FINAL REPORT

Federal Aid Grant No. F16AF01217 (T-95-R-1)

Investigation of Shinnery Oak Propagation and Establishment as a Framework for Restoration

Oklahoma Department of Wildlife Conservation

Grant Period: October 1, 2016 - December 31, 2018

FINAL PERFORMANCE REPORT

State: Oklahoma **Grant Number**: F16AF01217 (T-95-R-1)

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A. ABSTRACT:

Shinnery oak (*Quercus havardii*) is a poorly understood shrub that is a dominant species in a unique plant community in the southern Great Plains. It was historically more widely distributed but has been eradicated from any areas. Several high priority avian species use shinnery oak communities and understanding the plant's ecology and wildlife habitat associations is important for conservation. We evaluated shinnery oak seed germination, survival, and rhizome growth. We found that rhizome survival was poor, but larger rhizomes had higher sprouting and survival rates. Seedling germination was improved with a 2-week cold stratification and seedling survival was better with near-ambient light conditions. Additionally, we determined that soil type was the primary variable related to shinnery oak distribution. Finally, several avian species of high conservation value including Bell's Vireo, Cassin's Sparrow, and Painted Bunting were found in moderate to high numbers in shinnery oak communities. They tended to be most abundant in areas that had not been burned for 2 or more years although Cassin's Sparrow numbers fluctuated between years.

B. OBJECTIVES:

Objective 1: Identify environmental variables influencing seed germination and rhizome growth as a basis for shinnery oak restoration efforts.

Objective 2: Test the feasibility of seedling and rhizome transplantation as a means to propagate and establish shinnery oak.

Objective 3: Identify target areas for shinnery oak restoration meant to guide the conservation of sensitive wildlife species at a regional scale.

Objective 4: Examine the influence of vegetation structure on density of breeding songbirds in a shinnery oak community, with a focus on species of conservation concern.

C. NEED:

The Oklahoma Comprehensive Wildlife Conservation Strategy (OCWCS) indicates that shinnery oak (*Quercus havardii*) provides important habitat for a wide range of species of conservation concern in Oklahoma and calls for the identification of possible avenues for restoration and enhancement of shinnery oak. It is estimated that more than 1 million acres of shinnery oak shrublands have been eradicated from the Southern Great Plains (Peterson and Boyd 1998). Given that habitat loss and fragmentation can drive species declines (Herkert 1994, Haddad et al. 2015), the loss of shinnery oak likely confers substantial collateral impacts on wildlife species that benefit from, or rely on the presence of shinnery oak. Importantly, there is a diverse array of species that inhabit shinnery oak landscapes, many of which are Species of Greatest Conservation Need in Oklahoma. For example, Bell's Vireo and Cassin's Sparrows are identified in the OCWCS as priority species linked to shinnery oak communities. A key first step in conserving and restoring wildlife that benefit from shinnery oak, including these bird species, will implicitly require information that simultaneously promotes a framework for shinnery oak restoration and also helps to guide management of existing shinnery oak landscapes.

Despite its ecological importance, most management and research endeavors pertaining to shinnery oak have overwhelmingly focused on large scale control and eradication efforts (Peterson and Boyd 1998). Consequently, the implementation of shinnery oak restoration practices is severely hampered by an incomplete knowledge of basic shinnery oak biology. This knowledge gap presents a substantial barrier to implementing effective management for species of conservation concern that utilize shinnery oak communities.

D. APPROACH:

Experimental Design of Greenhouse Study - We used a greenhouse study in order to test potential treatment effects on shinnery oak germination, seedling emergence as well as seedling growth and survival. We used a randomized block design to distribute individual acorns evenly across the possible treatment combinations. Thus, acorns were randomly assigned a shade or ambient treatment, which corresponded to an individual grow tube at a specific location in the greenhouse and in a given tray. To ensure even distribution and representation of all collection sites, we placed four (4) acorns from each site in individual tubes within a tray, two (2) of which were from the ambient storage treatment and two (2) from the cold storage treatment (2˚C). Shade cloth was used to establish a shade treatment (30% light) as well as an ambient treatment (full light in the greenhouse). Thus 84 acorns were assigned to the shade treatment and 84 acorns were assigned to ambient light conditions. All acorns were watered evenly as needed. Acorns were monitored daily in order detect seedling emergence as soon as possible.

