

***DISTURBANCE QUANTIFICATION IN DUNES SAGEBRUSH
LIZARD HABITAT***

Texas Conservation Plan for the Dunes Sagebrush Lizard

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Submitted to:

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INTRODUCTION

The Texas Conservation Plan (TCP) for the Dunes Sagebrush Lizard (DSL) was implemented in 2012 by the State of Texas to provide conservation protection for the DSL and its habitat in the portion of the specie's range falling within the jurisdiction of the State of Texas. The largest threats to the species were considered to be oil and gas development and changes in land use practices resulting in loss and fragmentation of necessary habitat for persistence of this habitat specialist. Under the TCP, enrollees (Participants) voluntarily implement conservation measures to preserve the species and its habitat in Texas. The TCP was viewed (along with a similar plan for the species in New Mexico) to provide sufficient protection for the DSL that the United States Fish and Wildlife Service (FWS) determined that listing of the species was not warranted.

As with any new program, shortcomings in the implementation of the program were identified in the first several years and are being addressed by an adaptive management process to strengthen the program. The program has been successful in achieving conservation; however, this success has not been effectively quantified. In the management of any imperiled species, the diverse goals of numerous stakeholders can create conflict that continually place conservation programs under scrutiny. This project was designed to accurately quantify the effects of the implementation of the TCP on loss of DSL habitat to oil and gas development and land use practices within the permit area. As the permit area is large and access is limited in many portions of it, Geographic Information Systems (GIS) tools and analysis of aerial imagery were selected to facilitate estimation of habitat loss. BIO-WEST created a GIS dataset cataloging human caused disturbances within DSL habitat from April 2012 – September 2016. The Area of Interest (AOI) for this project is focused on the habitat polygons that define DSL habitat in the TCP (Figure 1). These areas are distributed in Andrews, Crane, Ector, Gaines, Ward, and Winkler counties in Texas.

METHODOLOGY

In order to interpret the changing nature of disturbances over time, ESRI ArcMap[®] was utilized to complete a change detection analysis (CDA). Employing the difference function within ESRI ArcMap[®] Imagery Analysis tools, difference layers were created between multiple sets of Rapid Eye imagery mosaics to provide an annual snapshot of land use changes from April 2012 through September 2016. Annual difference layers enabled the capture of disturbances (Figure 2) that occurred in early years of the program but might have become more difficult to detect in later years (e.g. re-establishment of vegetation over time).

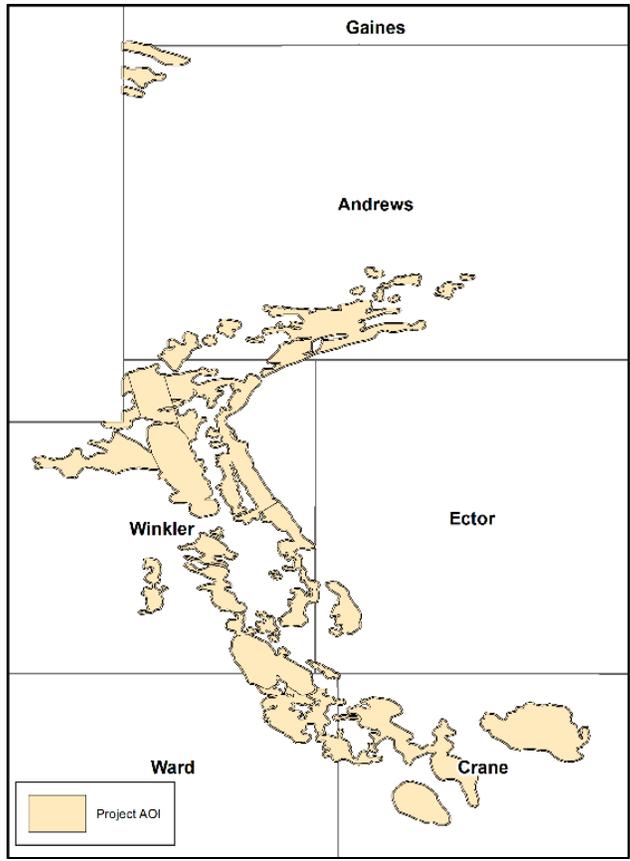


Figure 1. Project Area of Interest (AOI)

