

**TEXAS CONSERVATION PLAN
FOR THE DUNES SAGEBRUSH LIZARD**

Conservation Program

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The Texas Conservation Plan Conservation Program (TCPCP)

Executive Summary

The Texas Conservation Plan (TCP) commits to implementing recovery strategies that support the persistence and recovery/potential delisting of the Dunes Sagebrush Lizard (*Sceloporus arenicolus*, DSL). The species was federally listed as endangered in May 2024, confirming the need for targeted, science-based conservation. Since 2012, the TCP has enrolled over 572,000 acres, limiting habitat disturbance to only 438.58 acres, with just 15.12 acres within TCP-enrolled lands since transfer of the permit to American Conservation Foundation, Inc. (ACF) in 2020. While this reflects strong progress in avoidance and minimization, recovery requires a more comprehensive, research-driven framework.

The Texas Conservation Plan Conservation Program (TCPCP) provides a strategic five-year roadmap to advance DSL conservation and recovery in Texas. The TCPCP integrates two core components within an adaptive framework: Research and Management. Research priorities focus on four pillars: 1) understanding DSL habitat, occurrence, and distributions, 2) the effects of environmental conditions, 3) habitat enhancement, restoration, and creation, and 4) landscape and population ecology. The management component will be structured in two phases. Management Phase One will focus on the design, experimental application, and intensive monitoring of management techniques that protect, enhance, restore, or create conditions supporting DSL. Management Phase Two will use data and results from Phase One to design and implement local and landscape scale management plans.

Development of the TCPCP was guided by a comprehensive review of literature, regulatory documents, expert consultation, and knowledge from related ecological systems. The review process revealed areas of significant need to develop and enhance knowledge and understanding of DSL ecology, sand shinnery dynamics, and effective management practices. Addressing these gaps is essential to designing management strategies that yield measurable conservation outcomes.

The TCPCP establishes an adaptive research and management approach, creating a feedback loop where research findings inform management, management actions are rigorously monitored, serving as research projects in themselves, and all results are evaluated annually to guide adaptive revisions to research and management approaches and priorities. This ensures conservation actions become increasingly accurate and effective over time, enabling the TCP and its partners to optimize resources and contribute meaningfully to the long-term recovery of the DSL.

1. Introduction

1.1 Species Background

The DSL is a habitat specialist endemic to the shinnery oak (*Quercus havardii*) sand dune ecosystems of the Mescalero and Monahans Sandhills in the Permian Basin of southeastern New Mexico and western Texas. This species relies exclusively on the complex and dynamic structure of shinnery oak-dominated dunes for essential life history functions, including thermoregulation, shelter, reproduction, and foraging (Fitzgerald et al. 1997; Hibbitts et al. 2013; Ryberg et al. 2013; Walkup et al. 2018). Occupied habitats are characterized by loose, sandy substrates, interspersed with shinnery oak cover and open dune blowouts.

Habitat loss, degradation, and fragmentation are considered the most significant threats to the DSL. Anthropogenic land use (e.g., clearing and maintaining agricultural fields, construction of roads, well pads, frac sand mining, etc.) in some areas has converted DSL habitat for other uses. These surface impacts can reduce the area of habitat available for the species and may result in changes to DSL occupancy, movement and landscape ecology, population dynamics, or genetic connectivity. Some previous research has investigated how DSL may be impacted by one or more types of surface impacts such as roads and well pads (Hibbitts et al 2017, Smolensky and Fitzgerald 2011) and the effects of surface and landscape features more broadly (Hibbitts et al 2013, Walkup et al 2017, Walkup et al 2019, Smolensky and Fitzgerald 2011, Young et al 2018) . However, our knowledge of how surface impacts such as roads, well pads, frac sand mining, and agricultural practices, affect DSL is still significantly limited, and current knowledge is insufficient to inform the design and implementation of effective, efficient conservation and recovery efforts (Leavitt and Fitzgerald 2013; Walkup et al. 2018; U.S. Fish and Wildlife Service 2024). Other actions within existing DSL

habitat may reduce habitat quality; for example, targeted removal of shinnery oak vegetation through herbicide application can alter vegetation cover and structure in ways that may have deleterious effects on DSL fitness, though research on these impacts remains limited (Fitzgerald et al. 2011). Collectively, these factors may pose substantial challenges to the long-term persistence of DSL populations (U.S. Fish and Wildlife Service 2024).

1.2 Conservation Need

1.2.1 Current Species' Status

The DSL was federally listed as an endangered species under the Endangered Species Act (ESA) in May 2024 due to threats to the species' habitat (U.S. Fish and Wildlife Service 2024; Federal Register 89, no. 98). This designation stresses the need for implementing targeted conservation actions that prevent further population decline and ensure the species' long-term survival.

The DSL has a long history of conservation concern. The species was first identified as a candidate for listing in 1982 and was formally proposed for endangered status in 2010 (U.S. Fish and Wildlife Service 2022). In 2012, the listing proposal was withdrawn due to the implementation of several voluntary conservation measures, including two Texas Candidate Conservation Agreements with Assurances (CCAAs)— Texas Conservation Plan for the Dunes Sagebrush Lizard - American Conservation Foundation CCAA and the 2020 CCAA for the Dunes Sagebrush Lizard in West Texas— as well as the CEHMM CCAA for Lesser Prairie Chicken and Dunes Sagebrush Lizard in New Mexico. Despite these efforts, the federal listing document identified threats such as habitat degradation, loss, and fragmentation, ultimately leading to the species' federal listing in 2024.

1.2.2 TCP Pre-listing Conservation Efforts

Prior to federal listing, the TCP was developed to proactively protect the DSL and its habitat within the Hibbitts map to prevent the need for ESA regulatory protection. The ACF serves as the current permit holder for the TCP and administers the program in coordination with enrolled participants and conservation partners. Since its implementation in 2012, the TCP has demonstrated considerable success. By January 2025, 24 participants had enrolled 572,017 acres under conservation commitments, with avoidance and minimization strategies applied across these enrolled lands.

To support accountability and ESA Permit requirements, beginning in the first quarter of 2021, Natural Resources Solutions, L.C. (NRS), on behalf of ACF, initiated quarterly Change Detection Analysis (CDA) of the DSL enrolled acres to track habitat impacts within enrolled acres, providing a high-precision, landscape-scale evaluation of habitat change.

Between 2012-2020, reports indicated an average of 50 acres of DSL habitat were impacted per year. Following transfer of the TCP permit to ACF, with improvements in efficacy of avoidance and minimization and associated accountability measures, impacts were reduced to an average of only four acres per year from 2020–2025.

Since the creation of the TCP, 438.58 acres of designated DSL habitat (Hibbitts DSL habitat) have been disturbed, with only 15.12 acres occurring on lands enrolled in the TCP since ACF assumed permit holder responsibilities. Notably, 13.1 of these acres resulted from a single disturbance event. This low level of impact on DSL habitat during this time reflects the effectiveness of avoidance-based strategies and strong participant compliance with conservation commitments.

2. Purpose & Framework of the TCPCP

The TCP states that “The Plan will include a recovery strategy aimed at implementing activities that, if the species is listed, will help move the species toward recovery and potential delisting.” Although a Recovery Outline was completed by the FWS and published (U.S. Fish and Wildlife Service, *Dunes Sagebrush Lizard Recovery Outline* (Albuquerque, NM: U.S. Fish and Wildlife Service, June 14, 2024), a formal Recovery Plan for the DSL has not yet been completed. In the absence of a completed Recovery Plan, this TCPCP will guide ACF’s conservation and recovery actions.

