Appendix A

THE MAGNITUDE OF STRATIFICATION IN DSL HABITAT

On May 18, 2012, TAMU and CPA told the Service that the enrollment of DSL Habitat in the TCP would be 71 percent. The Service relied on the 71 percent enrollment of DSL Habitat in its decision to withdraw its listing determination. Within four months of the withdrawal decision, TAMU reported that the enrollment of habitat actually was 57 percent. It provided no explanation for the discrepancy, but it presumably resulted from double counting in the original estimate. Enrollment has remained in the mid-to-low 50 percent range and is currently at 58 percent.

Multiple distinguishable geologic strata containing oil and gas reservoirs or "plays" often have independent surface access rights via the same surface acreage. Thus, the enrollment of a property in the TCP by a participant does not necessarily preclude development or surface disturbances by another, non-participant entity who is not bound by the conservation measures in the TCP.

The calculation of the percentage of habitat enrollment does not take into account that numerous mineral leases in the DSL Habitat are severed from the surface estate. In many of these situations, the different lessees have rights to operate in different stratum, each with a right to use the surface. When non-participants share access to the same surface as an enrolled participant, the situation is referred to as "stratification." *See* Figure 1.

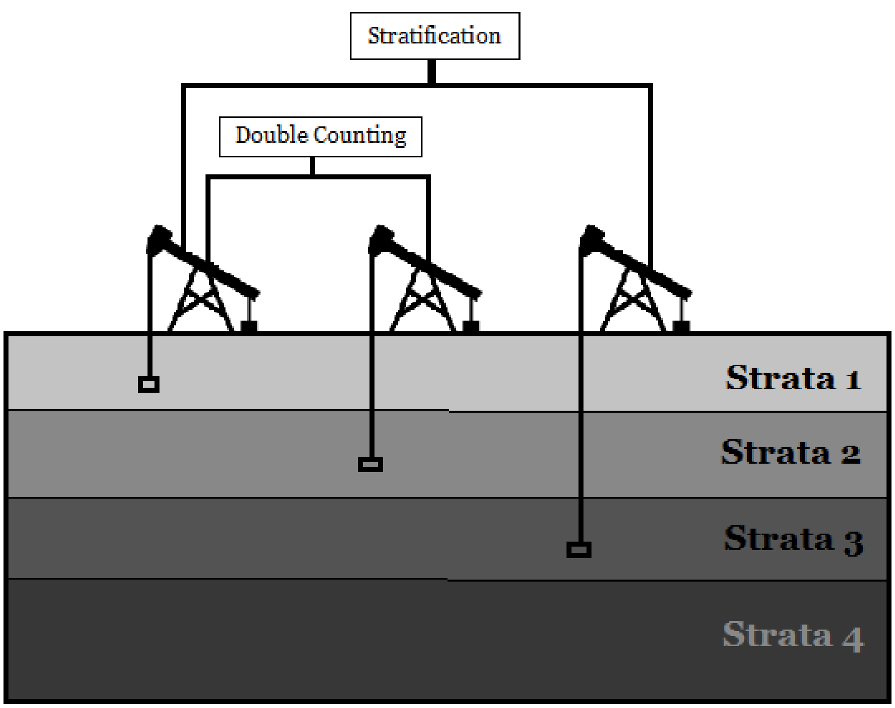

Figure 1: Illustration of Stratification: The surface is accessible to the three wells . The two wells on the left are enrolled by different participants in the TCP. If surface acreage was included in the percentage of Habitat enrolled, it would be double counting and overestimate the amount of DSL Habitat actually protected. The well on the right is not enrolled in the TCP but has access to the same surface as the two wells on the left. Thus, the protection afforded the enrolled surface estate is overstated.

The Service believes stratification is a significant issue with respect to the protection afforded the DSL by the TCP enrollment of Habitat. It asked CPA, as part of the revision of the TCP to analyze the magnitude of stratification in DSL Habitat as defined by the TCP. Our analysis supports the Service's concern regarding the potential impact of stratification.

