release them at least 100 yards from the trench;
d. Minimize footprint for development (i.e., width of pipeline ROW, centralized facilities, and interim reclamation);
e. Restrict traffic to existing roads;
f. Use SCADA or remote sensing where appropriate, to reduce traffic and need to clear ROW for line-of-sight inspection and monitoring;
g. Minimize OHV activity, "to the extent practicable;"
h. Reclaim ROWs "promptly" with native vegetation; and
i. Avoid introduction of invasive vegetation by using habitat appropriate native vegetation and best management practices employed in West Texas. If an activity is identified that introduces invasive vegetation, the activity or source will be controlled to manage or remove the invasive vegetation.

As previously noted with the other industries, it is unclear how compliance monitoring of many of these minimization measures will be conducted and verified or how much minimization of impacts and use of existing infrastructure will actually be implemented. The result will likely be more negative consequences to DSL through habitat destruction and fragmentation than is currently contemplated in the CCAA.

Under the TCP, 60 percent of pipelines constructed by Participants were in High and Intermediate habitat, with 40 percent in Low. The CCAA estimates there will be a three-fold increase in pipelines in the next 5 years and a 25 percent increase in the next 25 years. Despite the CCAA focusing on avoidance of High and Intermediate habitat, linear infrastructure incidental take is 1,355 acres across any habitat suitability type. If, like the TCP, 60 percent of the requested incidental take is in High and Intermediate I habitat, that would be a 0.63 percent reduction in remaining undisturbed habitat (813 acres of 130,049 acres of remaining undisturbed habitat); however, if all of the impacts occur in High and Intermediate I habitat, then that would result in a 1.0 percent reduction in remaining habitat. It is important to note that this does not include any assessment of fragmentation; therefore, the percent of habitat impacted will likely be higher than what is contemplated in the CCAA.

10. Agriculture, Ranching, and Local Government

Activities in High and Intermediate Suitability DSL habitat are discouraged; however, words like "refrain" from new disturbance and avoid "when possible" allow flexibility to deviate from these CCAA objectives, likely resulting in more negative effects on DSL through habitat destruction and fragmentation than is contemplated in the CCAA. Additionally, local governments' Covered Activities include new construction and maintenance of existing infrastructure. No fees are paid to the CCAA for any of these activities; therefore, no mitigation will occur to offset these impacts. The Administrator will request access to the enrolled land for DSL surveys, which are not required for enrollment. Additionally, no enrollment surveys or exceptions apply because fees are not charged for these activities. Overall, with no fees assessed but the possibility for additional DSL habitat destruction and fragmentation, these Covered Activities will likely result in greater impacts to DSL than contemplated in the CCAA and with no offset.

11. Agriculture, Ranching, and Local Government Minimization/Conservation

Minimization measures that these Participants must implement, as a requirement of being a Participant, include the following.

a. Stratification – if rights are severed, the Participant will work with non-participating landowners to develop approaches and encourage cooperation.
b. Comply with NRCS Code 528 for livestock rates and grazing management.
c. No release, planting or related actions to establish or introduce exotic or invasive species, including but not limited to feral pigs or other species that may degrade habitat.
d. Use of herbicides for shinnery oak management only when habitat goals cannot be achieved by other means, including grazing system management, "unless it can't be avoided" with several caveats.
    i. No herbicide application for the control of shinnery oak in dune complexes and dispersal corridors between dune complexes and shinnery oak associated with dune complexes.
    ii. Maintenance of buffers around dune complexes of 100 meters to ensure dune stability where tebuthiuron will be applied.
    iii. Herbicide application for the management/control of mesquite and other problematic woody and herbaceous plants will be conducted only with the Administrator's approval and concurrence by the Service.
    iv. Herbicides should be used at appropriate shinnery oak suppression rates. Application should follow the natural patterns on the landscape such that only patches needing treatment are treated.

v. Grazing will be deferred one growing season following treatment. If vegetation response to treatment has been hindered due to drought or other factors, additional deferments to ensure success of the treatment may be required.
vi. Experimental treatments outside these guidelines may occur with the Administrator's approval and concurrence by the Service. Experimental treatments must be part of a quantitative research design to study vegetation response, viability of shinnery oak, drift, sub-surface spread, the interaction of herbicide treatment and/or grazing management and the response of the DSL to various treatments.

e. Avoid introduction of non-native vegetation by using habitat appropriate native vegetation and best management practices, such as cleaning vehicle coming into the area to remove mud and seeds. If an activity is identified that introduces new nonnative vegetation, the activity or source will be controlled to manage or remove the invasive vegetation.

The CCAA expects little impact to DSL to result from these activities but has requested 1,087 acres of incidental take. It is not clear how these activities or minimization measures will be monitored; therefore, we expect greater negative effects to DSL through habitat destruction and fragmentation than is contemplated in the CCAA. We also assume impacts could occur in the highest quality habitat for analysis purposes. This would result in removal of 0.8 percent of the remaining undisturbed DSL habitat (1,087 acres of 130,049 undisturbed acres).

C. Summary of the Effects of the Action

If the majority (30,780 acres) of the incidental take occurs in High and Intermediate I Suitability habitat, that would result in a 11 percent of Hardy mapped habitat and an estimated 24 percent decline in remaining undisturbed habitat (130,049 acres). This is based on assumptions about current mine location and growth (as discussed above). If, however, all (34,940 acres) of the impacts occur in undisturbed High and Intermediate I Suitability habitat, that would result in a 26.5 percent decline overall, with potentially no permanent offset or set aside for these impacts. These impacts would occur without any geospatial configuration that would conserve the populations in the phylogeographic units, thereby possibly reducing the representation, resiliency, and redundancy needed to conserve or recover this species. Additionally, if the southern grouping of habitat (Ward and Crane counties) is confirmed not to be occupied by DSL, this results in a reduction in available high-quality DSL habitat by 16 percent. As previously noted, take will not be evenly distributed among the phylogeographic groups, particularly for sand mines. For example, as previously discussed in association with Figure 6, expected impacts will result in a 23 percent decline alone in the north/central group with likely destruction of at least 46 percent in one of the largest remaining patches of high-quality habitat across the range.