To be effective at working toward species’ recovery, this TCPCP must address these five key needs: (1) avoiding and/or minimizing impacts to existing habitat, (2) protecting existing habitat, (3) enhancing habitat quality as measured by DSL occurrence and fitness, (4) determining if and how areas that have previously been suitable habitat may be restored, (5) if and how new habitat can be created in strategic locations of the species’ range. Meeting these needs effectively and efficiently requires conservation and management actions, strategies, and plans at both the local and landscape scales that are based on robust knowledge of DSL ecology, including habitat and population dynamics, behavior, physiology, and ecosystem interactions.

Using an adaptive framework is also an essential feature of the TCPCP to optimize efficacy. The adaptive approach uses intensive biological and ecological monitoring and analysis of management actions to create a feedback loop that ensures that biologically effective management strategies and actions are identified and amplified, and less or ineffective actions are discarded and replaced.

The design of the TCPCP was informed by an extensive review of available literature, expert consultation, regulatory documentation, and ecological assessments. This review identified key knowledge needs relating to DSL habitat ecology, occupancy and distributions, population and landscape ecology, genetics, physiology, and ecology of the dune sagebrush system and plant communities that support DSL. The current gaps in knowledge constrain the capacity for data-driven conservation strategies to be developed. This underscores the need for targeted research to address the key knowledge needed to design effective conservation and management plans and strategies. The TCPCP prioritizes those targeted research questions that are necessary to inform management actions that effectively avoid and minimize impacts on the DSL, and enable habitat enhancement, restoration, and creation.

To achieve this, the TCPCP is organized into two major categories of effort working within an adaptive framework: Research and Management. This combined approach optimizes the effective and efficient use of available resources within the TCP and its partners to generate the greatest conservation benefit for the DSL and move the species toward recovery. This document details a strategic five-year plan to implement an integrated set of research and management activities to further the aims of conservation and recovery of the DSL in Texas.

3. Goals & Objectives

The goals, objectives, and structure of the TCPCP were informed by an extensive review of available literature and information about the DSL, similar species and ecological systems, current regulatory documents (e.g., from the DSL SSA and the Recovery Outline), expert input, and other credible sources of information to identify essential steps toward species recovery.

The review identified substantial knowledge needs, specifically operationally useable knowledge of DSL ecology that could inform and guide effective management activities and strategies. The review considered all available information and research through the lens of the goal of the TCPCP and of

conservation and recovery plans more broadly: designing and implementing local and landscape level plans for the long-term conservation and recovery of DSL.

Areas identified as “knowledge needs” and the selected research priorities below do not imply a complete lack of research touching on the topic, but rather, indicate that the available information is not yet sufficiently accurate, rigorous, or useful to inform conservation and management actions, techniques, strategies, or tools. Areas identified as “knowledge needs” are those for which we determined that thoughtfully designed studies addressing specific questions, to generate knowledge *that can be applied directly to conservation and management planning* are most needed and where the results will be most useful for guiding actions to move toward DSL recovery.

Previous research provides a starting point for additional, strategically-designed studies, that can yield the knowledge necessary to design and implement management *actions* to help recover the DSL (see examples: Chan et al 2020, Hibbitts et al 2013, Hibbitts et al 2017, Leavitt and Fitzgerald 2013, Walkup et al 2017, Walkup et al 2019). These priorities include: DSL habitat ecology, occupancy, and distributions; population and landscape ecology, DSL responses to environmental conditions (temperature, aridity, rainfall, etc.), and investigating approaches to habitat enhancement, restoration, and creation (through restoration and ecosystem ecology of the dune sagebrush ecosystem).

While some previous research has provided some information about DSL habitat requirements, species distributions, occupancy, and habitat quality for DSL, a more rigorous understanding of what drives DSL occupancy, and a spatially-explicit, quantitative understanding of patterns of DSL occupancy is essential for not only optimizing avoidance and minimization efforts but also guiding the most strategic prioritization and implementation of conservation and management actions. Research on population and landscape ecology of DSL has been relatively limited. Studies to provide information on population size and population dynamics, density, population parameters such as survivorship, mortality, and fecundity; movement and dispersal patterns and responses to landscape conditions are essential to guide conservation and management strategies that support long term population persistence.

Little is known about DSL responses to environmental conditions such as (temperature, aridity, rainfall, etc.). Addressing knowledge needs in this area is essential for designing conservation and

management strategies that account for the variable and changing conditions (e.g. drought/rainfall annual cycles) that can fundamentally affect DSL both directly through survival and fecundity as well as indirectly through effects on vegetation and other habitat conditions. Our review also identified significant gaps in knowledge regarding what management actions, tools, and techniques, at both the local and landscape scale, may affect DSL habitat and the surrounding ecosystem, and how the species and/or system respond to those actions. Past and current approaches to DSL conservation have largely focused on avoidance and minimization. Additional research is needed to improve our ability to accurately and effectively avoid and minimize, as well as what management actions and strategies may enhance, restore, or create DSL habitat. Our ability to move toward DSL recovery is contingent on developing a toolkit of techniques and strategies that can expand beyond avoidance approaches. The lack of knowledge has led to a lack of data-driven management approaches that can be confidently expected to benefit the DSL, limiting our ability to work toward species' recovery. To address this need, the TCPCP identifies a set of research questions essential to inform management actions to effectively avoid and minimize impacts to DSL, as well as to enhance, restore, or create habitat for the species.

Prioritizing these focal knowledge needs will build our ability to implement data-driven management actions likely to yield measurable conservation benefits for the species. The goal of the TCPCP research program is to fill critical knowledge needs for the DSL and its habitat that will directly translate to improvements in applied conservation and management efforts, to ensure that the TCPCP generates science-based, actionable guidance that supports both the near-term and long-term recovery and persistence of the DSL.

4. Research Component

4.1 Overview

The Research component of the TCPCP is based on a systematic review of literature including peer-reviewed journal articles, thesis and dissertations, technical reports, white papers, books, existing management plans, regulatory documents, anecdotal information, and expert opinion, to identify knowledge needs. Specifically, the TCPCP examined knowledge needs through an applied lens. This conservation plan prioritizes work on topics where currently available information constrains our

ability to design and implement actions expected to contribute to DSL recovery, and in which our conservation and management planning tools and guidance will be most enhanced by the planned work. If these priority knowledge needs are filled, conservation and management planners will be better equipped with reliable, data-driven strategies to implement actions that can effectively improve conditions for DSL.

The Research Component is organized around four primary goals:

1. To develop a rigorous, accurate understanding of the location, distribution, occupancy status, and quality of DSL habitat, identify key variables or characteristics that drive DSL occupancy and fitness (e.g., vegetation cover, topographic conditions, anthropogenic surface impacts, etc), and develop quantitative and spatially explicit mapping tools to guide conservation and management priorities and siting decisions.
2. To understand DSL responses to current and future environmental conditions and changes; this may include the effects of temperature, aridity, rainfall, and drought conditions. Assessing DSL responses to these factors will facilitate robust predictions of DSL occurrence and fitness across variations in space and in the future as conditions change across time.
3. To investigate the dynamics of the sand shinnery ecosystem, particularly in response to manipulation/management actions to provide much needed guidance to develop methods for enhancing existing DSL habitat, restoring areas that were once habitat, and creating habitat in new areas. This information is essential to extend the tools in the recovery toolbox beyond avoidance, minimization, and static “fortress” protection of existing habitat, to support the goals of DSL population persistence and species recovery.
4. Build research to address knowledge needs for DSL population and landscape ecology. The knowledge needs in these topic areas are vast. Research that addresses topics such as DSL population dynamics and population parameters (survival, mortality, fecundity, recruitment), as well as dispersal and movement ecology (e.g., barriers, corridors, gene flow) support the development of comprehensive conservation and management planning strategies that can be more effective at supporting recovery and long term population viability for the DSL.