Beginning in April 2017, we also began a study on rhizome growth which used a similar experimental design as was used for the acorn study. We used 12 rhizomes from each of 10 collection sites for a total of 120 rhizome sections used in our study. For each tray, we randomly distributed rhizomes into individual planting containers. Specifically, we randomized rhizomes across light treatments (shade or ambient light) and size treatments (6 cm or 12 cm sections). Therefore each tray contained 12 individual plants (in individual containers) that were comprised of six (6) from the shade treatment and six (6) from the ambient light treatment. We then evenly assigned size treatments (three 6cm sections and three 12cm sections). All rhizomes were watered evenly as needed. Rhizomes were monitored daily in order to detect sprout emergence as soon as possible.

Collection of Acorns and Rhizomes - Acorns were collected at the Packsaddle Wildlife Management Area in western Oklahoma on 12 September 2016. The timing of collection was scheduled in order to maximize our ability to locate and collect mature acorns before predators (primarily birds) consumed or cached them. As a result of this timing, the acorns were collected prior to the start date of the grant and the cost of their collection was not charged to the grant. Acorns were collected from shinnery oak plants and initially inspected for insect damage. At the study site, acorns were floated in a bucket of water in order to: 1) detect additional insect damage (i.e., damaged acorns float to the surface) (Bonner and Vozzo 1987, Greenberg et al. 2012) and 2) increase the moisture content of acorns prior to storage (Bonner and Vozzo 1987). Damaged acorns were removed from the sample and the remaining acorns were transported to the lab at the Oklahoma State Forestry Resources Center. Prior to its planting in the greenhouse, we measured each acorn's diameter, length, and weight.

We established two storage treatments that were applied in the lab. The first consisted of acorns that were stored at room temperature. The second involved storing acorns at $2^{o}C$ for two (2) weeks. This treatment has been shown to improve acorn germination for Gambel's oak (*Quercus gambelii*) (Sopp et al. 1977), which is a closely related species to shinnery oak.

Rhizomes were collected at the Packsaddle Wildlife Management Area on 4 April 2017. We conducted rhizome collection at 10 sites distributed across the study area. Rhizome sections were removed using shears that were dipped in bleach between collection bouts at each different site. After collection, the rhizome sections were immediately transported to the Forestry Resources Center. Rhizomes were trimmed into 6 cm and 12 cm sections and planted in the greenhouse.

Spatial Analysis – Occurrence data were obtained from the Biodiversity Information Serving Our Nation (BISON) data system. We restricted our temporal extent for occurrence records between the years 1961-1990 so as to temporally match the environmental layers that were included in our niche modeling analysis. This resulted in only 51 georeferenced records that were used as the initial data set for our occurrence records thus limiting the power of the model. We included environmental variables representing climatic conditions, topographic features, and soil types. Climatic data were obtained from the ClimateNA v5.10 database. We included 31 bioclimatic variables that represent potentially important climatic conditions for biological studies. Topographic variables included elevation, slope, and aspect. Finally, we obtained a categorical soil map from the Food and Agriculture Organization of the United Nations (FAO/UNESCO).

Maxent v 3.4.1 was used to estimate an ecological niche model for shinnery oak. The extent of our study area was estimated by creating a minimum convex polygon around all occurrence locations and then buffering this polygon by 200 km. All environmental layers were clipped to the extent of this 200 km buffered polygon. To avoid overfitting of models, we spatially rarefied occurrence locations to eliminate any locations that were identical or were within a certain proximity of one another. We then conducted a correlation analysis on all environmental layers and eliminated any variables that were highly correlated ($|r| = 0.80$). After eliminating highly correlated variables, we ran an initial Maxent model with default settings and 30 replications to eliminate any variables who contributed <5% to model accuracy gain. This resulted in the inclusion of nine environmental variables: aspect, slope, soil type, Hargreaves climatic moisture deficit (mm), degree-days above 5°C (growing degree-days), precipitation as snow (mm) between August in previous year and July in current year, winter precipitation (mm), relative humidity, and temperature difference between mean warmest month temperature (°C) and mean coldest month temperature (°C). To account for model complexity, we varied the Maxent regularization multiplier at different levels ad used a Kruskal-Wallis test to determine which model had the lowest test omission rate, which was then used as the final ecological niche model. If there was no statistical difference between models, we used the test Area Under the Curve (AUC) of the Receiver Operating Characteristic (ROC) to determine the best model as this incorporated a non-threshold dependent metric. Based on this criteria, models built with a regularization multiplier value of 4 were used.