There is a high likelihood that more high-quality habitat will be impacted than is anticipated by the Applicant through the implementation of the CCAA. For example, the approach to combining habitat categories, as is done in the CCAA, results in lower assessed fees and less funding generated to be available for conservation actions. In a system where fees are the primary deterrent to habitat impacts, the CCAA does little to disincentivize habitat loss. Also, using habitat assessments to delineate and classify areas within the greater dune complex ecosystem as non-habitat results in less assessed fees and mitigation obligations by Participants, and importantly, overlooks the complex mosaic patterns of the dune ecosystem. Over time the integrity of this shifting system will be lost. Similarly, allowing sand mining Participants to delineate habitat in a manner that is not supported by the Hardy *et al.* (2018) classification results

in potential habitat being reclassified as non-habitat. These reclassifications will have the same problems associated with the localized habitat exclusions that will be produced through the CCAA survey method. In our estimate above, we show that there could be an 11 percent decline in Hardy *et al.* (2018) mapped habitat and anywhere from a 24 to 26.5 percent decline in the highest quality habitat in the Action Area from the Covered Activities. These habitat losses will not be evenly distributed among phylogeographic units and will have uneven population effects; the stability of subpopulations will be affected by the current condition of the unit and future intensity of development leading to habitat loss, degradation and fragmentation in that unit. Phylogeograhpic units are affected by source and sink population dynamics. Population declines from changes in dispersal rates in one or a few units or subpopulations can negatively impact overall resiliency, redundancy, and representation of the species' population.

The CCAA relies heavily on minimization measures, but as described above, we have concerns that the positive impacts of these measures will not provide the degree of benefit that is needed to offset the harm that will occur. Efficacy is one concern, and another is whether the minimization measures will be realized. The CCAA use of language like "where feasible," "refrain," and "as practicable," make it unclear if these minimization measures will be implemented to the extent that they meaningfully reduce negative effects from the Covered Activities, and there is a considerable lack of detail used to describe the minimization measures. Additionally, the inconsistencies across industries regarding minimization measures are not explained in the CCAA. These inconsistencies will create difficulty in evaluating the plan's effectiveness and compliance. Furthermore, it is not clear how compliance monitoring of these measures will be conducted or verified. Therefore, we are not able to assess if these measures will be implemented, and if implemented, whether they will be beneficial in reducing impacts from Covered Activities.

The conservation program relies heavily on reclamation and restoration of disturbed habitat, but the removal of sand dunes to develop sand mines and other facilities will result in permanent removal of DSL habitat. Reclamation and restoration could potentially restore sand to some disturbed areas (for example, oil and gas pads and roads) and return them to usable sand features; however, this is an untested and unproven conservation measure. There is no evidence to support the concept of restoring or reclaiming destroyed duneland habitat to a condition such that DSL would reoccupy it. The CCAA recognizes this, which is why there is a significant emphasis on funding studying restoration and reclamation. As part of the AMC, we will encourage restoration actions be implemented and then to study the effects, but the final decision is at the discretion of the CCAA Administrator to determine if restoration projects are economically feasible to implement. While we cannot be certain that any restoration projects will occur, we recognize that the study of and potential for restoration would not occur but for the proposed action.

The CCAA does not provide any solutions for addressing the problem of mineral estate stratification. We know from TCP implementation that it is nearly impossible to limit impacts from non-Participants. Stratification is an ongoing threat to implementation of the TCP as it will be for the CCAA. Unfortunately, stratification undermines both on-the-ground permanent conservation and successful implementation of the CCAA, diminishing both aspects. With no real strategy to address stratification effects, we do not believe that permanent conservation of DSL habitat will be realized through the CCAA. And, while temporary easements or protections (protections are not defined in the CCAA) in DSL habitat could help in the short-term, it is not

an adequate offset for permanent impacts. We do, however, recognize that attempts at solving stratification issues would not occur but for the proposed action. Perhaps collectively the TCP and the CCAA Administrator with support from both committees will be successful in creating an approach that at least minimizes, if not fully addresses, how to overcome stratification on conservation lands.

In summary, because of the extensive fragmentation and habitat destruction, it is unlikely that all of the remaining high-quality habitat supports breeding, feeding, and sheltering evenly across the Action Area. Moreover, we do not fully understand how habitat fragmentation caused by industrial infrastructure has affected dispersal dynamics. We expect, once analyzed, the results will indicate there is less high-quality habitat available to sustain DSL populations due to small patch size and discontinuity with other patches. Additionally, the Texas population is already separated into phylogroups that may become more isolated with increasing habitat destruction and fragmentation. With little to no commitment in the CCAA for on-the-ground conservation and uncertain minimization and monitoring measures, we are concerned that the CCAA may impair the ability of the DSL to sustain into the future in Texas because it is unlikely to curtail the ongoing threats to the species. However, we recognize that these impacts would occur regardless of the proposed action. What would not occur, but for the proposed action, is implementation of the industry specific minimization measures, development of a conservation strategy, development of an approach to resolving stratification, potential water-use reduction targets, and outreach on the DSL and the importance of avoiding impacts to DSL habitat.

VI. CUMULATIVE EFFECTS

Cumulative effects are those "effects of future State or private activities, not involving federal activities, that are reasonably certain to occur within the action area" considered in this opinion (50 CFR 402.02). The Texas Workforce Commission created a tool, the Texas Labor Market Information (LMI), which can be used to assess industry trends in employment in the Permian Basin (https://texaslmi.com/). According to the LMI, agricultural activities, crop production and support activities for agriculture will decrease through 2026, but animal production will see a slight increase. Electric generation, transmission, and distribution will see a higher increase in employment needs than natural gas, which is also projected to increase through 2026. Oil and gas extraction will see a slight decrease while mining itself will see a slight increase with mining support activities seeing an increase in job growth exceeding 30,000 more jobs by 2026. Support activities include taking core samples and making geological observations at prospective sites; drilling, re-drilling, directional drilling, and well surveying; running, cutting, and pulling casings, tubes and rods; cementing and shooting wells; perforating well casings; acidizing and chemically treating wells; and cleaning out, bailing, and swabbing wells. As a result of industry growth, we expect a related expansion of residential and commercial development and associated infrastructure, all of which will increase demand for water resulting in additional pumping of the local groundwater aquifers.