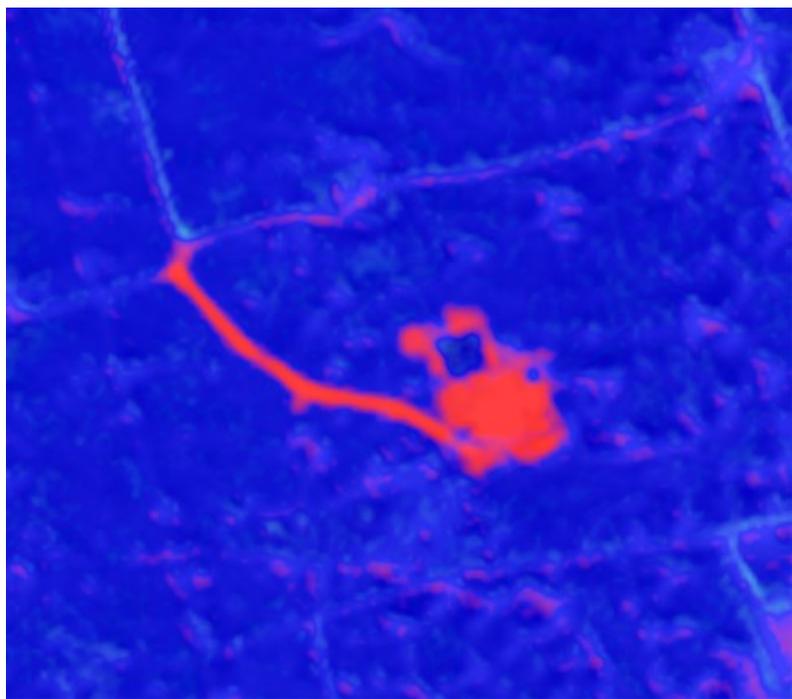


Figure 2. A newly constructed well pad highlighted red by a difference layer resulting from Change Detection Analysis (CDA).

METHODOLOGY

After the difference layers were generated utilizing the ArcMap® Raster Calculator tool, a manual search of the project area was performed using 64 km grid cells overlaid onto the project area. Cycling through annual difference layers in each 64-km grid cell, the perimeter of each detected disturbance was manually digitized. The estimation of each disturbance adhered to the following criteria:

1. The disturbance was drawn based on imagery that indicated its state of greatest disturbance or impact on the landscape (Figure 3).
2. If a disturbance crossed a feature that was disturbed prior to April 2012, that area was not included in the disturbance. For example, in the case of a pipeline easement crossing a previously existing caliche road, that part of the easement overlapping the road would not be digitized in the disturbance polygon (Figure 4).
3. Disturbances were located using Rapid Eye difference layers or Rapid Eye imagery but were digitized using imagery with a resolution of 1 m or finer (as available). The higher resolution imagery increased the accuracy of disturbance boundary definition.
4. Only disturbances within the Habitat Management Units (HMUs, Figure 1) or the 200-meter buffer of the HMUs were digitized. If portions of the disturbance continued outside of the HMUs and buffer, it was not included in the disturbance acreage counts.
5. The HMUs and associated portions of the 200-meter buffer were divided equally in areas where the buffers of multiple HMUs overlapped (Figure 5).

Four different imagery sources were used to digitize disturbance boundaries:

- Rapid Eye – 5 m resolution imagery mosaics of the AOI for April 2012, August 2013, July 2014, August 2015, and September 2016. Imagery was either sourced from a private vendor or previously purchased during the course of TCP administration.
- NAIP – 1 m resolution imagery from National Agriculture Imagery Program (NAIP) for 2012 and 2014 (TNRIS Texas).
- TNRIS – 50 cm resolution imagery from Texas Natural Resource Information System (TNRIS) for 2015 (TNRIS Texas)
- Google – 15 cm resolution imagery available as Web Map Service (WMS) from TNRIS. Temporal range of imagery is 2011-2017 (TNRIS).