Avian Sampling - We used a stratified random approach to distribute survey points evenly across time-since-last-fire intervals on the study area. We assigned four time-since-last-fire interval categories as 0-12, 13-24, 25-36, >36 months post fire. Point-counts were conducted at 140 locations and were each repeated three times during the course of the study in three rounds of surveys (420 sampling events) over two years. The timing of survey rounds was meant to provide a more comprehensive assessment of the bird community in the study area and to collect observations during the early, middle and latter portions of the breeding season (Brown et al. 2002, Hannon et al. 2004).

Vegetation Sampling – During 2017 and 2018, we collected vegetation data at each point count location as well as at three other locations within a 100 m radius of each respective point-count location. At each vegetation sampling location, we measured vegetation height as well as visual obstruction (Nudds 1977). At each location and in each of the four cardinal directions, we measured the percent cover of functional groups using a 0.5 X 0.5 m quadrat (Daubenmire 1959). Additionally, the point-quarter method (Cottam et al. 1953) was used to measure the distance to the nearest woody cover that was >2 m in height. Vegetation data were collected at a total of 560 locations (each point-count location and three locations within 100 m at each of the 140 point-count locations).

E. RESULTS:

Acorn Emergence – After removing weevil infested acorns (approximately 80% of the acorns collected), we had 168 remaining acorns for the acorn emergence study. It is unknown what proportion of those damaged acorns would have emerged. Acorns included in our study were highly variable in diameter (range; 11.5 – 23.1 mm) and length (range; 15.80 – 28.4 mm) and differed between sites ($F_{2, 165} = 131.3$, $p < 0.001$ and $F_{2, 165} = 85.7$, $p < 0.001$, respectively) (Figure 1.). Variation in acorn size was evident given that acorns from site 3 were on average 4.15 mm greater in diameter and 4.16 mm greater in length than those collected at site 1 ($p < 0.001$).

We observed that 35% (n = 58) of acorns emerged during our monitoring period. Using logistic regression analysis, we found that cold stratification and acorn length were predictors of emergence ($p < 0.001$). Specifically, we observed that 75% of the emerged acorns were from the cold stratification treatment and that greater acorn length also increased the probability of emergence. Light treatment was not a predictor of acorn emergence. Within the ambient light treatment, 74% (n = 25) and 26% (n = 9) acorns emerged following cold stratification and no cold stratification treatment, respectively. Within the shade treatment, 75% (n = 18) and 25% (n = 6) acorns emerged following cold stratification and no cold stratification treatment, respectively.

Seedling Growth and Survival - We observed the emergence of 58 seedlings from the 168 acorns that were planted in the greenhouse (35%). Of those, 34 were from the ambient light treatment and 24 were from the shade treatment. Mean seedling growth (± SE) at the conclusion of the study was 19.1 cm (± 3.0) in the shade treatment and 21.3 cm (± 1.3) in the ambient light treatment. Seedlings in the shade treatment had a mean number of leaves of 7.5 (± 1.2) compared to 18.5 (± 1.4) in the ambient light treatment. Consequently, we found that light treatment had a significant effect on leaf number ($p < 0.001$) but not on seedling height. At the conclusion of the seedling study, 50% and 88% of total seedlings had survived in the shade and ambient light treatments, respectively. Accordingly, we found that light treatment was a predictor of seedling fate ($p < 0.005$), however, acorn length was not.

