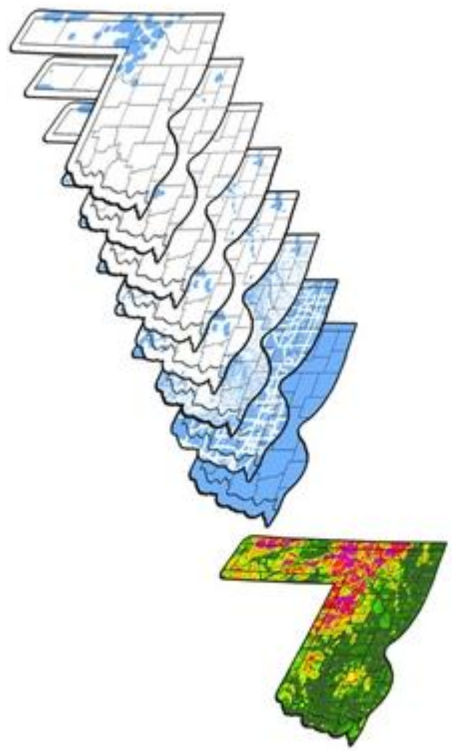
A Spatially-Based Planning Tool Designed to Reduce Negative Effects of Development on the Lesser Prairie-Chicken (*Tympanuchus pallidicinctus*) in Oklahoma

A Multi-Entity Collaboration to Promote Lesser Prairie-Chicken Voluntary Habitat Conservation and Prioritized Management Actions



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Developed in Partnership by:

Oklahoma Department of Wildlife Conservation

U. S. Fish and Wildlife Service

Playa Lakes Joint Venture

The Nature Conservancy

George Miksch Sutton Avian Research Center

Oklahoma State University

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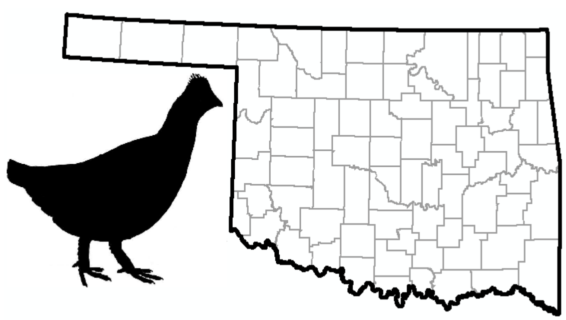
DISCLAIMER

The Oklahoma Lesser Prairie-Chicken Spatial Planning Tool (OLEPCSPT 2010) is a spatially explicit model designed to assist development planning by avoiding, minimizing and mitigating negative effects of development on the lesser prairie-chicken in Oklahoma. The model and all associated products are specific to the lesser prairie-chicken and Oklahoma.

It is extremely important to understand that the Oklahoma Lesser Prairie-Chicken Spatial Planning Tool does not address, or attempt to address, any other potential concerns to natural resources within the modeled area (Figure 2), except the LEPC. There may be additional natural resource concerns (e.g., public conservation lands, rare or sensitive habitats, state species of concern, federally listed species, and others) within the area that was modeled requiring developer's consideration and evaluation to ensure compliance with appropriate state and federal laws and ongoing conservation initiatives. Some sources for additional spatial tools and wildlife planning resources are located in Appendix D. If any uncertainty exists regarding potential for effects to natural resources, the appropriate state or federal authority should be contacted.

Ultimately, it is the responsibility of those involved with the planning, design, construction, operation and maintenance of proposed developments to complete all appropriate assessments, determine the likelihood of effecting natural resources, and pursue the appropriate course(s) of action in coordination with the appropriate statutory authority for a given resource.



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INTRODUCTION

The lesser prairie-chicken (*Tympanuchus pallidicinctus*; LEPC; Figure 1) is a species of prairie grouse endemic to the southern high plains of the United States. LEPC are polygynous and exhibit a lek mating system. The lek is a place where males gather to conduct a competitive mating display. Male LPC gather to display on leks at dusk and dawn beginning in late February through early May (Copelin 1963, Hoffman 1963, Crawford and Bolen 1976). Prairie grouse require large expanses of unfragmented, ecologically diverse native rangelands to complete their life cycles (Woodward et al. 2001, Fuhlendorf et al. 2002, Davis 2008), more so than almost any other grassland bird. The LEPC is an umbrella species for wildlife conservation with targeted LEPC management actions benefiting many other species that occur within the range of the LEPC and require all or portions of the same habitat components (Rich et al. 2004, Pruett et al. 2009a). Threats to the LEPC include, but are not limited to, conversion of habitat to cultivated agriculture, excessive livestock grazing, fire suppression, collision mortality, hybridization, and fragmentation of habitat.

Figure 1. Picture of a lesser prairie-chicken (*Tympanuchus pallidicinctus*)

This document describes the purpose, development, and application of the Oklahoma Lesser Prairie-Chicken Spatial Planning Tool (OLEPCSPT, *hereafter LEPC model*), a spatially explicit model designed to help reduce potential negative effects of development on the LEPC in Oklahoma. The LEPC model is a product of an ongoing effort in Oklahoma among the Oklahoma Department of Wildlife Conservation (ODWC), the Oklahoma Ecological Services Field Office of the U.S. Fish and Wildlife Service, the Playa Lakes Joint Venture, the Oklahoma Chapter of The Nature Conservancy, the George Miksch Sutton Avian Research Center, and Oklahoma State University to proactively address potential conflicts between development and LEPC conservation. The LEPC model is the synthesis of a complex issue utilizing the best available information and expert opinion.