VII. CONCLUSION

This concludes our review of the current range-wide status of the DSL, the environmental baseline for the Action Area, the effects of the proposed project, and the cumulative effects. As described in the "Effects of the Action" section above, we expect there to be adverse effects to

the DSL from the Covered Activities. These adverse effects could be from killing, disruption of the ability to disperse, habitat destruction, and habitat fragmentation.

We used the best available commercial and scientific data available at the time of this Opinion. However, it is important to note that the state of science regarding the trends and population dynamics of DSL is not robust. The majority of scientific work embodies threat identification and assessment on DSL, which this Opinion relies on heavily. Little work has been done on population viability, minimum population sizes, reproductive success, or dispersal. Studies are needed to understand the level of habitat loss and displacement the species can withstand and still remain viable. Species specific studies on the varying aquifers below the dunes and how they relate to dune structure and shinnery oak are needed. We are concerned that the phylogenetic diversity of the species is decreasing as habitat loss and fragmentation increase. More information is needed on the current state of the phylogroups, for example, habitat occupancy throughout these groups, whether immigration and emigration are occurring, and what the existing fragmentation effects are having on the viability of these units currently and into the future.

While the Applicant, in its CCAA, is relying on desired conservation outcomes, there are few assurances, resulting in these desires being largely unsupported by the CCAA. The plan emphasizes temporary conservation easements, which provide no long-term assurances for conservation and may be undermined with exiting stratification issues. There is a great reliance on studies, which are not mitigation, and are expected to be long-term, due to the sparsity of baseline data available. The CCAA relies heavily on future planning and minimization measures, which we are not sure will offset the habitat destruction and fragmentation that will result from implementation of the Covered Activities, because there are opportunities for each industry to request variances. We do, however, recognize that minimization, avoidance, outreach, or conservation would not occur without the proposed action.

"Jeopardize the continued existence of" means to engage in an action that reasonably would be expected, directly or indirectly, to reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing the reproduction, numbers, or distribution (50 CFR 402.02). Currently there is scarce data regarding the reproduction, numbers, or distribution of DSL. The SSA that is being prepared for the DSL is expected to provide a more detailed analysis of the current and projected future status for the species, including the species' resiliency, redundancy, and representation. The timing of the 2020 DSL CCAA and our section 7 requirement to confer on the proposed action are not ideally sequenced. We recognize the uncertainty with both species' biology and the CCAA and that it is difficult to project both positive and negative outcomes. We also acknowledge that without Permit issuance the activities would occur regardless but would not emphasize minimization or avoidance measures and would not pursue conservation measures. Therefore, using the best available scientific and commercial data available we have determined that issuance of the Permit will not jeopardize the continued existence of the DSL.

VIII. INCIDENTAL TAKE STATEMENT

Section 9 of the Act and Federal regulations pursuant to section 4(d) of the Act prohibit the take of endangered and threatened species, respectively, without special exemption. "Take" is defined as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or to attempt to engage in any such conduct. "Harm" is further defined (50 CFR § 17.3) to include significant habitat modification or degradation that results in death or injury to listed species by significantly impairing essential behavioral patterns, including breeding, feeding, or sheltering. "Harass" is defined (50 CFR § 17.3) as intentional or negligent actions that create the likelihood of injury to listed species to such an extent as to significantly disrupt normal behavior patterns which include, but are not limited to, breeding, feeding or sheltering. "Incidental take" is defined as take that is incidental to, and not the purpose of, the carrying out of an otherwise lawful activity.

The measures described below are non-discretionary and must be undertaken by the Service and the Applicant so that they become binding conditions of any permit issued to the project proponents, as appropriate, for the exemption in section 7(o)(2) to apply. The Service has a continuing duty to regulate the activity covered by this incidental take statement. If the Service (1) fails to assume and implement the terms and conditions or (2) fails to require the Applicant to adhere to the terms and conditions of the incidental take statement through enforceable terms that are added to the permit or grant document, the protective coverage of section 7(o)(2) may lapse. To monitor the impact of incidental take, the Applicant must report the progress of the action and its impact on the species to the Service as specified in the incidental take statement [50 CFR §402.14(i)(3)].

A. Amount or Extent of Take Anticipated

The Service anticipates DSL will be taken as a result of this proposed action. The incidental take is expected to occur in the form of killing and harming DSL from implementation of Covered Activities. This take will be authorized through issuance of an incidental take permit pursuant to 10(a)(1)(A) of the ESA. The Service anticipates incidental take of individual DSL will be difficult to document, since the species is not easily detected, as described in the Effects of the Action section above. However, take of this species can be expressed by the destruction and degradation of DSL habitat. The following amounts of incidental take, as described in the "Effects of the Action" section above, that will be authorized by the proposed Permit for each industry are:

1. Oil and gas: no more than 15,424 acres are likely to be adversely affected.
2. Linear infrastructure: no more than 1,355 acres are likely to be adversely affected.
3. Local government, agriculture and ranching: no more than 834 acres are likely to be adversely affected.
4. Sand mining: no more than 16,560 acres are likely to be adversely affected.
5. Renewable energy: no more than 767 acres are likely to be adversely affected.