All surviving seedlings from the acorn germination/emergence and survival portion of the study (n = 62) were transplanted to Packsaddle WMA on 10/26/17 at coordinates S0440074 3971429. The site chosen for planting is a previously cultivated food plot with no existing shinnery oak and limited plant competition. A few patches of weeping lovegrass (*Eragrostis curvula*) were removed at the time of shinnery planting. Prior to planting, the soil medium was thoroughly soaked so that plants were hydrated prior to planting. On 5/23/18, the seedlings were checked for survival and 70% were alive. Seedling survival and growth will be monitored for the next several years.

Rhizome Re-sprouting - We observed very low rates of rhizome resprouting with only 15 of 120 rhizomes (12.5%) exhibiting growth during our study. Of those, 73% were in ambient light treatments and 27% were in shade treatments. Moreover, 80% and 20% were from 12 cm and 6 cm rhizome sections, respectively.

Spatial Analysis - Our final model performed well with an average test AUC of 0.81 (SE = 0.02) and a test omission error rate of 0.13 (SE = 0.03) using a logistic threshold value of 0.3446. Based on our top model, the probability of environmental suitability for shinnery oak was influenced by soil type, the amount of precipitation as snow (mm) between August in previous year and July in current year, and the soil aspect. Of these three variables, the soil type was the primary driver of determining suitability, as it had an average 68.8% contribution to model accuracy gain. However, this relationship was heavily influenced by just one soil type: (soil type A) a dominant soil type characteristic of Chromic Luvisols with 150 mm of available water storage capacity per soil unit, a moderately-well-drained drainage class, medium (loam) topsoil texture, and a clay loam subsoil texture. This soil type had an average probability of suitability of 0.89. Precipitation as snow had a negative influence on probability of suitability, in which the probability of shinnery oak suitability was <0.01 when precipitation as snow was >570 mm. Finally, areas with a north-facing aspect had the highest probability of suitability for shinnery oak (0.53), while areas with an east slope had the lowest probability of suitability (0.44). However, these differences were not significant and are unlikely to be biologically significant.

The logistic probability Maxent output suggested that the highest areas of suitability in Oklahoma were located within the southwestern portion of the state, coinciding with the coverage of the primary soil type influencing our models (Figure 2). Furthermore, based on the logistic threshold value derived from our modeling efforts (0.3446), approximately 46.6% of the study area within Oklahoma was classified as environmentally suitable for shinnery oak. More specifically, it suggests that 46.6% of the study area within Oklahoma had a probability of environmental suitability <0.3446. This suggests, based on soils and climate, that a large portion of the western and southwestern parts of Oklahoma are still environmentally suitable for shinnery oak.

Avian Surveys - We detected 1,955 individuals represented by 46 bird species across three survey rounds from 2 June to 12 July 2017 (Table 1). In 2018, we detected 3,832 individuals represented by 75 species across three survey rounds from 22 May to 22 June (Table 1). A total of 76 species were detected both years combined. Of those, the most common species detected were Field Sparrow (n = 991), Dickcissel (n = 950), and Northern Bobwhite (n = 452). The Bewick's Wren, Brown-Headed Cowbird, Cassin's Sparrow, Cliff Swallow, Eastern Meadowlark, Lark Sparrow, Mourning Dove, Northern Cardinal, and Painted Bunting were also common. Focal study species of conservation concern included Bell's Vireos, Cassin's Sparrows, and Painted Buntings. We detected 51 Bell's Vireos and 197 Painted Buntings. Cassin's sparrows fluctuated dramatically between years with only 44 detected in 2017 and 194 detected in 2018.

We found that Painted Buntings were much more likely to be in pastures >2 years TSF (Time Since Fire) with 92% of all detections in TSF >2 and 74% of all detections in TSF >3. Similarly, Bell's Vireos favored pastures >2 years TSF with 83% of all detections in TSF >2 and 69% of all detections in TSF >3. Within shinnery oak communities, Cassin's Sparrows tended to return to burned areas more quickly with only 73% of detections in TSF >2 and 65% of all detections in TSF >3. These older TSF categories were characterized by higher amounts of litter and visual obstruction readings, taller shrub cover, and less bare ground. Additionally, both Painted Buntings and Bell's Vireos tended to be found within the scattered taller shrub/tree mottes within the shrub community. These taller patches typically consisted of hybrid post oak/shinnery oak, sand plum (*Prunus angustifolia*), and hackberry (*Celtis* spp.).