The plan identifies research priorities and targeted studies within each priority area. These are considered most important for providing information to guide biologically effective management strategies and actions for species recovery. These research priorities will aid in continued and improved data-driven avoidance, minimization, and mitigation efforts, and guide the planning and implementation of restoration, enhancement, or habitat creation actions.

4.2 Research Pillar 1: Understanding DSL Habitat, Occurrence, and Distributions

4.2.1 Overview

The DSL Habitat research pillar of the TCPCP aims to produce knowledge and information to enhance our understanding of DSL occupancy, distributions, and habitat relationships. This will inform ongoing and future efforts including the development of quantitative, spatially-explicit occupancy maps; decision support tools for avoidance, minimization, and mitigation; and optimize siting decisions and strategies for conservation actions such as the creation, restoration, and enhancement of DSL habitat. Additionally, it will serve as a crucial tool for identifying study sites for other research components.

The TCP has already initiated the first three-year phase of an ongoing research project in partnership with Texas A&M University Natural Resources Institute (NRI) to produce a rigorous, quantitative, spatially-explicit predictive model of DSL occurrence and habitat. In the absence of a data-driven habitat map for DSL that met standards for best practices in the field of wildlife ecology, ACF took the lead in commissioning a multi-year project to use existing data, augmented with additional field surveys, state of the art remote sensing data, and the most advanced analytical techniques to fill this need. A robust occupancy-data-driven DSL habitat map that incorporates key land cover conditions of importance to DSL, and that captures the gradient of DSL occurrence (e.g., moving beyond a black-and-white habitat/non-habitat delineation approach) is essential to guide effective conservation actions and priorities across the species' range.

Beyond this five-year TCPCP, we anticipate at a minimum, beginning in 2030, fieldwork to update or revise spatial analyses of DSL occupancy which will be conducted every five years. At the end of each

calendar year, the TCP Science Committee will review the TCPCP annual report and provide recommendations to the Steering Committee regarding any additional habitat research needs.

4.2.2 Justification

An accurate understanding of DSL habitat, occurrence, and distributions is critical for guiding avoidance and minimization, informing siting decisions, and prioritizing areas for conservation, restoration, and management. Data-driven maps provide the foundation for determining where DSL are most likely to occur, where conservation actions will be most effective, and where impacts can be strategically addressed.

In 2021, NRI completed preliminary work to model DSL habitat in Texas using data-driven, statistically rigorous approaches, which was published in 2022 (Walkup et al. 2022). This initial effort involved a thorough analysis of existing DSL occurrence data and remotely sensed land cover data. The model produced from this project, along with a combined model developed with the TCP Science Committee, provides a data-driven guide for siting decisions. Specifically, these models offer a high-precision capability for strategically addressing unavoidable impacts while primarily optimizing conservation efforts. However, these products remain preliminary and require further refinement to improve accuracy, particularly in predicting absence and addressing uncertainty.

To address these needs, ACF's Qualified Third Party Contractor (QTPC) NRS has contracted NRI to conduct additional research from 2024 to 2027 with three objectives: (1) evaluate the predictive accuracy and precision of the 2021 model, (2) augment available data to improve accuracy of predictions, particularly regarding the certainty of DSL absence, and (3) collaborate with the NRS Technical Analysis team (geospatial experts) to better identify which land cover features predict DSL presence and which features are most effective at explaining DSL absence. This effort is ongoing at the time of this draft and aims to provide improved guidance for implementing conservation initiatives within this plan.

Additional investigations are essential to provide precise and accurate information about where DSL are likely or unlikely to occur. It is also necessary to understand how occurrence may be affected by past, current, or future anthropogenic surface features and surface changes. Furthermore, research is needed to assess how occurrence may change with changing environmental conditions such as

temperature and aridity. Current habitat, occurrence, and distributions research is contracted to continue through 2027.

Results from this effort, combined with findings from the other research pillars described in this TCPCP, will adaptively guide the direction of future habitat, occurrence, and distributions research. This integration will ensure that spatial analyses not only improve predictive accuracy but also incorporate insights from studies on environmental factors such as rainfall and aridity, habitat management experiments, and landscape ecology, thereby strengthening the overall foundation for conservation planning and decision-making.

4.2.3 Goals & Objectives

The DSL Habitat, Occurrence, and Distribution research pillar of the TCPCP is designed to refine and expand the understanding of DSL distribution and habitat conditions by integrating baseline occupancy data with analyses of anthropogenic surface features and future development scenarios. This work will ensure that conservation and management strategies are supported by reliable, spatially explicit data and decision-support tools.

One objective is to continue building upon the existing DSL baseline occupancy model (Walkup et al. 2021) by evaluating the predictive accuracy of the current model. Additionally, this project will begin to investigate approaches to identify areas with low or no likelihood of DSL occupancy with greater confidence and clear quantification of detection probabilities, and will use double sampling and other sampling approaches to provide increased understanding of DSL detection probabilities and provide robust guidance on effective survey techniques to enhance probability of detection, increasing confidence in the occupancy status of an area. This effort also seeks to identify specific areas of the species' range, or habitat conditions, where further data collection would improve model precision, accuracy, or utility to guide future research priorities.

A second objective is to use updated assessments of the current condition of anthropogenic surface features across the DSL range in Texas to investigate, through statistical and spatial analysis, how these surface features affect occupancy. Integrating spatially explicit data on surface features such as roads or well pads into occupancy models will improve the understanding of how anthropogenic impacts shape DSL occurrence and distribution and may support updates of the DSL habitat model to include surface impact conditions.

A third objective is to incorporate updated spatially explicit predictions of future surface conditions into predictive DSL habitat models and projections for future habitat and occupancy patterns and changes. Updated analyses of existing surface features, combined with remote sensing, industry practices, and development projections, will generate predictions of future anthropogenic impacts at multiple time points that may be incorporated into occupancy models to project how DSL distributions may shift under potential development scenarios.

A fourth objective is to integrate spatially explicit data from other research pillars, such as modelling of current and future environmental conditions (e.g., temperature, aridity), where applicable. This integration will strengthen the predictive capacity of the DSL habitat model(s), by incorporating multiple drivers of habitat change.

Finally, the results of habitat, occurrence, and distribution research will be used to produce map-based tools and guidance for siting and prioritizing conservation activities within the TCP. These products will provide land managers and conservation partners with practical, decision-support resources to optimize habitat protection, restoration, and management efforts across the DSL range.

4.2.4 Outcomes & Deliverables

The current map products, as well as subsequent products developed during the 2024-2027 contracted work, will be used to identify and prioritize sites for management actions. Probability of occupancy values will be a key metric for determining where management funds can be most effectively allocated. Priority will be given to areas where the greatest positive effect can be achieved by the specified management action. For example, areas with a high probability of occupancy will be prioritized for avoidance and protection. Areas adjacent to high probability sites, or areas with more moderate occupancy predictions may be ideal for enhancement actions. Impacted areas in or near sites with moderate to high occupancy may be prioritized for restoration techniques. Use of the quantitative predictive DSL habitat models may allow planners to simulate and evaluate various management approaches and siting scenarios to determine where the greatest benefit can be attained, or areas where management can significantly improve occupancy likelihood based on vegetation or other ground conditions being managed. The TCP Science Committee will offer guidance on applying the model and map results for management siting and prioritization, and

implementation of these results will also be informed by management agency partners working with ACF on on-the-ground management strategies.

Updates to the existing occupancy model, along with results of model evaluation, will be presented in a technical report and, if warranted by the results, in a peer-reviewed publication.