Figure 3. A pipeline easement is depicted in 2013 (left) and 2015 (right). Imagery on the left was used to digitize the boundaries of this disturbance because it represented the state of greatest impact on the landscape. Encroachment of vegetation into the pipeline easement is visible in the 2015 imagery, making it difficult to identify the original boundary of the disturbance.



Figure 4. A caliche road (left) existed prior to the creation of this pipeline easement disturbance (right). The area where the road intersects the disturbance was not digitized and therefore not included in the disturbed acreage count.

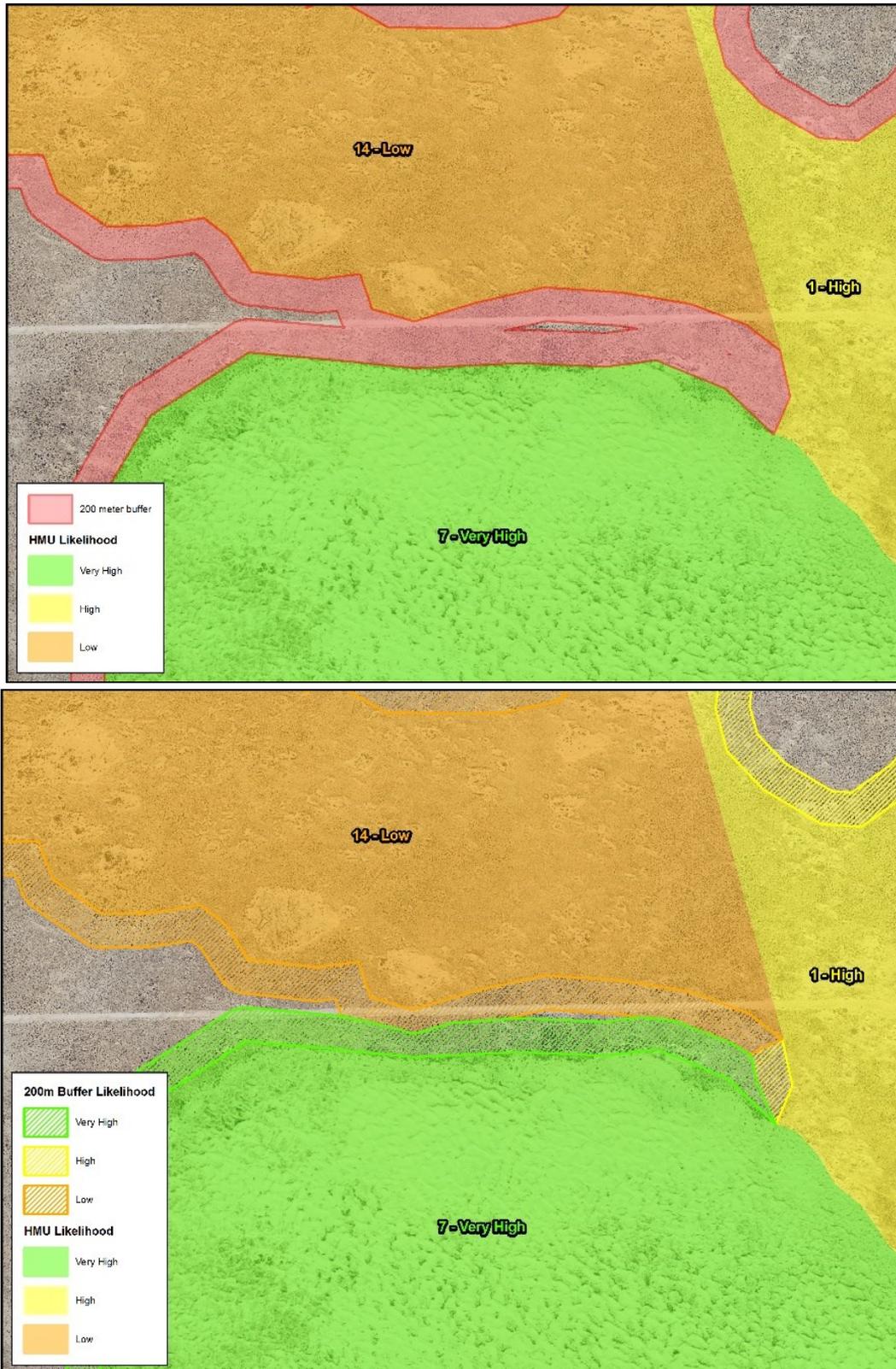


Figure 5. To eliminate the ambiguity inherent in overlapping buffer among different HMU's (top), the 200-meter buffer in was divided between all associated surrounding HMU Likelihood categories.

METHODOLOGY

After all disturbances were initially digitized, the following disturbances were removed from the dataset to be consistent with the context of this project:

- Mitigation sites (well pad removal and remediation)
- Recovery Project sites (mesquite removal projects)
- Well pad maintenance operations

While the above are visible in difference layers, they do not qualify as disturbances as they do not represent habitat loss. Mitigation and Recovery Project sites were identified from TCP and Texas Habitat Conservation Foundation (THCF) program documentation.

Established and older well pads are frequently grown-over with vegetation and it is common practice for the well pad operator to periodically perform vegetation removal, which is detected by CDA difference layers. This activity falls under normal operations and maintenance activities covered under the TCP and thus were not attributed as a disturbance. However, there were also instances where a new well bore was added to a preexisting well pad and required expansion beyond its original footprint. Co-located wells, such as these, were attributed as a disturbance when they increased the original well pad's footprint. It can often be difficult to distinguish the difference between these two activities from satellite imagery. During the digitization of disturbances, both types of disturbances were given a similar identifier to allow further post hoc investigation.