F. RECOMMENDATIONS:

1) Acorn production is sporadic and highly variable between years. Further, weevil damage is high (as much as 80%) in shinnery acorns but it is unknown what proportion of these damaged acorns can germinate.
2) To maximize shinnery oak acorn germination, acorns should be cold stratified at 2^{o}C for two (2) weeks. Additionally, acorns should be floated with damaged acorns discarded prior to planting. Even with these steps, only about 50% of acorns should be expected to emerge.
3) Seedlings should not be covered in shade cloth but rather receive near ambient light in the greenhouse. Seedling survival in ambient light can approach 90%.
4) Based on our documented weevil damage, emergence rates, and seedling survival under best management recommendations, 1000 collected acorns could yield about 200 acorns for planting, and about 100 seedlings for transplant.
5) Rhizome survival was poor in this study and labor to acquire rhizomes was high. Therefore, we recommend using acorns, when available, to grow shinnery seedlings. However, if rhizomes are used, rhizomes of at least 12 cm should be planted and given ambient light to increase survival.
6) The distribution of shinnery is most strongly related to soil type. Specifically, Chromic Luvisols with 150 mm of available water storage capacity per soil unit, a moderately-well-drained drainage class, medium (loam) topsoil texture, and a clay loam subsoil texture should be targeted for potential restoration.

7) Many species of birds occur in shinnery oak during the breeding season. However, Field Sparrow, Dickcissel, and Northern Bobwhite dominate the breeding bird community at Packsaddle WMA. Bell's vireos occur irregularly, mostly associated with taller patches of shrubs. Cassin's sparrow numbers fluctuated wildly (>4x) from year to year but can be fairly common in shinnery oak communities.
8) Species of high conservation concern such as Bell's Vireo, Cassin's Sparrow, and Painted Bunting tended to favor greater TSF (i.e. >2 TSF). However, shinnery oak communities return to pre-burn conditions within 2-4 years.

G. SIGNIFICANT DEVIATIONS

There were no significant deviations from the objectives of this grant or the approaches that were originally proposed.

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REFERENCES:

Bonner, F.T. and J.A. Vozzo, J.A., 1987. Seed biology and technology of Quercus. General Technical Report. SO-66. New Orleans, LA: US Department of Agriculture, Forest Service, Southern Forest Experiment Station.

Brown, D.R., Strong, C.M. and P.C. Stouffer. 2002. Demographic effects of habitat selection by Hermit Thrushes wintering in a pine plantation landscape. The Journal of Wildlife Management 62 (2): 407-416.

Daubenmire, R. 1959. A canopy-coverage method of vegetational analysis. Northwest Science 33:43-64.

Cottam G., Curtis, J.T. and B. W. Hale. 1953. Some sampling characteristics of a population of randomly dispersed individuals. Ecology 34:741-757.

Greenberg, C.H., Keyser, T.L., Zarnoch, S.J., Connor, K., Simon, D.M. and G.S. Warburton. 2012. Acorn viability following prescribed fire in upland hardwood forests. Forest Ecology and Management 275:79-86.

Haddad, N.M., Brudvig, L.A., Clobert, J., Davies, K.F., Gonzalez, A., Holt, R.D., Lovejoy, T.E., Sexton, J.O., Austin, M.P., Collins, C.D. and W.M. Cook. 2015. Habitat fragmentation and its lasting impact on Earth’s ecosystems. Science Advances 1(2) e1500052.

Hannon, S.J., Cotterill, S.E. and F.K.A. Schmiegelow. 2004. Identifying rare species of songbirds in managed forests: application of an ecoregional template to a boreal mixedwood system. Forest Ecology and Management 191(1):157-170.

Herkert, J.R., 1994. The effects of habitat fragmentation on midwestern grassland bird communities. Ecological Applications 4(3):461-471.