4.3 Research Pillar 2: DSL Responses to Current and Future Environmental Conditions

4.3.1 Overview

While existing maps and models of DSL habitats and occupancy (e.g., Walkup et al. 2021) provide valuable information, they represent only a snapshot of current or recent environmental conditions and species occurrence. To attain long-term recovery, conservation planning must account for how current biotic and abiotic environmental conditions affect DSL, how those conditions may change over time, and how those changes may impact DSL in the future. Predicting future conditions and how they may impact DSL is essential for developing a plan for DSL recovery under both current and future conditions. Developing an understanding of how DSL respond to temperature, rainfall and aridity conditions, multi-scale microclimates, and other abiotic factors and how these conditions vary across space and may change over time, provides critical information for designing effective conservation and management strategies over space and time. Variations in these conditions over space and across time can affect DSL physiology, survival, reproductive success, vegetation characteristics, prey availability, and a myriad factors that play a role in the long-term viability of DSL. A strong TCPCP therefore requires a broad spatial and temporal approach, integrating research on both current conditions and potential future changes, to predict future scenarios and guide proactive strategies that support population-level success for species recovery.

4.3.2 Justification

Criteria for determining if a species is recovered, or on the path to recovery, often relies on population viability analysis which evaluates both the likelihood that a population will persist in the future and the reliability of that estimate. To make these evaluations meaningful, particularly for species sensitive to environmental conditions that vary over space and time, conservation planning must account for variability in current and projected future conditions. Incorporating the effect of

environmental conditions allows managers to prioritize sites that not only provide suitable habitat today but are also expected to remain suitable over the next 10–20 years, ensuring that limited conservation resources are directed toward areas with the greatest long-term potential to support viable populations.

Currently, our knowledge of how DSL respond to temperature, rainfall, drought, or aridity conditions, or other related factors is insufficient. These factors can affect DSL physiology and fitness directly and can shape the surrounding habitat conditions that support DSL. DSL exhibit specific, narrow habitat preferences which may be driven in part by thermal or aridity characteristics of the environment. Such environmental conditions vary across the species range at broad and local scales and may change over time due to both interannual variation (e.g., drought/rainfall cycles) and longer-term patterns in temperature, rainfall, and other weather conditions. Understanding how DSL respond to spatial variations and temporal changes in environmental conditions can provide essential insights for identifying areas likely to remain suitable for DSL in the future, predicting which currently occupied areas may change in ways that could impact DSL population size and viability, and informing management actions that support species long-term persistence. Research on these conditions and their effects on DSL is essential to ensuring that future management strategies are grounded in reliable knowledge of DSL physiology, ecology, and environmental change.

4.3.3 Goals & Objectives

The “Environmental Factors” research pillar will undertake a series of four primary research tasks to quantify how temperature, aridity, and related environmental conditions influence the DSL and its habitat. Together, these tasks will establish the foundation for predictive models that can guide conservation strategies. The work will proceed in two phases: initial empirical studies (Phase One) and integrated predictive modeling (Phase Two).

Phase One

Retrospective Analysis of Historical Conditions (Task 1)

The task will analyze past, recent, and current DSL responses to spatial and temporal variability in temperature and precipitation/aridity. This work using existing data will begin to provide and test preliminary hypotheses about how DSL respond physiologically, ecologically, and behaviorally to

environmental variability, including extremes such as high heat or prolonged drought. This work will also seek to characterize how ecosystem conditions that may influence DSL habitat availability and quality may vary spatially and temporally.

Experimental and Field Studies of Current Responses (Task 2)

The task will investigate DSL responses under controlled and natural conditions. Laboratory studies will focus on how physiology and fitness metrics such as survival, mortality, and reproductive success are affected by gradients of temperature, aridity, and other key variables. Complementary field research will examine how habitat conditions, behavioral strategies, and physiological responses influence DSL fitness in the wild, with particular attention to survival and fecundity under various environmental conditions.

Projections of Environmental and Vegetation Dynamics for the DSL Range (Task 3)

The task will generate projections of temperature, aridity, and other critical variables across the DSL range at operational scales for informing conservation and management planning. These analyses will also address knowledge gaps regarding how the sand shinnery vegetation community may respond to shifting conditions. Research will integrate existing datasets with new field measurements to predict structural and compositional changes in vegetation and assess how these changes may affect both DSL habitat availability, quality, and other species responses across the range.

Phase Two

Integrating Results of “Environmental Conditions” Research Pillar into Predictive Models (Task 4)

This task will integrate results from the preceding studies with habitat, occurrence, and distributions to develop predictive models of future DSL habitat availability, habitat quality, and population viability in response to environmental conditions and predicted changes. These models will be based on the most up-to-date, locally specific environmental projections. Outputs will include decision-relevant maps and analyses to directly inform conservation planning, site prioritization, management design, and adaptive monitoring strategies.

4.3.4 Outcomes & Deliverables

Reporting and Publications

Results from all tasks will be compiled in a comprehensive technical report. Where analyses meet standards of rigor and sample adequacy, findings may result in one or more submissions to peer-reviewed journals for publication. Tasks 2 and 4 are especially likely to yield peer-reviewed publications given their emphasis on DSL responses to environmental conditions and the development of spatially explicit predictive models.

Data and Decision-Support Products

Preliminary research on DSL responses to environmental conditions variables, combined with spatially explicit environmental projections, will produce decision-support tools to guide management. These outputs will include datasets, maps, and model products designed to directly inform site prioritization, adaptive management, and conservation planning for the DSL.

Research Partnerships and Implementation

Tasks will be contracted to qualified research partners to ensure rigor and technical expertise. Task 3, which involves projecting environmental and vegetation dynamics, may be particularly well suited for a Request for Proposals (RFP) process to identify the most appropriate research team. Task 2, focused on laboratory and field studies of DSL physiology and fitness, may potentially be conducted in conjunction with preliminary efforts to evaluate the feasibility of captive breeding programs.

4.4 Research Pillar 3: Habitat Enhancement, Restoration, & Creation

4.4.1 Overview

To date, applied, on-the-ground DSL conservation and management actions for DSL have largely focused on avoidance, minimization, and static “fortress” conservation. Current land management practices conducted in the DSL range to benefit DSL conservation and recovery are limited. Where such practices have been attempted, they have often been guided more by anecdotal information and expert opinion than by empirical evidence.

Achieving long-term conservation and recovery of the species requires moving beyond avoidance alone. It is essential to identify and test management strategies that can enhance existing habitat, restore degraded areas, or create new habitat capable of supporting DSL populations. Such efforts are necessary to increase population size, improve habitat quality, and strengthen overall population viability.

The habitat enhancement, restoration, and creation research pillar will focus on two primary management themes:

Management of Anthropogenic Surface Features

Research will evaluate techniques for removing, reclaiming, and restoring unnecessary, redundant, or otherwise unused anthropogenic features. The objective is to determine which practices most effectively return sites to conditions that support DSL habitat creation, restoration, or enhancement.

Management of Vegetation and Environmental Conditions

Research will also investigate how targeted management of vegetation and other ecological features can improve habitat suitability. This includes assessing whether practices such as invasive species removal, revegetation of disturbed areas, or modification of vegetation structure can create, restore, or enhance conditions favorable to DSL persistence.

4.4.2 Justification

A systematic review of the literature and other available information clearly indicates that little to no rigorous information is available on whether, and how, DSL habitat may be created, restored, or enhanced. Existing occupancy analyses and a small number of other research efforts have provided limited information on vegetative and landcover features that may be important for DSL presence and fitness.

Few published or unpublished efforts have examined restoration or enhancement practices in a data-driven way. Techniques currently applied to reclamation after surface disturbance are largely untested and rarely coupled with robust biological effectiveness monitoring. As a result, there is no clear understanding of how quickly or effectively the ecosystem recovers once anthropogenic disturbances are removed. Critical processes, such as changes in soil or sand cover, shifts in topographic structure, vegetation regrowth, and the relative colonization of invasive versus

desirable species, remain poorly understood. Similarly, there are no evidence-based best management practices to guide reclamation or restoration efforts across the DSL range.