B. Effect of the Take

In the accompanying conference opinion, we have determined that the level of anticipated take is not likely to result in jeopardy to the DSL because there is no evidence that issuance of the Permit will appreciably reduce the likelihood of both the survival and recovery of the DSL in the wild. Impacts from the Covered Activities are expected to occur regardless of Permit issuance as legally allowable. Issuance of the Permit will, however, likely be the only reason that avoidance, minimization, conservation, and outreach occur regarding the DSL. The procedures for a conference state that, "during the conference, the Service will make advisory recommendations,

if any, on ways to minimize or avoid adverse effects" (50 CFR 402.10). We have made numerous advisory recommendations to minimize and avoid adverse effects to the Applicant, which have not been included in the CCAA. Additionally, if the species is listed (with or without critical habitat), we will revisit the current state of science at that time, review the activities that have occurred in DSL habitat (both Participant and non-Participant) since approval of the CCAA, and reassess whether the proposed action would result in jeopardy (and adverse modification of critical habitat, if necessary) prior to transitioning this conference opinion into a biological opinion.

C. Reasonable and Prudent Measures

The Service believes the following Reasonable and Prudent Measures (RPMs) are necessary and appropriate to minimize impacts of incidental take on the DSL caused by the proposed action in the Action Area:

All conservation measures including avoidance, minimization, restoration of habitat, biological and compliance monitoring, and reporting requirements are provided in the CCAA and are incorporated herein by reference. No additional reasonable and prudent measures were identified during consultation; therefore, no terms and conditions are necessary.

IX. CONSERVATION RECOMMENDATIONS

Section 7(a)(1) of the ESA directs federal agencies to use their authorities to further the purposes of the ESA by carrying out conservation programs for the benefit of endangered and threatened species. Conservation recommendations are discretionary agency activities to minimize or avoid adverse effects of a proposed action on listed species or critical habitat, to help implement recovery plans, or to develop information.

The following discretionary conservation recommendations are being made to support the conservation of the DSL and implementation of the proposed CCAA, but are not mandatory:

1. Minimize DSL habitat loss and fragmentation on enrolled properties through coordination with the Applicant and oversight of the proposed Permit.
2. Maximize the conservation of habitat that maintains or improves the species' redundancy, resiliency, and representation in the Permit Area.
3. Make recommendations and provide technical assistance to the Administrator to improve the measurable DSL conservation provided through implementation of the CCAA.
4. The Service, in coordination with species experts, is updating the Hardy *et al.* (2018) habitat suitability map. We will distribute this map, and any subsequent revisions, to the Administrator ensuring that the updated habitat map is available for use for DSL habitat determinations used to enroll Participants. The CCAA describes the process.
5. Request the Administrator to monitor and report Participants' groundwater use and chemical composition of disposal water to evaluate the effects of water withdrawal and wastewater disposal on DSL habitat.
6. Request the Administrator require all linear projects avoid High and Intermediate I DSL habitat and assess fees on all entities that construct new facilities in DSL habitat.
7. Request the Administrator require all expansions of facilities already in High and Intermediate I Suitability DSL habitat to move away from, out of, or toward the edge of this high-quality habitat, to the extent practicable.

8. Recommend the Administrator define all components of a single sand mine included in the enrollment, such that a single mine owner cannot enroll multiple mines within the boundaries of the original mine's leasehold. Request the Administrator require mine enrollment applications include the entire lease area, even if only a portion of that lease area will be enrolled at any one time. This will ensure that any contiguous parcels enrolled within that lease area at a later time are not counted as new mines, but simply an extension of the existing mine, preventing a single mine from acting as two or more and acquiring authorization for an additional maximum of 60 acres/year per "site" versus mine.
9. Recommend that the Administrator develop mitigation measures based on the biological needs of the DSL and be designed to offset the impacts of the take from the Covered Activities. If habitat will be permanently lost, protect alternative habitat in perpetuity to offset the loss, and maintain the appropriate habitat conditions at the mitigation site in perpetuity (Service and NMFS 2016). Request the Administrator set specific goals for mitigation acreage through mitigation ratios; higher ratios for higher quality habitat and even higher ratios for impacts to conservation lands. Request the Administrator implement mitigation measures, removing well pads/roads in High Suitability habitat, and then study the efficacy, not vice versa. Use a non-wasting endowment where necessary for long term management of easements.
10. Request the Administrator draft a plan that specifically lays out steps to address stratification, including lessons learned from the TCP, outreach methods, and incentives for encouraging participation of all mineral estates. Make recommendations to the Administrator to include adaptive management actions and resolutions, and changed circumstance measures and responses, particularly if stratification issues cannot be overcome.
11. Request the Administrator requests approval by the Service of the Conservation Plan, so we can ensure a net conservation benefit is achievable as outlined in the strategy.
12. Recommend the Administrator improve the adaptive management process in the CCAA to include identifying uncertainties in the CCAA, providing hypotheses to test the uncertainties, providing triggers as to when changes need to be made, and defining what those changes should be. Also, adaptive management should be linked when testing uncertainties in the plan to Changed Circumstances.
13. Request the Administrator for at least the first three years of implementation, request review and concurrence from the Service on application packages and determinations.
14. Request the Administrator clearly define success and effectiveness for each of the items outlined in Chapter 8.2, effectiveness monitoring. Each of these should have specific targets set and steps that will be taken if those targets are exceeded. For example, increasing mitigation to offset increasing impacts across the landscape. Explain what the Administrator will do as a result of recommendations from the AMC, including when the Administrator chooses not to act on the AMC's recommendations.

X. REINITIATION NOTICE

This concludes our conference opinion for the 2020 DSL CCAA. The Service may adopt this conference opinion as a biological opinion if the proposed species is listed or critical habitat is designated. If there have been no significant changes in the action that would alter the content of the opinion or no significant new information, the Service will adopt the conference opinion as the biological opinion. An incidental take statement provided with a conference opinion does

not become effective unless the Service adopts the opinion once the listing is final (50 C.F.R 402.10). If significant new information is provided, for example as a result of the SSA, the Service will need to reinitiate consultation to update the opinion to reflect this information and to analyze what effects, if any, the Permit will have on the listed species or its designated critical habitat.

The incidental take statement provided in this conference opinion does not become effective until the species is listed and the conference opinion is adopted as the biological opinion. At that time, the project will be reviewed to determine whether any take of the proposed species has occurred and what conservation actions have been implemented. Modifications of the opinion and incidental take statement may be appropriate to reflect that take and what conservation benefits, if any, have occurred.