Nudds, T.D. 1977. Quantifying the vegetative structure of wildlife cover. Wildlife Society Bulletin 5(3):113-117.

Peterson, R.S. and C.S. Boyd. 1998. Ecology and management of sand shinnery communities: a literature review (pp. 71-87). US Department of Agriculture, Forest Service, Rocky Mountain Research Station.

Sopp, D. F., Salac, S.S., and R.K. Sutton. 1977. Germination of Gambel oak seed. Tree Planters' Notes 28: 4-5.

TABLES AND FIGURES

Table 1. Seventy-six species of birds were detected on Packsaddle Wildlife Management Area, June-July 2017 and 2018. The 12 most common species are bold.

Common Name	Scientific Name	Total Individuals	% of Points with Detections
American Crow	*Corvus brachyrhynchos*	36	9
American Goldfinch	*Spinus tristis*	29	8
American Kestrel	*Falco sparverius*	1	0
American Robin	*Turdus migratorius*	3	1
Ash-throated Flycatcher	*Myiarchus cinerascens*	2	1
Barn Swallow	*Hirundo rustica*	42	9
Baltimore Oriole	*Icterus galbula*	3	1
Bell's Vireo	*Vireo bellii*	51	11
Belted Kingfisher	*Megaceryle alcyon*	2	1
Bewick's Wren	***Thryomanes bewickii***	**150**	**27**
Blue-gray Gnatcatcher	*Polioptila caerulea*	102	18
Blue Grosbeak	*Guiraca caerulea*	66	15
Blue Jay	*Cyanocitta cristata*	4	1
Bobolink	*Dolichonyx oryzivorus*	3	1
Brown-headed Cowbird	***Molothrus ater***	**378**	**48**
Brown Thrasher	*Toxostoma rufum*	90	21
Bullocks Oriole	*Icterus bullockii*	3	1
Bushtit	*Psaltriparus minimus*	4	1
Carolina Chickadee	*Poecile carolinensis*	30	6
Carolina Wren	*Thryothorus ludovicianus*	5	1
Cassin's Sparrow	***Aimophila cassinii***	**237**	**28**
Cattle Egret	*Bubulcus ibis*	1	0
Chimney Swift	*Chaetura pelagica*	2	1
Cliff Swallow	***Petrochelidon pyrrhonota***	**312**	**30**
Common Grackle	*Quiscalus quiscula*	2	1
Common Nighthawk	*Chordeiles minor*	9	3
Cooper’s Hawk	*Accipiter cooperii*	2	0
Dickcissel	***Spiza americana***	**950**	**68**
Downy Woodpecker	*Picoides pubescens*	2	1
Eastern Bluebird	*Sialia sialis*	50	8
Eastern Kingbird	*Tyrannus tyrannus*	9	2
Eastern Meadowlark	***Sturnella magna***	**187**	**29**
Eastern Phoebe	*Sayornis phoebe*	17	5
Eastern Wood Peewee	*Contopus virens*	1	0