4.4.3 Goals & Objectives

The TCPCP's Habitat Enhancement, Restoration, and Creation research pillar is designed to develop science-based strategies for improving DSL habitat through reclamation of anthropogenic features and targeted vegetation management. The TCPCP will engage academic and agency partners to conduct several targeted research projects that will specifically investigate on-the-ground management practices and ecosystem responses. The primary objectives are to identify which practices most effectively restore ecosystem conditions, determine the timeframes required for ecological recovery, and generate applied guidance for conservation partners. The goal is to generate applied, science-based guidance for habitat restoration efforts, and enhancement, while providing improved understanding of the spatial and temporal dynamics of the sand shinnery and dune complex systems.

To achieve this goal, the TCPCP will employ experimental designs, such as before–after and control–impact (BACI) studies, to evaluate in real time how ecosystems respond to reclamation and restoration actions. This approach will provide direct evidence of the effectiveness of specific management practices, ensuring that results are both scientifically rigorous and directly applicable to conservation decision-making.

The Habitat Enhancement, Restoration, and Creation research pillar's objectives include:

Assessing Ecosystem Responses to Existing Anthropogenic Features

Research partners will conduct post-hoc analyses of existing anthropogenic features such as decommissioned structures, capped wells, and abandoned roads. Sites representing a range of timeframes since decommissioning or disuse will be analyzed to evaluate ecosystem recovery trajectories. Knowledge produced through the habitat, occurrence, and distributions research pillar will guide site identification. This work will provide foundational knowledge of how ecosystems respond once features are removed or left unused.

Evaluating Reclamation and Restoration Practices for Anthropogenic Features

Research will also investigate ecosystem and, where possible, DSL responses to reclamation of anthropogenic structures in real time. Studies will be conducted at sites where structures are slated for decommissioning or reclamation in collaboration with landowners and company partners. This work will test the effectiveness of specific reclamation practices (e.g., well capping, well site recontouring, or reseeding) and provide insights into the timeframes necessary for these interventions to yield ecological benefits. Currently, almost nothing is known about the effectiveness of these practices for improving conditions relevant to DSL.

Investigating Vegetation Management Techniques

Research will examine the role of vegetation management in improving DSL habitat conditions. Specific practices may include the removal of invasive species, reduction of excessive woody cover, or promotion of desirable vegetation such as shinnery oak. Experimental vegetation management will be applied and tested at sites where ecosystem conditions are suitable for DSL habitat, but where the species is not currently present, including locations in Upton County. Additional sites will be identified in partnership with agencies, companies, and landowners. Research will focus on identifying which techniques are effective, the ecological mechanisms by which they enhance conditions, and the time scales over which benefits can be expected.

4.4.4 Outcomes & Deliverables

Results from each of the three primary research tasks will be compiled into annual summaries and a final technical report at project completion. Where analyses achieve sufficient rigor and sample size, findings may result in one or more peer-reviewed publications.

In the fifth year of the TCPCP, results from all studies will be synthesized to develop a detailed set of best management practices (BMPs) for DSL habitat restoration, enhancement, and creation. This guide will provide land managers, agencies, and conservation partners with science-based recommendations to inform future restoration projects and improve the effectiveness of management actions across the species' range.

4.5 Research Pillar 4: DSL Landscape and Population Ecology

4.5.1 Overview

Effective conservation and management efforts for DSL require a more comprehensive understanding of both population ecology (e.g., abundance, density, and vital rates) and landscape ecology (e.g., distributions, dispersal, movements, effects of landscape configuration, and landscape genetics). This research pillar will build on existing data, as well as integrate the knowledge generated from the three other research pillars to provide a more complete picture of the factors influencing DSL persistence across its range.

4.5.2 Justification

Research to date on DSL population ecology has provided a foundation to build from (Chan et al 2020, Dzialak et al 2013, Ryberg et al 2015, Ryberg and Fitzgerald 2016) but does not provide the guidance necessary to design and implement management actions that can be expected to move toward species recovery. Building on prior research to fill significant knowledge needs will support efforts to develop local and landscape-scale actions designed to advance the goal of species recovery. Additional research is needed to expand knowledge on DSL population parameters such as abundance, density, and vital rates. How these critical fitness parameters differ spatially and temporally, and how they may be affected by environmental and landscape changes is not sufficiently well understood. Similarly, further information on DSL landscape ecology, such as dispersal patterns and barriers to movement, is critical to provide the basis for effective management planning at the landscape scale. Additionally, the extent to which landscape-scale features and landscape configuration may affect DSL distributions, occupancy, movement, dispersal, and population viability remains poorly understood.

In the absence of such data-driven information, landscape-scale management guidance, such as the role of barriers or movement corridors, relies heavily on best guesses, assumptions, or expert opinion. This limits the ability to design effective strategies that protect or enhance population viability and landscape connectivity. Addressing these gaps is essential for developing reliable, evidence-based guidance for managing DSL at both local and landscape scales.

4.5.3 Goals & Objectives

The goals of the DSL Landscape Ecology research pillar are to establish clear priorities in both population ecology and landscape ecology, and to translate those priorities into actionable research. Because the knowledge needs are vast, initial objectives include identifying the most critical research needs and developing the framework for their implementation, including requests for proposals, budget parameters, and project timelines. Once priority projects are selected, the TCPCP will fund and oversee their execution to ensure rigor and alignment with conservation goals. Results and outcomes from these projects will be carefully evaluated and integrated into management guidance, providing practical direction for on-the-ground conservation. As new knowledge emerges, the TCPCP will adaptively identify the next set of research priorities, ensuring that efforts remain responsive to the evolving needs of DSL recovery.

4.5.4 Outcomes & Deliverables

Research on DSL landscape and population ecology will generate products that directly inform management and conservation planning. Results will be delivered in technical reports, and where sufficient rigor and sample size allow, in peer-reviewed publications. Key deliverables will include analyses of DSL abundance, density, survival, and fecundity across the range, as well as assessments of dispersal, movement, and connectivity in relation to landscape features and configuration. Together, these outputs will provide the scientific foundation for developing evidence-based management guidance, improving strategies for habitat protection, restoration, and connectivity, and informing future rounds of research prioritization.

5. Management Component

5.1 Overview

The management component of the TCPCP aims to identify opportunities and strategically implement on-the-ground actions that optimize positive effects on DSL populations. This component is designed to operate in two phases. Phase One will focus on: a) developing and implementing rigorous protocols to monitor and assess the biological effectiveness of current avoidance, minimization, and mitigation actions, and b) building and implementing opportunities

for partnership with other land management agencies to apply appropriate land management techniques that may benefit DSL and the surrounding ecosystem and to intensively monitor biological outcomes to guide future directions. Phase Two will emphasize implementing management strategies that are directly guided by new and updated information generated through the TCPCP research component and the biological effectiveness monitoring generated in Management Phase One.

By structuring management in this way, the TCPCP will use real-world actions as opportunities to study and measure their effects, creating a feedback loop that enhances management efficacy and efficiency within the TCP. The management component will apply existing knowledge while integrating newly generated data to refine strategies for avoidance, minimization, and mitigation. It will also prioritize the design, placement, and implementation of conservation actions that create, restore, or enhance DSL habitat. In addition, the lessons learned will provide valuable insights and examples for other landowners and managers across the DSL range.