Because access to development sites is confined to areas enrolled by Participants and thus limited opportunities for field verification, a method was developed to provide a criterion for distinguishing operations and maintenance from well pad expansion. Eight known co-located wells were evaluated to determine the size of pad expansion required for this purpose. The smallest of the well pad expansion associated with co-located wells was 0.6 acres. In cases where it was not possible to confidently distinguish between pad expansion and maintenance using imagery alone, disturbances ≥ 0.6 were considered pad expansions. When this filter was applied, 81% of 216 such instances were subsequently classified as maintenance, totaling 44.1 acres. This criterion was validated by including sites with known histories, in addition to sites that could be clearly distinguished by imagery classification and verifying that they were classified correctly.

Responsibility (Participant or non-Participant) for disturbed acreage was assigned by comparing imagery to TCP program documentation, Railroad Commission of Texas (RRC) data, and publicly available county record data.

Estimation of area using aerial imagery and GIS is an effective way to quantify disturbances in cases where scale and access issues make quantification via other methods impractical or impossible. The resulting values must be interpreted as estimates, however, as they will not be as accurate as a formal on-the-ground survey. For the purposes of this project, these values are of sufficient accuracy to determine overall trends in habitat loss over the study period. While access to disturbances that occurred during the study period and were recent enough to be

quantified by both imagery and field methods (access to developments is limited to enrolled acreage, and participants have not developed at an appreciable rate during the study period), BIO-WEST nonetheless attempted to estimate measurement error in this process. Twenty-four accessible sites within the permit area of various configuration (well pads, roads, etc.) that were recently constructed or maintained, were field surveyed using a Trimble® Geo XH6000 GPS. The field and GIS area estimates were then compared to estimate accuracy. The deviation of acreage totals between the two estimation methods was 12%. It is notable that in nearly every case, the GIS estimate was higher than the field estimate and thus the results of this study can be considered unlikely to have under-estimated habitat loss.