To evaluate the magnitude of the impact of stratification, CPA's consultant, BIO-WEST, Inc. used records of well development from the Texas Railroad Commission from 2012 through 2017. BIO-WEST compiled the location of the wells in DSL Habitat with the properties enrolled by the TCP participants. Table 1 shows the results of this analysis. Stratified wells in Table 1 are non-participant wells on enrolled property.

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

The total number of wells on property enrolled in the TCP from 2012 through 2017 is 285 wells. Two hundred thirty-five of those wells (82 percent) were stratified wells, *i.e.*, on property where non-participants share access to the same surface as an enrolled participant. Three participant wells were on non-enrolled habitat and are not considered stratified although they could be in the future. Thus, it appears that a significant part of the development on enrolled property in DSL Habitat during this period involved stratification. The analysis does not identify the number of non-enrolled wells on a specific enrolled property or the acreage involved in stratification leasing. The latter will be the subject of further analysis in the near future.

The magnitude of the effects of stratification was further revealed by using Change Detection Analysis to evaluate the amount of surface disturbance by non-participants over the first five and one-half years of the TCP. As reported previously, non-participants disturbed 776 acres of enrolled properties within DSL Habitat compared to 1288 acres of surface disturbance on non-enrolled properties by non-participants over the same time period. Thus, the disturbances by non-participants on enrolled properties within DSL Habitat represents a significant part (38 percent) of the total surface disturbances by non- participants during the existence of the TCP.

Appendix B

THE POTENTIAL THREAT FROM WELL DENSITY IN DSL HABITAT

The TCP did not evaluate the potential threats posed by areas of concentrated well density. The literature suggests the existence of a negative relationship between well density and the number of DSL present at a site. A regression analysis predicted a 25 percent reduction in the abundance of DSL at well densities of 13.64 wells /mi^2. (*See*, Sias and Snell 1998). At a well density of 29.82 wells/mi^2, reductions of 50 percent were predicted in the abundance of DSL. Sias and Snell concluded that "moderate density oil well development does not present an imminent threat." *Id.* at 23. Painter *et al*. recommended, based on the study, that well densities in New Mexico be limited to 13 wells/mi^2. (Painter *et al*. 1999).

Leavitt and Fitzgerald found that fragmented areas (*i.e.*, areas with 13 wells/mi^2 or greater) had considerably lower abundance of DSL than non-fragmented sites. (Leavitt and Fitzgerald, 2013). Further, they found that high well and road density at the landscape scale resulted in smaller, fewer, and more dispersed sand dune blowouts that were less suited to DSL persistence (Leavitt and Fitzgerald 2013; *see also* Walkup *et al.* 2017).

Walkup *et al*. found that habitat specialists, such as the DSL had a relatively high susceptibility to local extinction in landscapes with 13 or more well pads/mi^2- there were too few DSL to "maintain the demographic structure of a self-sustaining population." (Walkup *et al.* 2017 at 10). They concluded that the network-like development of well pads and their connecting roads both isolates populations and disrupts the underlying geomorphologic processes that maintain the shinnery oak dune blowout formations. *Id*. at 11.

Based on recent, low uncertainty-distance occurrence data, Johnson *et al*. found that DSL declines with increasing well density. (Johnson *et al*. 2016). The number of DSL occurrences/mi^2 declines sharply at eight wells/mi^2.

The distribution of wells is not uniform in DSL Habitat. *See* Figure 1.