Eurasian Collared Dove	*Streptopelia decaocto*	3	1
European Starling	*Sturnus vulgaris*	10	3
Field Sparrow	***Spizella pusilla***	**991**	**73**
Grasshopper Sparrow	*Ammodramus savannarum*	22	4
Great Crested flycatcher	*Myiarchus crinitus*	43	8
Greater Roadrunner	*Geococcyx californianus*	13	4
Hairy Woodpecker	*Leuconotopicus villosus*	5	1
House Finch	*Haemorhous mexicanus*	2	1
House wren	*Troglodytes aedon*	2	0
Horned Lark	*Eremophila alpestris*	15	3
Indigo Bunting	*Passerina cyanea*	35	8
Killdeer	*Charadrius vociferus*	16	5
Ladder-backed Woodpecker	*Dryobates scalaris*	7	3
Lark Sparrow	***Chondestes grammacus***	**200**	**34**
Lazuli Bunting	*Passerina amoena*	1	0
Lincolns Sparrow	*Melospiza lincolnii*	1	0
Loggerhead Shrike	*Lanius ludovicianus*	2	1
Mallard	*Anas platyrhynchos*	1	0
Mississippi Kite	*Ictinia mississippiensis*	52	11
Mourning Dove	***Zenaida macroura***	**227**	**38**
Northern Bobwhite	***Colinus virginianus***	**452**	**67**
Northern Cardinal	***Cardinalis cardinalis***	**200**	**32**
Northern Mockingbird	*Mimus polyglottos*	62	14
Northern Roughed-wing swallow	*Stelgidopteryx serripennis*	30	9
Orchard Oriole	*Icterus spurius*	2	1
Painted Bunting	***Passerina ciris***	**197**	**33**
Peregrine Falcon	*Falco peregrinus*	2	0
Red-bellied Woodpecker	*Melanerpes carolinus*	33	8
Red-eyed Vireo	*Vireo olivaceus*	1	0
Red-headed Woodpecker	*Melanerpes erythrocephalus*	25	5
Red-tailed Hawk	*Buteo jamaicensis*	1	0
Red-winged Blackbird	*Agelaius phoeniceus*	11	4
Scissor-tailed Flycatcher	*Tyrannus forficatus*	102	19
Swainson's Hawk	*Buteo swainsoni*	7	2
Tree Swallow	*Tachycineta bicolor*	13	3
Tufted Titmouse	*Baeolophus bicolor*	3	1
Turkey Vulture	*Cathartes aura*	40	9
Upland Sandpiper	*Bartramia longicauda*	1	0
Wild Turkey	*Meleagris gallopavo*	8	1
Western Kingbird	*Tyrannus verticalis*	7	2
Western Meadowlark	*Sturnella neglecta*	10	3
Yellow-billed Cuckoo	*Coccyzus americanus*	54	13
Unknown Meadowlark	*Sturnella* sp.	29	8