RESULTS

This work lead to documenting 487 disturbances in the habitat polygons, which were then digitized to estimate the amount of disturbance. (Table 1).

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

Table 1. Estimated habitat loss due to development disturbances in DSL habitat during the 2012-2016 period.

Of these disturbances, 262 were on property enrolled in the TCP. Based on public records and those held by the Comptroller’s office, 204 of these were attributable to non-participant activities and 58 to participants in the TCP.

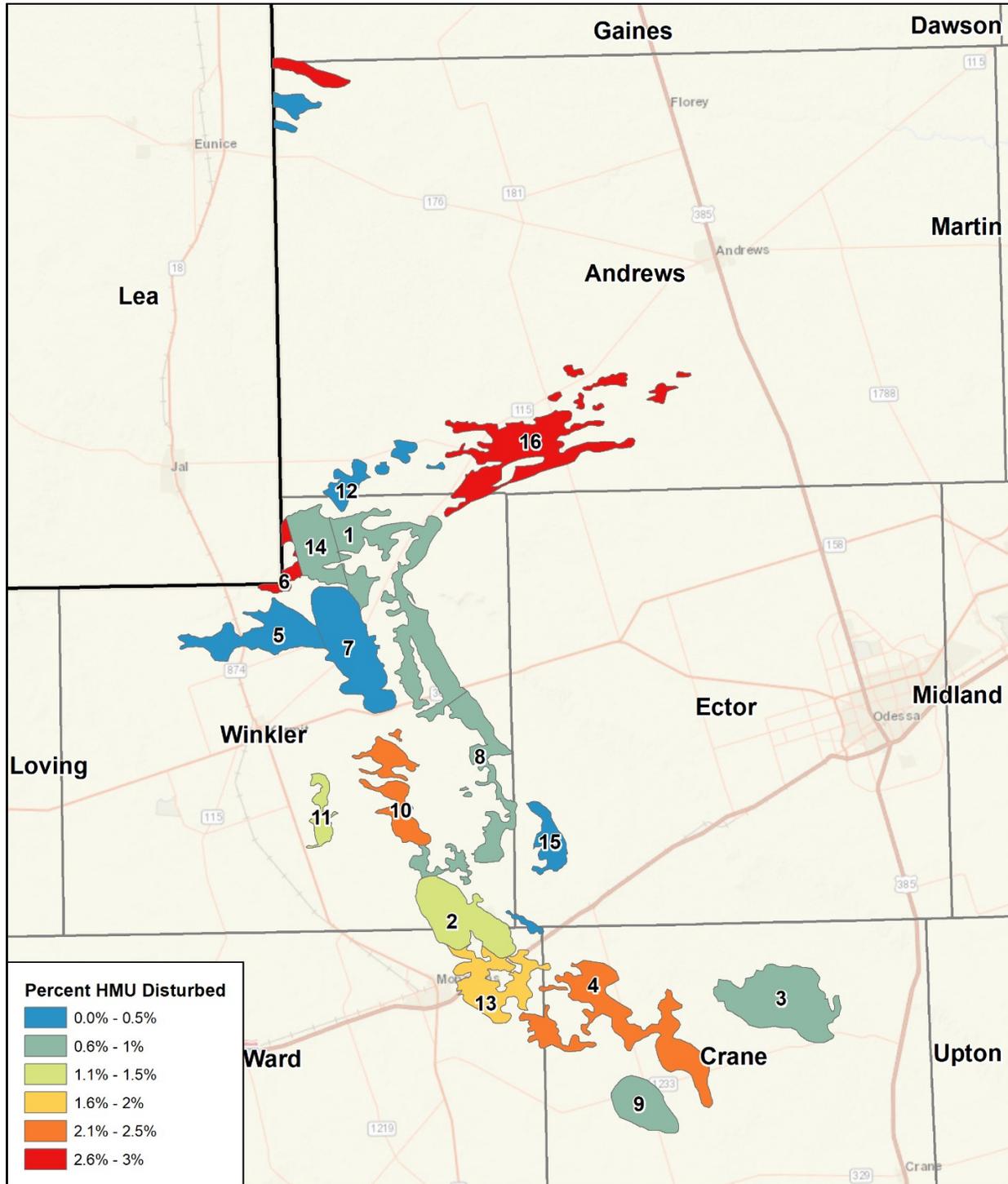
The reason non-participants can be responsible for 77% of the disturbance on enrolled property is because property ownership in the oil and gas producing areas of Texas is often stratified to separate not only the mineral rights from the surface rights, but also the individual layers below the surface. This means that while a Participant may have a sufficient interest or control to enroll a parcel of land, they may be only one of several owners with a similar right to the same property.