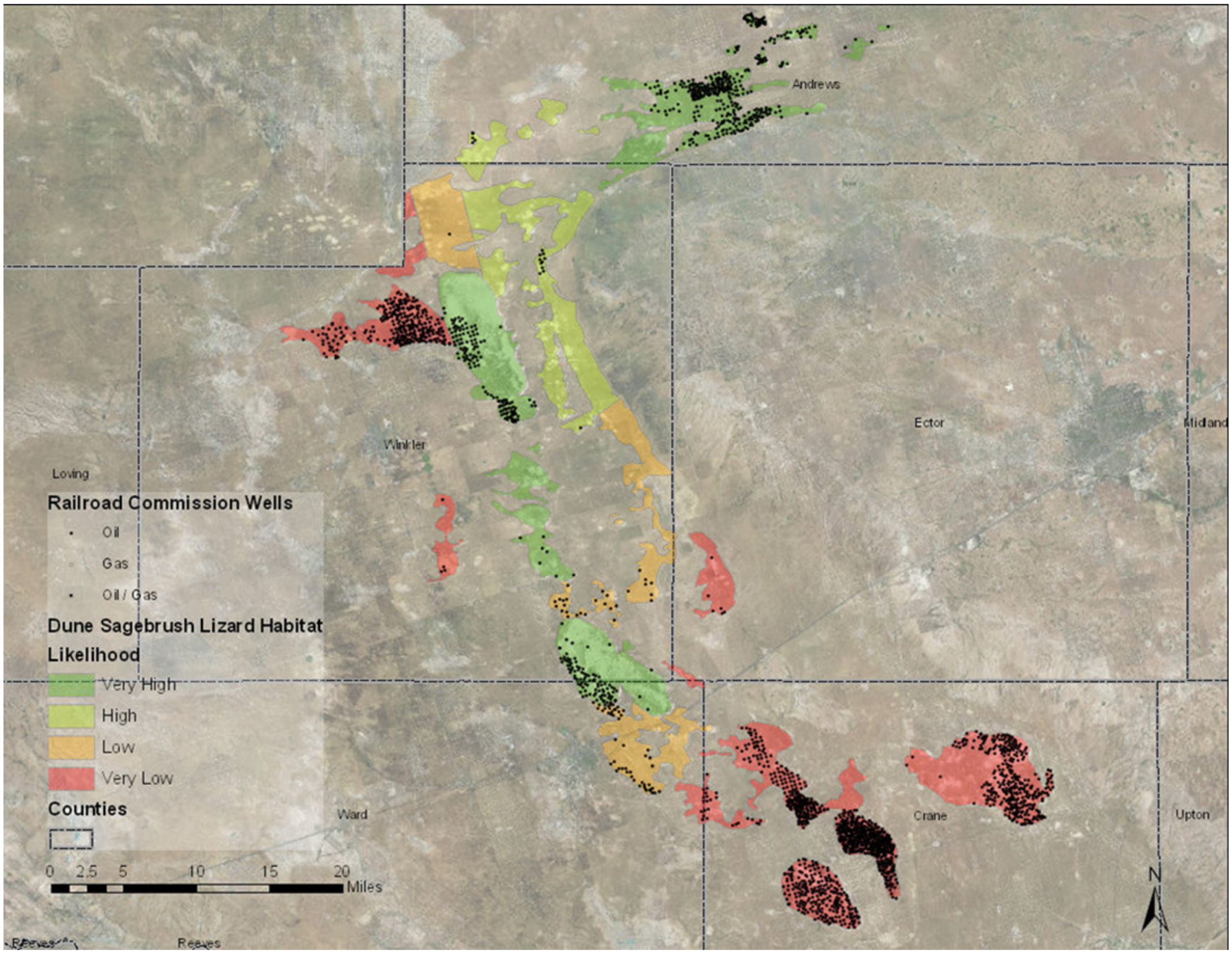

Figure 1: Wells in DSL Habitat in 2017.

Many of the wells are in Very Low Likelihood of Occurrence Habitat in Crane County and the western part of Winkler County. They also are aggregated in part of the very High Likelihood Habitat in Andrews County and along the western border of HMU 7 and western edge of Very High Likelihood Habitat near Monahan in Winkler and Ward counties.

The concentration of roads in DSL Habitat is very similar to that of the wells. *See* Figure 2 (TAMU 2016).