Reinitiation of consultation is required where discretionary Federal involvement or control over the action has been retained or is authorized by law (50 C.F.R. 402.16). After listing as threatened or endangered and any subsequent adoption of this conference opinion, the Service shall reinitiate consultation: 1) if the amount or extent of incidental taking specified in the incidental take statement is exceeded; 2) if new information reveals effects of the action that may affect listed species or critical habitat in a manner or to an extent not previously considered; 3) if the identified action is subsequently modified in a manner that causes an effect to the listed species or critical habitat that was not considered in the opinion or written concurrence; or 4) if a new species is listed or critical habitat designated that may be affected by the identified action.

Approved:

ADAM ZERRENNER Digitally signed by ADAM ZERRENNER
Date: 2021.01.20 10:41:33 -06'00'

Adam Zerrenner, Field Supervisor
Austin Ecological Services Field Office

Date

Concur:

PETER FASBENDER Digitally signed by PETER FASBENDER
Date: 2021.01.20 09:50:04 -07'00'

Pete Fasbender, Assistant Regional Director, ES Region 2

Date

XI. LITERATURE CITED

Alderfer, J. 2006. National Geographic field guide to birds: Texas. 272 pp.

Anaya, R., and I.C. Jones. 2009. Groundwater availability model for the Edwards-Trinity (Plateau) and Pecos Valley Aquifers of West Texas: Texas Water Development Board, Report 373, 103 p.

Ashkenazy, Y. and E. Shilo. 2018. Sand dune albedo feedback. Geosciences 8:82. 12 pp.

Axtell, R.W. 1988. Interpretive atlas of Texas lizards – *Sceloporus graciosus arenicolus*. Privately printed. No. 5:1-4.

Benson, M.E. and A.B. Wilson. 2015. Frac sand in the United States—A geological and industry overview. U.S. Geological Survey. Open-File Report 2015–1107. 78 pp.

Boghici, R. 1998. Updated evaluation of groundwater resources in parts of Trans-Pecos, Texas: Texas Water Development Board, Open-File Report 98-03, 29 pp.

Bovey, R.W., R.E. Meyer, and H. Hein, Jr. 1982. Soil persistence of tebuthiuron in the claypan resource area of Texas. Weed Science. 30:140-144.

Boyd, C.S. and T.G. Bidwell. 2002. Effects of prescribed fire on shinnery oak (*Quercus havardii*) plant communities in western Oklahoma. Restoration Ecology. 10(2):324-333.

Breckle, S-W., A. Yair, and M. Veste. 2008. General conclusions – sand dune deserts, desertification, rehabilitation, and conservation. In: Arid Dune Ecosystems, The Nizzana Sands in the Negev Desert. Ecological Studies 200(30): 441-460.

Brody, A.R. 2018. Blown sway: wind energy in the Southern states (Part II). Available at: https://knowledgecenter.csg.org/kc/content/blown-away-wind-energy-southern-states-part-ii.

Campbell, J.E., M.R. Sharifi, P.W. Rundel. 2017. Impact of ground water depletion on the mesquite community at Edwards Air Force Base, Western Mojave Desert, California. Aliso. 35:2. 9 pp.

Carroll, J.M., R.D. Elmore, C. Davis, S.D. Fuhlendorf. 2019. Propagation of shinnery oak as a framework for restoration. Rangeland Ecology & Management. 72:4. 3 pp.

Chan, L.M., C.W. Painter, M.T. Hill, T.J. Hibbitts, D.J. Leavitt, W.A. Ryberg, D. Walkup, L.A. Fitzgerald. 2020. Phylogeographic structure of the dunes sagebrush lizard, an endemic habitat specialist. PLoS ONE 15(9). 21 pp.

Chan, L.M., L.A. Fitzgerald, and K. Zamudio. 2009. The scale of genetic differentiation in the dunes sagebrush lizard, an endemic habitat specialist. Conservation Genetics 10:131-142.

Chan, L., J. Archie, A. Yoder and L.A. Fitzgerald. 2013. Review of the systematic status of *Sceloporus arenicolus* Degenhardt and Jones, 1972 with an estimate of divergence time. Zootaxa 3664 (3):312-320.

Cole, C.J. 1975. Karyotype and systematic status of the sand dune lizard of the American Southwest. Herpetologica 32:288-293.

Cooke, R.U. and A. Warren. 1973. Geomorphology in Desserts. xii+374 pp., 100 maps and diagrams, 80 pls. B. T. Batsford, London.

Cornett, J.W. 2013. The Chihuahuan Dessert. Publisher: Nature Trails Press, 1st Edition.

Cox, R.D. and W.J. Davis. 2013. Restoration of habitat for *Sceloporus arenicolus a* final report to CEHMM. 15 pp.

CPA (Texas Comptroller of Public Accounts). 2018. Texas conservation plan for the dunes sagebrush lizard. Annual Report 2017. Submitted March 2018. 19 pp.

Degenhardt, W. and K. Jones. 1972. A new sagebrush lizard, *Sceloporus graciosus*, from New Mexico and Texas. Herpetologica 28:212-217.

Degenhardt, W.G., C.W. Painter, and A.H. Price. 2005. Amphibians and reptiles of New Mexico. University of New Mexico Press. Albuquerque. 431 pp.

Dhillion, S.S. and M.H. Mills. 2009. The sand shinnery oak (*Quercus havardii*) communities of the Llano Estacado: history, structure, ecology, and restoration. In: R.A. Anderson, J.S. Fralish, and J.M. Baskin, eds. Savannas, Barrens, and Rock Outcrop Plant Communities of North America. 1999.

Dhillion, S.S., M.A. McGinley, C.F. Friese, and J.C. Zak. 1994. Construction of sand shinnery oak communities of the Llano Estacado: Animal disturbances, plant community structure and restoration. Restoration Ecology. 2(1):51-60.