For example, in the Permian Basin it is not uncommon for a landowner to lease the right to drill on his or her property to different depths to different companies, while also leasing grazing rights on the surface and selling easements to pipeline companies. The result for the TCP is that a single acre of land can easily have a half dozen entities with the ability to enroll in the TCP.

This study found habitat loss resulting from non-participant surface disturbances on enrolled property was 776.25 acres. Disturbances in habitat on non-enrolled property totaled 1,287.67 acres (Table 2). Habitat classified as Very High Likelihood of Occurrence (LOO) by the TCP

experienced the most habitat loss, followed by habitat classified as Very Low LOO. These classifications include large areas with high historic densities of oil and gas development in Andrews and Crane counties, particularly HMU's 4 and 16. (Figure 6)

Figure 6. Habitat loss observed from 2012-2016 presented as percentage of total HMU acreage disturbed.



The specific date of these disturbances could not be established due to the limits of the imagery used. NAIP, TNRIS, and Google imagery mosaics consist of imagery photographed over several months to over a year then stitched together afterwards. This leads to instances where a disturbance was not consistently detectable across all imagery mosaics in the same year. Different areas of the same county could have been photographed weeks or months apart within the same imagery set. The only imagery with known dates were those associated with the Rapid Eye imagery. If a disturbance appears on the August 2013 imagery but not the April 2012 imagery, then it is known to have occurred sometime between April 2012 and August 2013. This was the only way to link an image of a specific disturbance to a point in time. The temporal availability of aerial imagery useful for this project was also influenced by the climate, as ground imagery collected may be obscured by clouds or shadows.

Habitat loss resulting from the activity of Participants on their enrolled property was consistent with the previously reported estimate. The Annual Report 2016, Texas Conservation Plan for the Dunes Sagebrush Lizard, submitted to the USFWS by the Texas CPA EGESM in March of 2017, reported 294.75 acres of disturbance. This number was based off of on the ground surveys and participant reports to the TCP. This GIS-based-estimation found 314.9 acres of disturbance.

Most of the difference between these two estimates results from re-estimation of a Participant pipeline. The pipeline was not built along the path originally set out in the participant's documentation and was not corrected afterwards. The disturbed acreage was thus calculated using the GIS digitized polygon rather than their original enrollment shapefile from TCP program documentation, as this was thought to be more representative according to high resolution imagery.

Overall, habitat loss observed annually over the period of this study was highest in the initial year of the TCP (Table 2) with the exception of Participant caused disturbances which were higher in the second year. This is possibly due to lag as Participants learned to adapt their development plans to their obligations under the TCP and the time it took the TCP program administration to process approved and planned developments. Non-participant activity on enrolled property was highest in the initial year of the TCP, remaining much lower for the duration of the period of this study. There was a reduction in the acreage disturbed on non-enrolled property over this time period as well, however disturbances here consistently occurred on a larger scale compared to enrolled areas. Given that 49.97 % of the total area described as habitat or buffer is enrolled in the TCP (based on Participant enrollment within HMUs and 200-meter buffer as a portion of total GIS-calculated HMU and 200-meter buffer acreage) and thus the overall area comprised enrolled and non-enrolled habitat is equivalent, this supports that there is a positive (from the conservation perspective at least) effect of enrollment despite the fact that all rights are not captured by enrollment under the TCP.