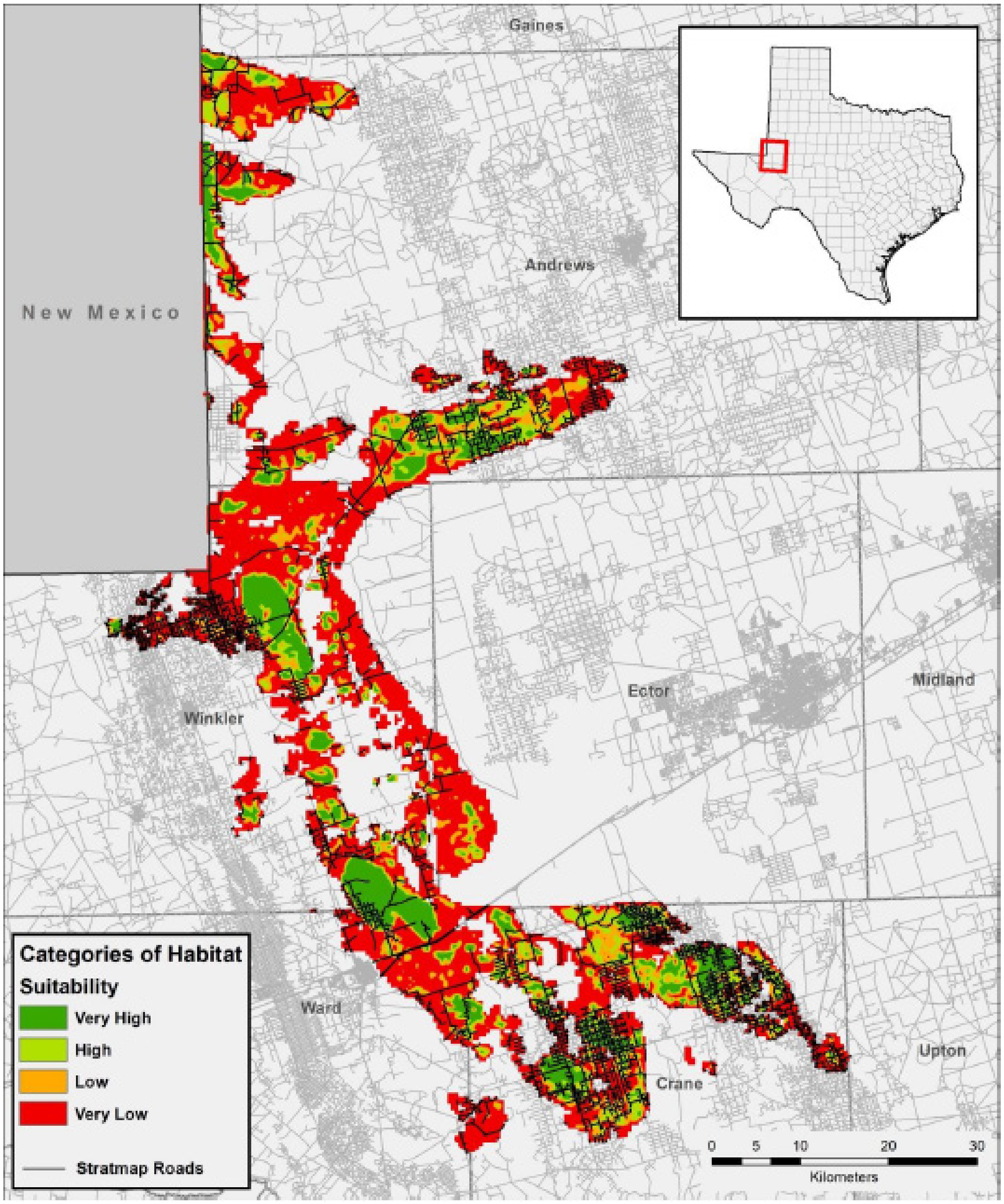

Figure 2: Roads in DSL Habitat in 2016.

CPA has also mapped the well densities in DSL Habitat. *See* Figure 3.