Dzialak, M.R., D.J. Houchen, S.M. Harju, J.P. Mudd, J.J. Wondzell, S.L. Webb, N.P. Gould, J.E. Hess, J.B. Winstead. 2013. Ecosystem-level dynamics of soil-vegetation features, with implications for conserving a narrowly endemic reptile. Landscape Ecology. 28:1371-1385.

Enverus. 2020. Ultimate guide for Permian news, information, facts and statistics. Available at: https://www.enverus.com/permian-basin/

Emmerich, W.E. 1985. Tebuthiuron – environmental concerns. Rangelands. 7:1. 3 pp.

ERCOT (Electric Reliability Council of Texas). 2017. The Texas competitive renewable energy zone process. Presentation accessed at: https://cleanenergysolutions.org/sites/default/files/documents/jeff-billo_webinar-ercot-crez-process.pdf. 23 pp.

Ferguson, G., W. Gehrmann, A. Brinker, and G. Kroh. 2014. Daily and seasonal patterns of natural ultraviolet light exposure of the western sagebrush lizard (*Sceloporus graciosus gracilis*) and the dunes sagebrush lizard (*Sceloporus arenicolus*). Herpetologica. 70(1):56-68.

Fitzgerald, L.A. and C.W. Painter. 2009. Dunes sagebrush lizard (*Sceloporus arenicolus*). In: Jones, L.L.C. and R.E. Lovich (Eds.), Lizards of the American Southwest: A Photographic Field Guide. Rio Nuevo Publishers, Tucson, Arizona. pp. 198–120.

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

Fitzgerald, L.A., M. Sears, and C.W. Painter. 2005. Interdune dispersal of sand dune lizards in the Mescalero Sands ecosystem. Report to New Mexico Department of Game and Fish.

Fitzgerald, L.A. and C.W. Painter. 2009. Dunes sagebrush lizard (*Sceloporus arenicolus*). p. 198-201. In: Jones, L. and R. Lovich. Lizards of the American Southwest. Rio Nuevo Publishers. Tucson, AZ. 567 pp.

Fitzgerald, L.A., C.W. Painter, T.J. Hibbitts, W.A. Ryberg, and N. Smolensky. 2011. The range and distribution of *Sceloporus arenicolus* in Texas: results of surveys conducted 8-15 June 2011: Final Report. Texas A&M University.

Forstner, M.J., D. Neuharth, M. Kiehne, D. Foley III, T. Hardy, and J. Jensen. 2018. West Texas frac-sands threats analysis to the dunes sagebrush lizard (*Sceloporus arenicolus*). Texas

State University System. Prepared July 25, 2018, for the Texas Comptroller of Public Accounts. 31 pp.
Garza, S. and J.B. Wesselman. 1959. Geology and ground-water resources of Winkler County, Texas: Texas Board of Water Engineers. Bulletin 5916. 200 pp.
Gucker, C.L. 2006. *Quercus havardii*. In: Fire Effects Information System. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory (Producer). Available: https://www.fs.fed.us/database/feis/plants/shrub/quehar/all.html
Hammerson, G.A. 2007. *Sceloporus graciosus*—The International Union for Conservation of Nature Red List of Threatened Species. IUCN web site.
Hardy, T., J. Jensen, and M.J. Forstner. 2018. Alpha Texas dunes sagebrush lizard (*Sceloporus arenicolus*) habitat model. Texas State University, San Marcos, TX.
Henle, K., K.F. Davies, M. Kleyer, and C. Margules. 2004. Predictors of species sensitivity to fragmentation. Biodiversity and Conservation. 13(1):207-251.
Hibbitts, T. and T. Hibbitts. 2015. Texas lizards: a field guide. University of Texas Press. 352 pp.
Hibbitts, T.J., W.A. Ryberg, C.S. Adams, A.M. Fields, D. Lay, and M.E. Young. 2013. Microhabitat selection by a habitat specialist and a generalist in both fragmented and unfragmented landscapes. Herpetological Conservation and Biology 8: 104-113.
Hibbitts T.J., L.A. Fitzgerald, D.K. Walkup, and W.A. Ryberg. 2017. Why didn't the lizard cross the road? Dunes sagebrush lizards exhibit road avoidance behavior. Wildlife Res. 44(3): 194–199.
Hill, M. and L.A. Fitzgerald. 2007. Radiotelemetry and population monitoring of sand dune lizards during the nesting season. Share with Wildlife Project Report: Dispersal and radio tracking of the sand dune lizard.
Hokit, D.G. and L.C. Branch. 2003. Associations between patch area and vital rates: Consequences for local and regional populations. Ecological Applications 13:4. 1060-1068.
Holliday, V.T. 2001. Stratigraphy and geochronology of upper Quaternary eolian sand on the southern high plains of Texas and New Mexico. United States. Geological Society of America Bulletin 113(1):88-108.
Hughes, J.M. 1996. Greater roadrunner (*Geococcyx californianus*). In The birds of North America, No. 244., edited by A. Poole and F. Gill. Washington, D.C: Acad. Nat. Sci., Philadelphia, PA, and Am. Ornithol. Union.
Intergovernmental Panel on Climate Change. 2013. Climate change 2013, The physical science basis. Working Group 1 Contribution to the Fifth Assessment Report. 222 pp.
Jiang, X. and Z-L.Yang. 2012. Projected changes of temperature and precipitation in Texas from downscaled global climate models. Clim Res 53:229-44. https://doi.org/10.3354/cr01093
Johnson, K., M. Horner, E. Muldavin, P. Neville, T. Neville, and J. Smith. 2016. Dunes sagebrush lizard habitat map and models, New Mexico. Natural Heritage New Mexico Publ. No. 15-387. Natural Heritage New Mexico, University of New Mexico, Albuquerque, NM.
Johnsen, Jr., T.N. and H.L. Morton. 1991. Long-term teburhiuron content of grasses and shrubs on semiarid rangelands. Journal of Range Management 44:3. pp. 249-253.