Table 2. Estimated annual habitat loss (in acres) over the 2012-2016 period.

| Year | Participant Surface Disturbances on Enrolled Property | Non-Participant Surface Disturbances on Enrolled Property | Surface Disturbances on Non-Enrolled Property | Annual Total |
|-------------------|---|---|---|--------------|
| 04/2012 - 08/2013 | 29.14 | 401.53 | 496.79 | 927.45 |
| 08/2013 - 07/2014 | 107.51 | 118.91 | 285.47 | 511.88 |
| 07/2014 - 08/2015 | 85.98 | 114.06 | 283.71 | 483.74 |
| 08/2015 - 09/2016 | 92.36 | 141.75 | 221.73 | 455.83 |

DISCUSSION

The temporal period of this study was not only an eventful period for conservation policy but also a period of turmoil in the oil and gas industry in the Permian Basin as well as globally. Thus, superficially it is easy to assume that any changes in activity in DSL habitat over the study period were consequent of larger issues in the industry rather than impacts of the TCP. When the annual disturbance data is compared to production data from the region, however, the patterns of development observed in this study do not match well with the timing of production trends. The greatest reduction in disturbance for both enrolled and unenrolled property occurred in the first year of the program, when the rig count (the generally accepted metric of oil and gas activity) was still very high. Overall, disturbance levels in DSL habitat have remained reasonably static after the initial year of the program (Figure 7). Variation in estimated overall habitat loss, after the first year, are in fact within the previously mentioned measurement error consequent of the estimation process. While it is tempting to attribute reductions in habitat loss to falling oil prices, the higher rates of initial disturbance, especially on unenrolled habitat areas, could have resulted from industry responses to uncertainty regarding the perceived risk of regulatory complications prior a decision being made on listing of the DSL. In other words, some operators may have moved plans for development ahead in 2010-2011 “just in case”. Clarification of the effects of TCP enrollment vs. falling oil prices could be clarified by similarly estimating development in areas outside the LOO polygons and comparing to see if similar trends are evident in areas not affected by interest in the TCP.

It is also interesting to note that the production data illustrates a rapid increase in production that has offset the downturn in oil prices. This is likely to be good news for DSL habitat preservation, as new technology and improved methods may allow more options for avoidance and minimization of habitat loss in the extraction process. Conversely, however, this demonstrates the ability of producers in the Permian Basin to be able to continue to extract resources at a much lower oil price than is feasible in other producing regions. This may mean that if oil prices remain low, interest in developing the Permian will only increase. Indeed, after the “downturn” that shook the industry in 2014-2015 and has still kept many production areas closed or nearly so, the Permian Basin has risen to produce more than 20% of US oil and is considered the second largest oil field in the world. This heightened interest and increased

importance of the regions resources could enhance opportunities for conservation, as failure to effectively conserve DSL habitat under the TCP could have much more substantial impacts on the industry. Based on this study, the organizations that have enrolled in the TCP have met their obligations in good faith. This is evidenced by the absence of any development by enrolled Participants that was not reported and appropriately accounted for previously per their inclusion agreements. It is also appears evident that their conservation interest has some effect on the development practices of non-enrolled entities that share overlapping surface access in habitat areas (Table 3).