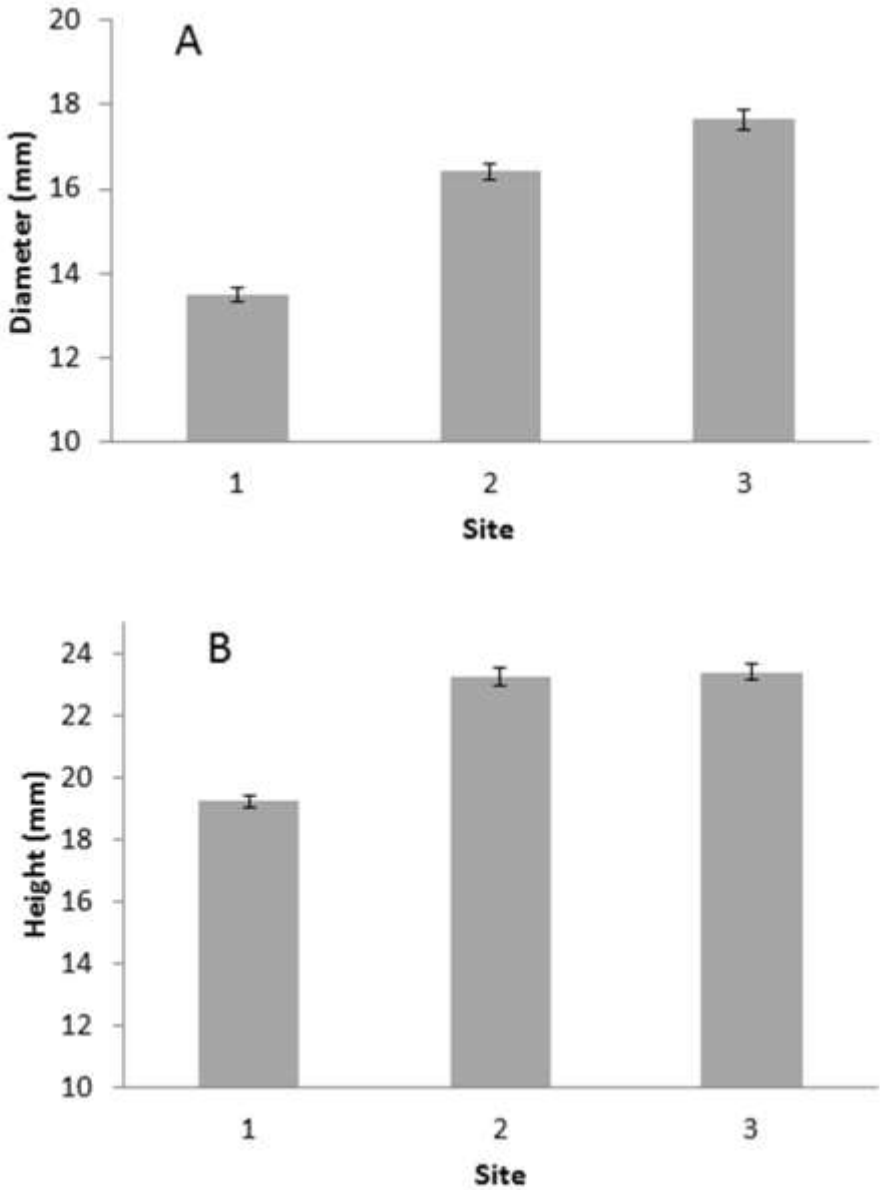

Figure 1. Mean size (length (height) and diameter) of shinnery oak acorns collected at the 3 different sites (i.e., 1, 2, and 3) at the Packsaddle Wildlife Management Area, Ellis County, Oklahoma (2016).

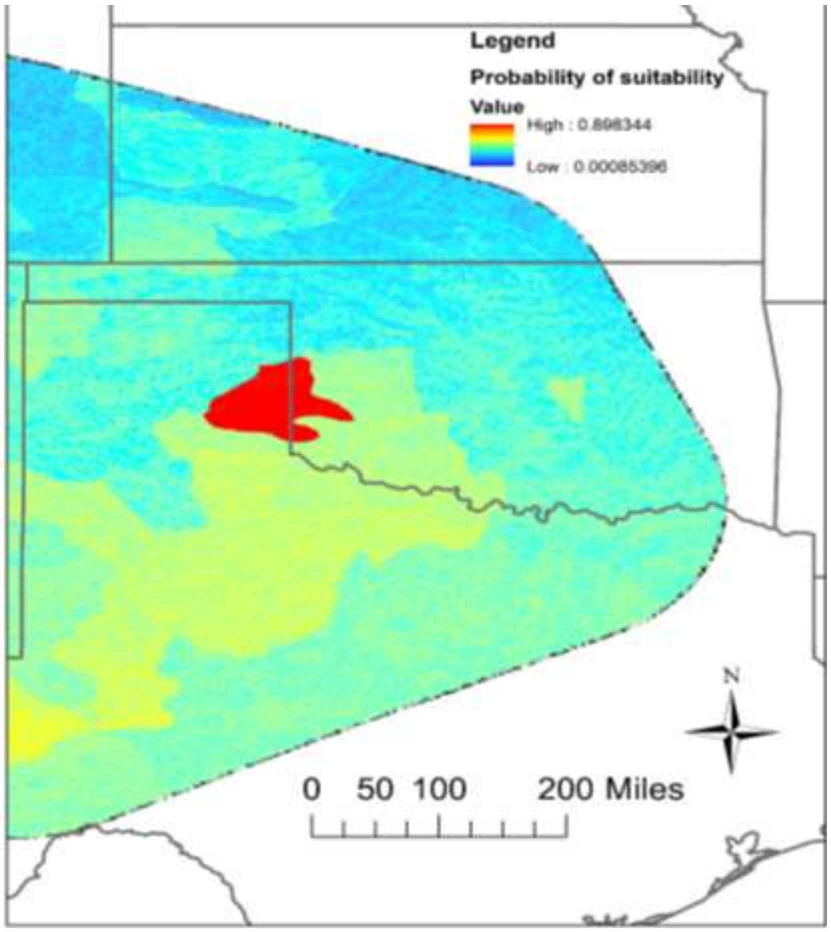

Figure 2. Average logistic probability of suitability for shinnery oak (*Quercus havardii*) as determined from 30 replicated Maxent models.