Jones, I.C. 2004. Cenozoic Pecos Alluvium Aquifer. In: Mace, R.E., W.F. Mullican III, and E.S. Angle (Eds). Aquifers of West Texas: Texas Water Development Board Report 356, pp. 120–134.

Jones, V.E. and R.D. Pettit. 1984. Low rates of tebuthiuron for control of sand shinnery oak. Journal of Range Management, 37(6), 488-490.

Kiehne, M.L. 2019. An assessment of visual encounter surveys for an elusive species – the dunes sagebrush lizard (*Sceloporus arenicolus*). A thesis submitted to Texas State University. August 2019. 57 pp.

Kinniburgh, F., M.G. Simonton, and C. Allouch. 2015. Come heat and high water: Climate risk in the Southeastern U.S. and Texas. Published by Risky Business. 114 pp.

Kocurek, G. and K.G. Havholm. 1993. Eolian sequence stratigraphy – a conceptual framework. In: Weimer, P. and H. Posamentier. 1993. Siliciclastic sequence stratigraphy: Recent developments and applications. AAPG Memoir, Vol. 58.

Laity, J. 2003. Aeolian Destabilization Along the Mojave River, Mojave Desert, California: Linkages Among Fluvial, Groundwater, and Aeolian Systems, Physical Geography, 24:3, 196-221, DOI: 10.2747/0272-3646.24.3.196.

Laurencio, L.R. and L.A. Fitzgerald. 2010. Atlas of distribution and habitat of the dunes sagebrush lizard (*Sceloporus arenicolus*) in New Mexico. Texas Cooperative Wildlife Collection, Department of Wildlife and Fisheries Sciences, Texas A&M University, College Station, TX 77843-2258. ISBN# 978-0-615-40937-5.

Laurencio, L., D. Laurencio, and L.A. Fitzgerald. 2007. Geographic distribution and habitat suitability of the sand dune lizard (*Sceloporus arenicolus*) in Texas. Final Report, Section 6 Grant No. E-64, submitted to Texas Parks and Wildlife Department. 40 pp.

Leavitt, D.J. 2019. Climatic conditions of the Mescalero-Monahans Shinnery Sands and how they relate to activity patterns of the Dunes Sagebrush Lizard. Report prepared for Center of Excellence in Hazardous Materials Management.

Leavitt, D. and L. Fitzgerald. 2013. Disassembly of a Dune-dwelling Lizard Community due to Landscape Fragmentation. Ecosphere 4(8): 97.

Mace, R.E. 2019. Frac sand facilities and their potential effects on the groundwater resources of the Monahans-Mescalero Sand Ecosystem, Permian Basin. The Meadows Center for Water and the Environment, Texas State University. A report for the Texas Comptroller of Public Accounts, Contract CMD No. 19-6754CS, January 2019. 135+ pp.

Machenberg, M. 1984. Geology of Monahans Sandhills State Park, Texas. Guidebook 21. University of Texas at Austin. Bureau of Economic Geology.

Mangal, M. and C. Tier. 1993. A simple direct method for finding persistence times of populations and application to conservation problems. Proceedings of the National Academy of Sciences of the USA 90:1083-1086.

Maslowski, A. 2012. Where does frac sand come from? Well Servicing Magazine, published by Association of Energy Service Companies.

Mossa, J. and L.A. James. 2013. Impacts of mining on geomorphic systems. In: John F. Shroder (Ed.), Treatise on Geomorphology, Volume 13, pp. 74-95. San Diego: Academic Press.

Muhs, D.R. and V.T. Holliday. 2001. Origin of late Quaternary dune fields on the southern high plains of Texas and New Mexico. Geologic Society of America Bulletin 113(1):75-87.

Natural Resources Solutions. 2021. Analysis of Sand Mining Activities in Texas: Change Detection Analysis. Developed by Natural Resources Solutions and Presented by American Conservation Foundation. Part 3 of 3. 13 pp.

Newton, B.T. and B. Allen. 2014. Hydrologic investigation at White Sands National Monument. New Mexico Bureau of Geology and Mineral Resources. Aquifer Mapping Program. Report 559. 98 pp.

Nicotra, A.B., E.A. Beever, A.L. Robertson, G.E. Hofmann, and J. O'Leary. 2015. Assessing the components of adaptive capacity to improve conservation and management efforts under global change. Conservation Biology 29:1268-1278.

Nusser, N. 2020. Texas solar hits a turning point; As the coronavirus pandemic devastates the state's already flailing oil and gas industry, solar energy production is on a trajectory for record growth.

Ouren, D.S., C. Haas, C.P. Melcher, S.C. Stewart, P.D. Ponds, N.R. Sexton, L. Burris, T. Fancher, and Z.H. Bowen. 2007. Environmental effects of off-highway vehicles on Bureau of Land Management lands: a literature synthesis, annotated bibliographies, extensive bibliographies, and internet resources. US Geological Service, Denver, Colorado, 241 pp.

Painter, C.W. 2004. Conservation of the sand dune lizard in New Mexico. New Mexico Department of Game and Fish. Santa Fe, NM.

Painter, C.W. and D.S. Sias. 1998. Geographic Distribution. *Sceloporus arenicolus*. Herpetol. Rev. 29(1):52.

Painter, C.W, D.S. Sias, L.A. Fitzgerald, L. Pierce, and H. Snell. 1999. Management Plan for the Sand Dune Lizard *Sceloporus arenicolus* in New Mexico.

Peterson, R. and C.S. Boyd. 1998. Ecology and management of sand shinnery communities: a literature review. Gen. Tech. Rep. RMRS-GTR-16. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 44 p.

Pettit, R.D. 1979. Effects of picloram and tebuthiuron pellets on sand shinnery oak communities. Journal of Range Management, 32(3), 196-200.

Pye, K. and T. Haim. 2009. Management and human use of sand dune environments. In Aeolian Sand and Sand Dunes. pp.329-367.

Rainwater, K. 2020. Sand mining water use in West Texas. 35 pp.