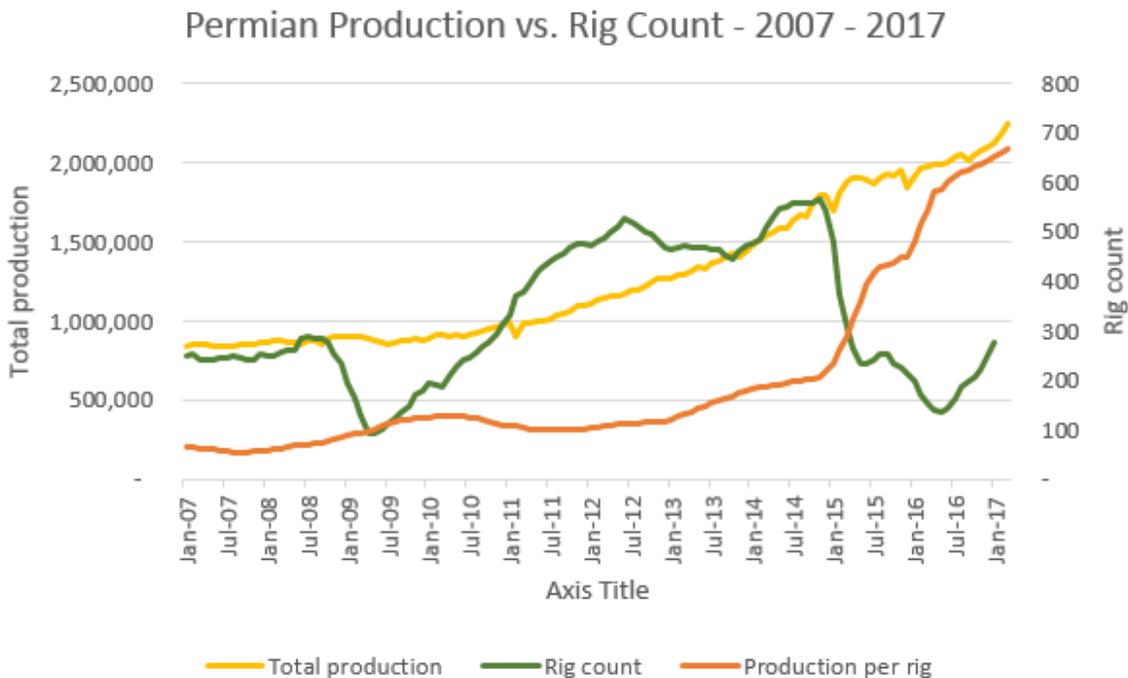


Figure 7. Production data for the Permian Basin (<https://www.eia.gov/petroleum/drilling/>)

The TCP and the associated Enhancement of Survival Permit (ESP) use habitat as a proxy for the DSL to evaluate threat to the species. Thus, there is an explicit limitation on habitat loss under the TCP within the life of the associated permit. Total loss of habitat estimated by this study at the end of 2016 was 2,378.9 acres across all habitat polygons in Figure 1-2 of the TCP (Table 4) or 1.2 % of the overall acreage in the habitat description from the TCP (197,604 acres). The argument may be made that the TCP and thus the permit supporting it, can only be responsible for habitat loss caused by enrolled Participants (as they alone have an obligation under the CCAA). In this case, only 314.9 acres (or 0.15 % of total habitat acreage as calculated above) of habitat loss or disturbance are estimated to have resulted from Participant activities.

| Likelihood of Occurrence | Allowable Incidental Take | |
|--------------------------|---------------------------|-------------------|
| | Allowable | To Date |
| Very High | 7,027.16 | 1,121.31 (191.62) |
| High | 3,506.39 | 176.62 (4.16) |
| Low | 3,582.87 | 329.06 (46.11) |
| Very Low | 7,575.03 | 751.91 (73.1) |
| Totals | 21,736.45 | 2,378.9 (314.99) |

Table 1. Incidental Take of DSL habitat allowable under the TCP and current estimates of habitat loss in acres from this study (parenthetical values are enrolled participant areas only).

In conclusion, to date, the levels of habitat loss since the implementation of the TCP have been much lower than plan limitations. Only a small portion of the habitat described by the TCP has been impacted to date. This study found no evidence that Participants had failed to comply with their voluntary conservation measures under the TCP and signals a trend toward conservation since implementation of the TCP when comparing differences between enrolled vs. non-enrolled disturbances over time