Within this framework, management strategies and actions fall into three main categories. First, avoidance and minimization will be prioritized through the use of high-precision habitat mapping, including the 2021 Texas A&M AgriLife DSL occupancy model, to ensure impacts are reduced as much as possible and to quantify the biological benefits of avoidance. Second, mitigation through habitat protection will be strengthened by using the same habitat, occurrence, and distributions products to identify and prioritize high-value areas for protection, with targeting capacity expected to improve as new spatial analyses and technologies become available. Third, the creation, restoration, and enhancement of DSL habitat will be pursued through active management techniques informed by ongoing and future research. These techniques will include improving vegetation and surface conditions, restoring areas following reclamation of anthropogenic features, and strategically locating conservation projects to expand or connect existing habitats.

The unifying feature of all these components is a robust, carefully designed biological effectiveness monitoring process. Each management component will have an appropriately designed sampling, data collection, and analysis strategy to yield information that provides a measure of the efficacy of plan actions but also feeds back into the adaptive structure of the conservation program to inform other research and management efforts.

5.2 Management Component: Phase One

5.2.1 Overview

Phase One will focus on developing and implementing rigorous protocols to monitor and assess the biological effectiveness of ongoing avoidance, minimization, and mitigation actions under the TCP. This effort is designed to establish a robust framework for evaluating the efficacy of current management practices, generating data to adaptively refine best management practices, and ensuring that conservation actions are producing measurable biological benefits for DSL. Current, ongoing avoidance, minimization, and mitigation actions to monitor and assess include:

Avoidance and Minimization

The implementation of the TCP over the last 10 years has successfully supported avoidance and minimization measures, resulting in approximately 438.58 acres of DSL habitat impact, averaging about 40 acres per year for enrolled lands. Alongside the development of technologies that improve efficiency in production methods and high-resolution change detection methods, the TCP will utilize current and anticipated future DSL habitat, occurrence, and distributions data to enhance our ability to avoid and minimize impacts. The TCP will continue to reference the Hibbitts map to broadly guide avoidance and minimization efforts.

By using the 2021 Texas A&M AgriLife DSL occupancy model, ACF can quantify the net beneficial impacts of these actions by identifying areas where surface impacts are effectively avoided in high-occupancy regions. Current and ongoing avoidance and minimization actions under the TCP will be maintained and adaptively improved as new research-driven information becomes available regarding the most effective approaches. These actions will be monitored, assessed, and analyzed to quantify their biological benefits. Analysis may include assessing the maintenance or change in DSL occupancy, ecological conditions of avoidance sites. In some cases, particularly where mitigation is specifically implemented, broader scale analysis of land use conversion risk and the broader net benefits of mitigation measures may also be conducted.

Ongoing Avoidance and Minimization Actions

All construction of new infrastructure projects have been located outside of DSL habitats whenever possible. These siting decisions are guided by the best available DSL habitat maps and supported by

technologies that allow for more efficient and targeted operations, thereby reducing the likelihood of new disturbances.

Operational efficiency has also been improved through increased well density, where multiple wells are developed on a single pad. This approach reduces the per-well surface footprint, minimizes new surface disturbances, and facilitates habitat avoidance while maintaining oil production. Directional drilling has further supported this effort by allowing access to resources with minimal surface disturbance in high-value DSL areas.

Additional strategies have focused on centralizing facilities to reduce the need for multiple infrastructure sites, thereby minimizing surface impacts and avoiding DSL habitats wherever possible. Redundancy in infrastructure has also been reduced by limiting unnecessary construction, such as excess roads and maximizing the use of existing roads, powerlines, and other facilities. Where complete avoidance has not been possible, minimization has been achieved through techniques and technologies that promote operational efficiency and reduce surface impacts per well or production unit.

5.2.2 Justification

Phase One is necessary to establish rigorous protocols for monitoring and assessing the biological effectiveness of ongoing avoidance, minimization, and mitigation actions. While implementation of the TCP has successfully limited DSL habitat disturbance through these measures, no systematic framework currently exists to quantify their biological benefits or adaptively refine practices based on data collection and analysis of outcomes. A structured monitoring approach is essential to strengthen accountability, evaluate effectiveness, and improve best management practices over time.

5.2.3 Goals & Objectives

The primary objective of Phase One is to design and implement a robust monitoring system to evaluate the biological impacts of current avoidance and minimization measures. Specific goals include:

- Integrating current and future DSL habitat, occurrence, and distributions data (e.g., Walkup et al. 2021) into management decisions.
- Quantifying the net benefits of avoidance and minimization by assessing DSL habitat availability, occupancy, and habitat quality maintenance and/or change; in some cases, analysis of land use conversion risk with and without avoidance and minimization measures may be possible
- Maintaining and adaptively improving ongoing management actions as new research findings become available.

5.3 Management Component: Phase Two

5.3.1 Overview

Phase Two of management will focus on implementing actions guided by new and updated information generated through the TCPCP research component. These actions will move beyond avoidance and minimization to include targeted efforts to protect, enhance, restore, or create habitat. All management actions will be deployed within an experimental design framework, ensuring that outcomes can be rigorously monitored, evaluated for biological effectiveness, and used to guide adaptive modifications over time.

5.3.2 Justification

Phase Two is needed to move beyond avoidance and minimization by implementing habitat protection, enhancement, restoration, and creation strategies. Limited research exists on effective reclamation and vegetation management techniques, and existing practices have not been rigorously evaluated for their biological effectiveness. Phase Two will apply and test these strategies under an experimental framework to generate evidence-based guidance for long-term DSL recovery.

5.3.3 Goals & Objectives

Phase Two of the management component is designed to expand conservation actions beyond avoidance and minimization by actively improving habitat conditions for DSL. The goals of this phase focus on two primary objectives: (1) the creation, restoration, and enhancement of areas affected by existing infrastructure through reclamation and other targeted management practices

and (2) the implementation of vegetation management strategies across the DSL range to improve habitat availability and habitat quality. Together, these efforts aim to test and refine management practices within an experimental framework, generating the data needed to guide effective, large-scale habitat conservation and recovery.

Creation, Restoration, and Enhancement – Existing Infrastructure

This component will work in conjunction with research efforts to advance DSL habitat enhancement, restoration, and creation. It will investigate the conditions in and around areas that have been reclaimed, decommissioned, capped, or otherwise left unused, in order to understand how these sites recover over time. In addition, multiple techniques for reclaiming existing infrastructure will be deployed within an experimental framework, accompanied by carefully designed monitoring to assess their biological effectiveness.

Creation, Restoration, and Enhancement – Vegetation Management

The TCPCP will collaborate with agency partners such as USDA-NRCS to identify appropriate sites for vegetation management and monitor the outcomes. The TCP Conservation Plan will apply and assess the biological effectiveness of management approaches that may have the potential to enhance habitat availability and use by DSL. Management actions deployed will be determined with guidance from agencies, land management expert opinion, and others, and may include approaches including but not limited to:

1. Removal or reduction of invasive plant species
2. Management of total vegetation cover (e.g., removing a certain percentage of vegetative cover in areas where excessive growth may exceed DSL cover preferences)
3. Establishment or re-establishment of Shinnery oak or other desirable cover species in areas where vegetation has been removed or is otherwise limited

Site selection for these management efforts will be a collaborative process, integrating the partner agency's selection criteria with the DSL habitat map. Eligible sites will be assessed based on their value to DSL or their contribution to DSL conservation, as determined by the best available DSL habitat maps.

Funding for these management projects will combine TCP Conservation funds with additional partner agency funds, enabling larger on-the-ground conservation actions than could be accomplished under the TCP alone. Monitoring these sites to assess biological effectiveness will be conducted in collaboration with research partners as part of the aforementioned research component.