Redford, K.H., G. Amato, J. Baillie, P. Beldomenico, E.L. Bennett, N. Clum, R. Cook, G. Fonseca, S. Hedges, F. Launay, S. Lieberman, G.M. Mace, A. Murayama, A. Putnam, J.G. Robinson, H. Rosenbaum, E.W. Sanderson, S.N. Stuart, P. Thomas, and J. Thorbjarnarson. 2011. What Does It Mean to Successfully Conserve a (Vertebrate) Species? BioScience 61: 39–48.

Rich, J. and S. Stokes. 2011. A 200,000-year record of late Quaternary Aeolian sedimentation on the Southern High Plains and nearby Pecos River Valley, USA. Aeolian Research **2**:221–240.

Robinson, T.W. 1958. Phreatophytes. U.S. Geological Survey, Water Supply Paper No. 1423. 84 pp.

Ruppel, S.C. 2009. Integrated synthesis of the Permian Basin: data and models for recovering existing and undiscovered oil resources from the largest oil-bearing basin in the U.S. Final Technical Report DOE Award No. DE-FC26-04NT15509

Ryberg, W.A. and L.A. Fitzgerald. 2015. Sand Grain Composition Influences Subsurface Oxygen Diffusion and Distribution of an Endemic Psammophilic Lizard. Journal of Zoology 295 116-121.

Ryberg, W.A. and L.A. Fitzgerald. 2014. Sand grain size composition influences subsurface oxygen diffusion and distribution of an endemic, psammophilic lizard. Journal of Zoology 295:2.

Ryberg, W.A, M.T. Hill, D. Lay, and L.A. Fitzgerald. 2012. Observations on the Nesting Ecology and Early Life History of the Dunes Sagebrush Lizard. Western North American Naturalist 72(4). 582-585.

Ryberg, W.A., M.T. Hill, C.W. Painter, and L.A. Fitzgerald. 2013. Landscape Pattern Determines Neighborhood Size and Structure within a Lizard Population. PLOS ONE: 8(2).

Ryberg, W.A., M.T. Hill, C.W. Painter, and L.A. Fitzgerald. 2015. Linking irreplaceable landforms in a self-organizing landscape to sensitivity of population vital Rates for an Ecological Specialist. Conservation Biology 29 (3): 888-898.

Sartorius, S.S., J.P.S. do Amaral, R.D. Durtsche, C.M. Deen, and W.I. Luterschmidt. 2002. Thermoregulatory accuracy, precision, and effectiveness in two sand-dwelling lizards under mild environmental conditions. Canadian Journal of Zoology 80:1966-1976.

Service and NMFS (U.S. Fish and Wildlife Service and National Marine Fisheries Service). 2016. Habitat conservation planning and incidental take permit processing handbook. December 2016. 409 pp.

Shaffer M.L. and B.A. Stein. 2000. Safeguarding our precious heritage. In: Stein, B.A., L.S. Kutner, J.S. Adams (Eds). Precious heritage: the status of biodiversity in the United States. New York: Oxford University Press. Pp. 301-321.

Sias, D.S. and H.L. Snell. 1998 The Sand Dune Lizard *Sceloporus arenicolus* and Oil and Gas Development in Southeastern New Mexico. Final Report of field studies 1995-1997. Report to New Mexico Department of Game and Fish.

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

Smallwood, J.A. and D.M. Bird. 2002. American Kestrel (*Falco sparverius*). In: Poole, A. (Ed.) The Birds of North America Online. Ithaca: Cornell Lab of Ornithology; Retrieved from the Birds of North America Online: http://bna.birds.cornell.edu/bna/species/602 doi:10.2173/bna.602

Smolensky, N. and L.A. Fitzgerald. 2010. Distance sampling underestimates population densities of dune dwelling lizards. Journal of Herpetology 44:372-381.

Smythe, L., and D.A. Haukos. 2010. Density of grassland birds in sand shinnery oak communities treated with tebuthiuron and grazing in eastern New Mexico. Restoration Ecology 18:215-223.

Stromberg, J.C., J.A. Tress, S.D. Wilkins, and S. Clark S. 1992. Response of velvet mesquite to groundwater decline. Journal of Arid Environments, 23:45–58.

Stromberg, J.C., S.D. Wilkins, and J.A. Tress. 1993. Vegetation-hydrology models as management tools for velvet mesquite (*Prosopis velutina*) riparian ecosystems. Ecological Applications, 3: 307–314.

TAMU (Texas A&M University). 2016. Best Practices for Managing Dunes Sagebrush Lizards in Texas. Institute of Renewable Natural Resources, Department of Wildlife and Fisheries Sciences, Biodiversity Research and Teaching Collections. Dunes Sagebrush Lizard Team. 93 pp.

Van Pelt, W.E., S. Kyle, J. Pitman, D. Klute, G. Beauprez, D. Schoeling, A. Janus, and J. Haufler. 2013. The lesser prairie-chicken range-wide conservation plan. Western Association of Fish and Wildlife Agencies. Cheyenne, Wyoming. 367 pp.

Walkup, D.K., W.A. Ryberg, L.A. Fitzgerald, and T.J. Hibbitts. 2018. Occupancy and detection of an endemic habitat specialist, the dunes sagebrush lizard. Herpetological Conservation and Biology. 13(3):497-506.

Walkup D.K., D.J. Leavitt, and L.A. Fitzgerald. 2017. Effects of habitat fragmentation on population structure of dune-dwelling lizards. Ecosphere. 8:3, 14 pp.

Wisconsin Department of Natural Resources. 2012. Silica sand mining in Wisconsin. January 2012. 43 pp.

Yosef, R. 1996. Loggerhead shrike (*Lanius ludovicianus*). In: Poole A. and F. Gill (Eds). 1996. The Birds of North America, No.231. The Academy of Natural Sciences, Philadelphia, and The American Ornithologists' Union, Washington, D.C.

Young, M.E., W.A. Ryberg, L.A. Fitzgerald, and T.J. Hibbitts. 2018. Fragmentation alters home range and movements of the Dunes Sagebrush Lizard. Canadian Journal of Zoology 96: 905-912.