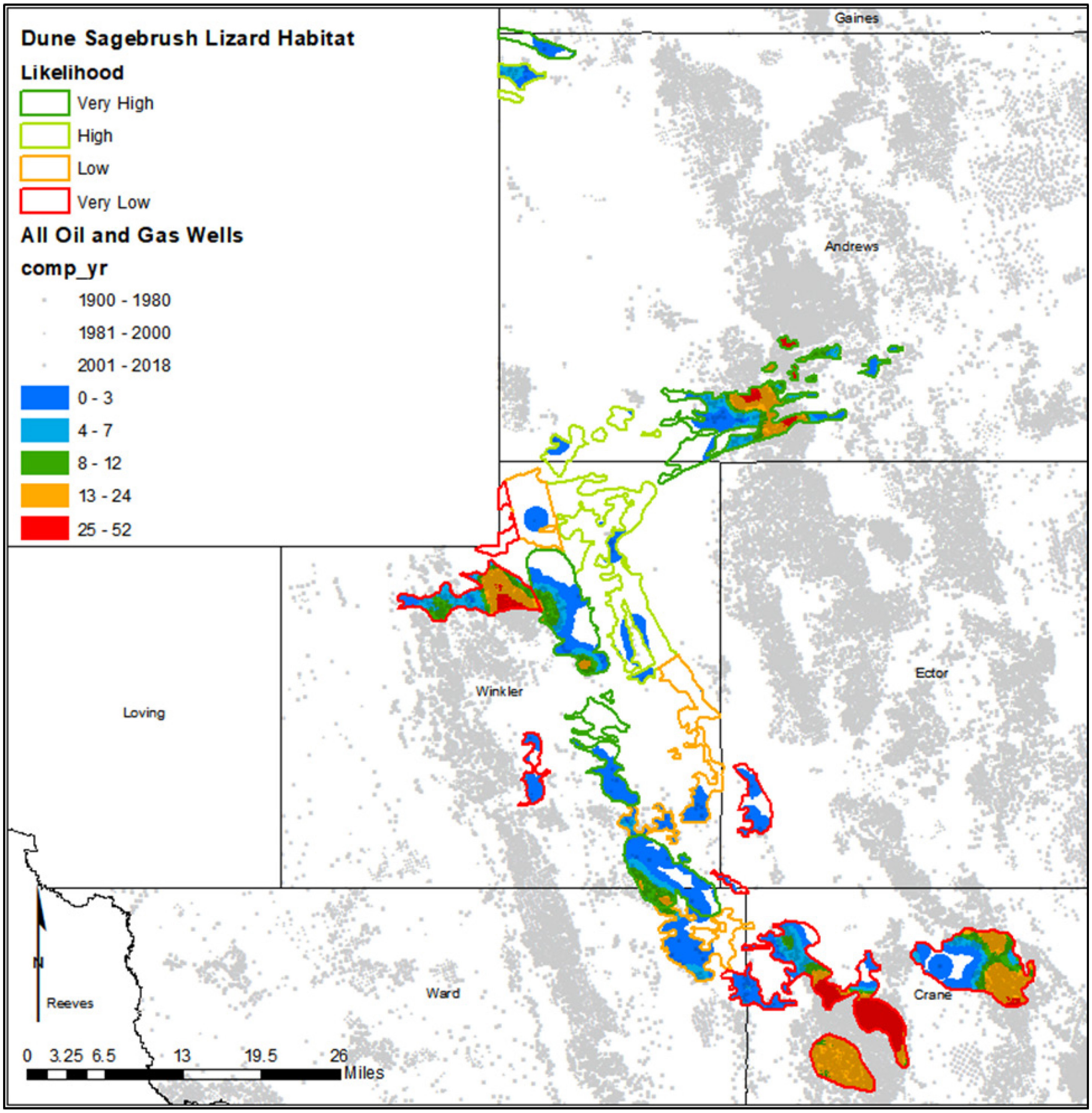

Figure 3: Well density map.

Approximately 47,750 acres of DSL Habitat have greater than eight wells/mi^2 (24 percent). Of these, approximately 32,781 acres of DSL Habitat (17 percent) have greater than 13 wells/mi^2.

Patterns in well density may fragment DSL populations. *See* Figure 4.