5.3.4 Outcomes & Deliverables

Phase Two will deliver applied management practices along with documented evaluations of their effectiveness. Anticipated outcomes include case studies that capture ecosystem responses to infrastructure reclamation and data on the results of vegetation management and its relationship to DSL habitat use. The TCPCP will also generate prioritized site lists for habitat enhancement, restoration, or creation, ensuring that conservation actions are strategically targeted. Annual reports will integrate monitoring results with updated management recommendations, providing a mechanism for adaptive refinement. Finally, guidance documents developed in collaboration with agency partners will support the scaling of effective practices across the DSL range, extending the impact of successful management approaches.

By linking research with management, Phase Two will provide the tools, data, and applied strategies necessary to expand conservation from site-level avoidance toward landscape-scale recovery efforts.

5.4 Captive Breeding & Release

5.4.1 Overview

Captive breeding and release is another tool that may support recovery of the DSL. Successful captive breeding and release efforts require careful study of the species' physiology and reproduction to support survival and fecundity in captivity. Additionally, any captive breeding and release program will be inefficient and ineffective in the absence of rigorous knowledge about existing habitat for the species, metrics of habitat quality (e.g., what conditions are most suitable for the species' survival and reproduction), population dynamics of the species (e.g., optimum densities), and methods to enhance, restore, or create new habitat for habitat-limited species such as the DSL. The TCPCP addresses these needs through the aforementioned research component and management component.

Results of these efforts represent essential information necessary for a successful captive breeding and release program. The captive breeding and release component will begin with a pilot effort to test if and how DSL can be successfully maintained in captivity, and whether breeding may be feasible in captivity. Pilot efforts, if successful, will be scaled up with the objectives of generating DSL for future release, to be deployed when TCPCP research and management studies provide results to inform a well-designed release and monitoring program for captively bred individuals.

5.4.2 Justification

Successful recovery of DSL may be supported by not only protecting existing habitat and restoring impacted habitat but also augmenting DSL populations and genetic stability through captive breeding and release.

5.4.3 Goals & Objectives

The Captive Breeding and Release component of the TCPCP is intended to develop a program that is phased over time, beginning with a pilot effort to determine if DSL can be maintained in captivity, reproduce successfully, and produce enough surplus individuals to design, implement and evaluate release methods. Step one aims will include evaluating whether and how DSL can be successfully maintained in captivity, and will include work determining appropriate habitation, nutrition, and meeting other physiological and behavioral needs for survival. Subsequent efforts to support DSL breeding in captivity, assess fecundity, egg viability, juvenile survival, and other related metrics will be a second step. From there, further work building on successes in steps one and two would evaluate and refine approaches for scaling up to generate sufficient surplus individuals for prospective release. Additionally, identifying multiple release approaches and a plan for implementation and effectiveness monitoring of release strategies will also be essential at this stage.

The first three preliminary steps will likely require substantial time, problem-solving, and adaptive refinement of methods. If pilot efforts are successful, the captive breeding program may be scaled up with the aim of developing and monitoring a carefully designed production and release strategy guided by the results of the integrated Research and Management components of the TCPCP. Successful implementation of this stage of captive breeding efforts is contingent on the results of ongoing research and management efforts to create and identify suitable sites for release, and the development of robust knowledge about DSL habitat carrying capacity, optimal densities, and

density-dependent effects, to ensure that release programs are most likely to be successful. An intensive study assessing release methods and post-release outcomes will be an essential component that enables adaptive revisions and improvement of the release program and allows for and integrating findings into other aspects of DSL conservation planning; (Parker et al 2023).

The TCPCP Captive Breeding component has implemented an initial effort to identify prospective collaborators and research partners, locate potential facilities and/or determine preliminary infrastructure needs, and assess what other supplies and equipment are required. This preliminary scoping phase will establish budgetary needs and determine what partnership and management structure will best support building a pilot captive breeding effort within an adaptive framework with the capacity to scale up if pilot efforts are successful. This stage will also begin defining preliminary and secondary biological and conservation objectives in an adaptive management framework such as captive survival goals, captive population targets, and other targets and trigger points to guide decision-making throughout the pilot process (e.g., what level of survival is attained to direct the next steps toward advancement, versus triggering a pivot in the approach or objectives if survival goals are not attained in a reasonable time frame). If pilot efforts are successful, targets such as release targets, the number and distribution of release sites, survivorship thresholds for released individuals, and other goals will be identified.

Once the scoping effort is completed, a team of collaborators is identified, a planning and management structure is established, and a budget is developed, the plan will be reviewed by the TCP Science Committee and TCP Steering Committee, input and guidance will be considered and the project will move forward to implementation.

The pilot stage of the captive breeding program will investigate the feasibility of maintaining and breeding DSL in captivity. This includes determining the environmental conditions necessary to support survival, identifying requirements for successful reproduction, and assessing key reproductive parameters such as fecundity, egg viability, and hatch rates. Research will also focus on juvenile survival, body condition, and other factors critical to preparing individuals for release. Findings from these investigations will be used to refine project goals and objectives over time.

With input from the other research and management components of this plan, a framework for selecting release sites will be developed. Potential release methods will be identified and a plan for

experimental implementation of preferred release methods will be designed with an emphasis on during and post-release monitoring, to assess short and long-term survival under various release methods and release sites. A rigorous, multi-year research and monitoring plan will be developed to evaluate post-release outcomes and assess whether biological and conservation objectives are being met. This essential step will provide data to adaptively revise and refine subsequent site selection and release approaches to ensure that conservation and release activities can be expected to continue to support long-term recovery goals.

5.4.4 Outcomes & Deliverables

Outcomes and deliverables are largely to be determined after Phase One of the project is underway. Research to attempt captive breeding will yield annual technical reports and will likely result in one or more peer-reviewed publications. If captive breeding is successfully achieved, results of release and post-release research will be reported in annual technical reports as well as peer-reviewed publications.

6. Implementation & Governance

6.1 Overview

The TCPCP establishes a structured framework for implementing proposed research and management actions, while allowing for adjustment and adaptation as new information emerges. Priorities, timelines, and budget allocations specified in the TCPCP are not static; they will be reviewed and modified as necessary in response to evolving conditions or emerging findings. This adaptive structure ensures that conservation actions remain effective, efficient, and grounded in the best available science.

6.2 Governance Structure

Oversight of the TCPCP involves multiple committees with distinct roles. The TCP Science Committee provides comments, technical input, and recommendations on research and management priorities. Importantly, the Science Committee does not hold approval authority for the TCPCP. Instead, its recommendations are reviewed by the TCP Steering Committee, which

provides guidance on program direction, priorities, and resource allocation. Because implementation involves significant expenditures, final recommendations for adoption may involve the Steering Committee.

As the TCP permit holder, ACF maintains ultimate responsibility for TCPCP implementation. At the discretion of the permit holder, the TCPCP or specific program components may also be presented to the ACF Board of Directors for review and approval when budgetary commitments warrant higher-level oversight. This structure ensures that fiscal accountability is maintained while still allowing for science-driven recommendations to shape conservation priorities.

6.3 Annual Review and Reporting

Each fall, an annual report will be produced summarizing program activities, progress, and findings. This report will serve as the basis for a formal review by the Science Committee, which will evaluate results and provide recommendations for adaptive modifications to the TCPCP. At the end of each calendar year, the Steering Committee will review these recommendations and determine whether adjustments to priorities, strategies, or budget allocations are necessary. This annual cycle of reporting and review provides a consistent mechanism for adaptive management and ensures that lessons learned are rapidly incorporated into program design.

6.4 Research Implementation

Research projects under the TCPCP will be conducted in collaboration with partners from academic institutions, agencies, or other qualified organizations. ACF has contracted NRS to identify and engage the most appropriate partners for each research project or group of projects. NRS will oversee the development of agreements, scopes of work, and funding structures to ensure accountability and alignment with conservation objectives.

Research partners will be selected through one of two processes. In cases where specific expertise or geographic relevance is required, NRS may directly select the institution or research team best suited to carry out the work. In other cases, NRS may issue a call for proposals to conduct a competitive review process and select the partner organization that presents the strongest, most scientifically rigorous research proposal. This dual approach ensures that research efforts are

matched with the most qualified collaborators while maintaining flexibility to address the diverse needs of the TCPCP.

7. Timeline Overview

Detailed timelines for each research and management area or phase are provided in Appendix A1-A5. Figure 1. gives an overview that depicts multiple project areas that will be initiated and ongoing during the five-year span of the TCPCP.

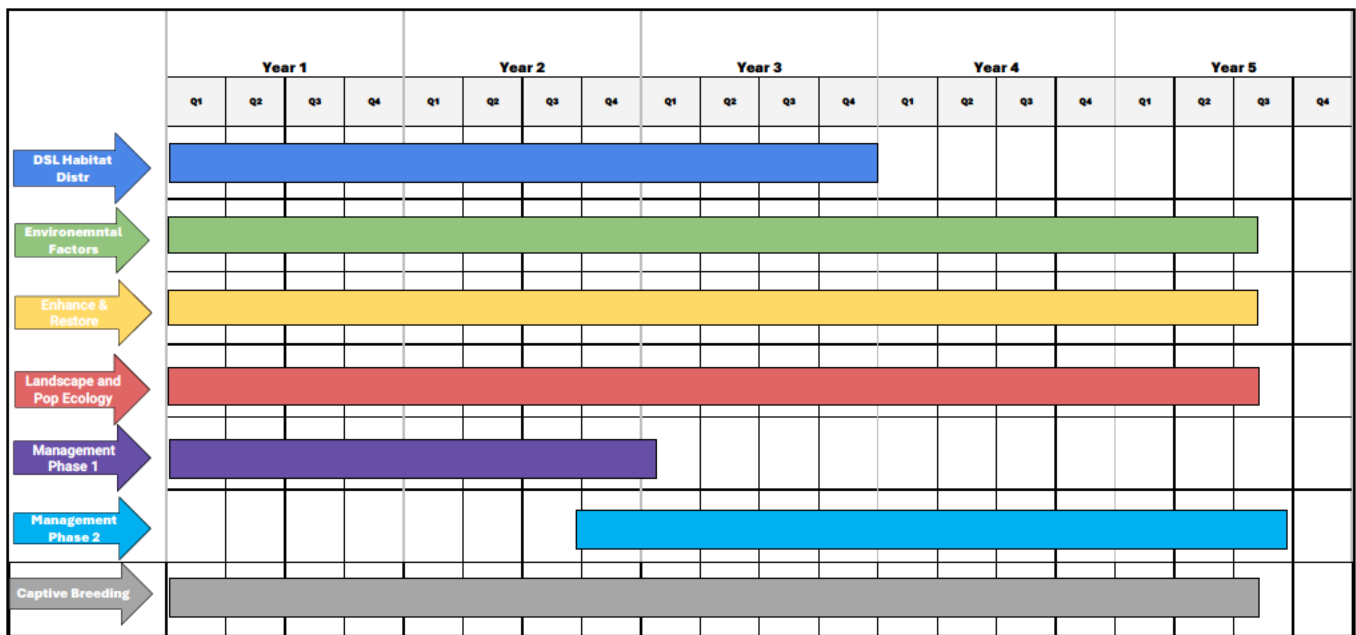


Figure 1. Timeline of TCPCP activities over the initial five-year program period, including research initiatives and management phases.

8. Five-Year Budget Summary

ACF anticipates an estimated \$5 million available over the years 2026-2030 (see Table 1) to be applied to the TCPCP; approximately \$1 million annually. An estimated \$500 thousand will be allocated to research, and \$500 thousand allocated to on-the-ground management actions, per year. A detailed breakdown of the budget is provided in Appendix B1-B4.

We expect that research and management in the 2026 calendar year will be slightly lower, with the focus on development of projects, research partners, and agency collaborators for land management programs with matching funds. The amount of funding applied to on-the-ground management will

vary from the aforementioned general estimates based on the specifics of participating partners' match requirements and other related factors. Working with partner agencies such as the United States Department of Agriculture (USDA) and the Natural Resources Conservation Service (NRCS), to leverage agency programs that implement on-the-ground management to include or increase a focus on DSL habitat restoration and enhancement. We expect that the realized amount of funds that are applied to on-the-ground management will be greater than the TCP contributions alone.

Table 1. A Five-Year Summary of Compiled Budget Estimates for the TCPCP

COMPILED BUDGET ESTIMATES

	Year 1	Year 2	Year 3	Year 4	Year 5	Total
HABITAT AND DISTR: IMPACTS	0	0	51,292	56,696	58,972	166,960
HABITAT AND DISTR: NEW DATA	0	0	79,842	80,738	83,108	243,688
EC EXISTING DATA	50,514	52,765	0	0	0	103,279
EC FIELD	0	68,087	68,983	71,353	72,318	280,741
EC LAB	0	61,096	58,966	58,936	0	178,998
ECE MAP/MODEL	0	51,714	53,965	0	0	105,679
HABITAT EXISTING RECLAMATION	0	78,642	79,538	81,908	0	240,088
HABITAT EXP RECLAMATION	0	71,087	71,983	72,913	69,318	285,301
HABITAT EXP VEG	0	70,487	71,383	72,313	74,718	288,901
POP AND LANDSCAPE ECOLOGY: PROJECT 1	0	0	72,464	73,361	75,731	221,556
POP AND LANDSCAPE ECOLOGY: PROJECT 2	0	0	72,464	73,361	75,731	221,556
TOTALS	50,514	453,877	680,882	641,580	509,896	2,336,750

All budgets are estimated. Specific details of each project will be determined during the project scoping process with participating collaborators; for projects secured via a competitive proposal process, budgets will be proposed by applicants and revised or approved by the TCP.

9. Conclusion

The TCPCP represents a comprehensive, science-based framework designed to advance the conservation and recovery of the DSL in Texas. By integrating research and management within an adaptive structure, the TCPCP ensures that conservation actions are both informed by the best available science and continually refined in response to new knowledge.

The research component addresses four critical areas: habitat, occurrence, and distributions, environmental conditions, habitat enhancement, restoration, and creation, and landscape and population ecology, that collectively fill essential gaps in understanding DSL ecology and the dune

sagebrush ecosystem. These efforts will generate the data required to design effective conservation strategies and provide tools for guiding on-the-ground management.

The management component translates research findings into applied conservation. Through its two-phase approach, the TCPCP first establishes rigorous protocols for monitoring and evaluating ongoing avoidance, minimization, and mitigation actions, then expands to implement habitat protection, restoration, and enhancement strategies informed directly by research outcomes. This structure not only strengthens the effectiveness of current conservation actions but also builds the foundation for long-term recovery efforts.

Additional tools, such as captive breeding and release, will be explored to augment population support and genetic stability, contingent on rigorous feasibility testing and habitat readiness. Governance and implementation mechanisms—including oversight by the Science and Steering Committees, annual reporting, and adaptive review processes—ensure that accountability, transparency, and scientific rigor remain central to program operations.

Taken together, the TCPCP provides a clear five-year roadmap that leverages partnerships, science, and adaptive management to maximize conservation outcomes. By systematically addressing knowledge gaps, implementing evidence-based management strategies, and fostering collaboration among agencies, landowners, and conservation organizations, the TCPCP positions the TCP and its partners to make meaningful progress toward the long-term recovery and persistence of the DSL.

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