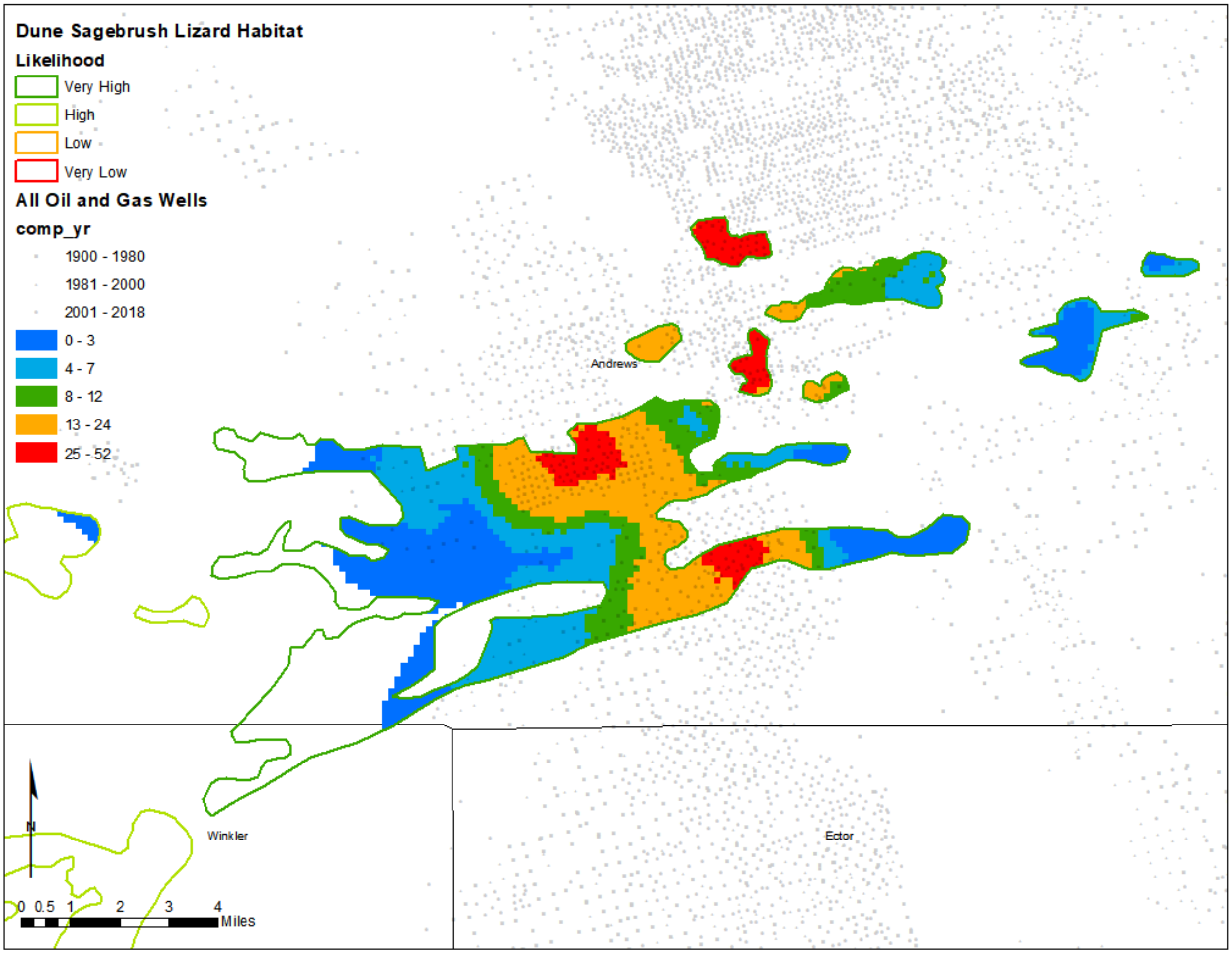

Figure 4: Well density map for DSL habitat in Andrews County.

Fragmentation disrupts landscape features, including relatively large expanses of shinnery oak dunes utilized by DSL. Walkup *et al*. found "the network-like development of well pads and their connecting roads…drives processes that result in large-scale degradation of irreplaceable landforms on which the habitat specialist depends." Patterns of oil and gas development that bisect habitat, as illustrated in Figure 4, may be of particular concern, as "movements [of DSL] among disconnected patches have never been observed (Walkup *et al.* 2017 at 11).

Except for specific limited spatial areas where reversal of the density in quality habitat may show gains or maintenance of low well and road density, the limited distribution of the wells and roads may limit the utility and cost effectiveness of well pad and road removal as a Conservation Action.

Literature Cited

Johnson, K., M. Horner, E. Muldavin, P. Neville, T. Neville, and J. Smith. 2016. Dunes sagebrush lizard habitat map and models, New Mexico. Natural Heritage New Mexico Publ. No. 15-387. Natural Heritage New Mexico, University of New Mexico, Albuquerque, NM.

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