Information regarding other resources (e.g., wetlands, rare or sensitive habitats, state and federal trust species, etc.) in Oklahoma that should be considered in the planning phase of development projects can be found at a variety of sources, including the Oklahoma Department of Wildlife Conservation, U.S. Fish and Wildlife Service Ecological Services Field Office, Playa Lakes Joint Venture, Oklahoma Chapter of The Nature Conservancy, G. M. Sutton Avian Research Center, the Oklahoma Biological Survey, the Oklahoma Natural Heritage Inventory and many others.

Purpose

The purpose of the model is to provide a tool for proactive planning to avoid, minimize and mitigate the negative effects of development on the LEPC in Oklahoma. The model accomplishes this by providing industry and wildlife professionals a tool that can help: 1) site development with consideration to LEPC conservation, 2) estimate the amount of a voluntary contribution to the LEPC Habitat Conservation fund needed to offset the impact of potential developments, and 3) locate areas to apply Habitat Conservation fund contributions for effective LEPC conservation work.

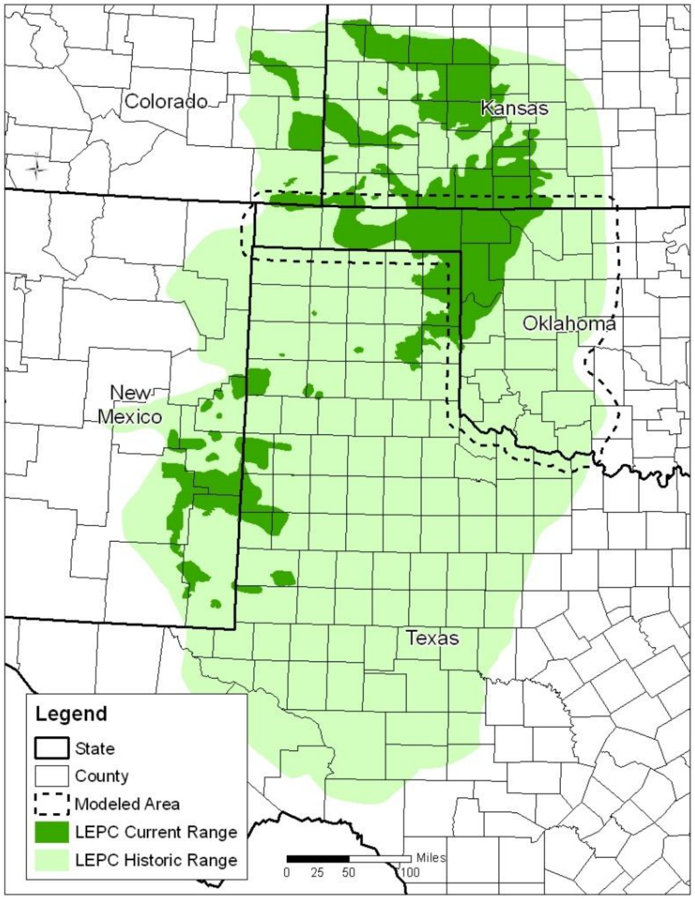

Figure 2. Map of the historical and current range of the lesser prairie-chicken. Modeled extent is delineated by dotted line.

Justification

The impetuses for the LEPC model are the steady decline of the LEPC populations and increasing development pressures in the range of the LEPC in Oklahoma. The LEPC is a candidate species for listing under the Endangered Species Act and its listing priority number was elevated in 2008 from 8 to 2 (U.S. Department of Interior 2008a), bringing the species closer to listing (U.S. Department of Interior 2008b). The historical range of the LEPC has declined to approximately 10 percent of its former range and the species' population has declined to only 5 percent of historical numbers (Hagen et al. 2004, Figure 2). According to the USFWS, "the most serious threat to the lesser prairie-chicken is the present and threatened destruction, modification, and curtailment of its habitat and range" (U.S. Department of Interior 2008b).

In Oklahoma, the LEPC occurs only in the northwest portion of the state (Figure 2). The LEPC is sensitive to habitat fragmentation caused by roads, human development, and habitat conversion (Crawford and Bolen 1976, Pitman et al. 2005, Davis et al. 2008) and requires large contiguous patches of suitable habitat (Crawford 1974, Hagen et al. 2004). LEPCs can collide with electric lines and fences, causing injury and mortality (Bidwell et al. 2003, Wolfe et al. 2007), and (especially nesting hens) avoid or abandon areas with vertical structures such as wind turbines, oil wells and transmission towers (Robel 2002, Hagen et al. 2004, Robel et al. 2004, Pitman et al. 2005, Chamberlain et al. 2006, Wolfe et al. 2007, Pruett et al. 2009b) and areas with human activity (Robel 2002, Pitman et al. 2005).

Existing Products

At the request of industry representatives working to avoid vulnerable areas, a number of map products have been created since 2003 by The Nature Conservancy, U.S. Fish and Wildlife Service, Playa Lakes Joint Venture and other conservation organizations active in the Oklahoma. In most cases, the maps depict generalized areas of concern, and were intended to provide a basic tool for siting developments away from important wildlife habitats. These map products were broadly distributed, often without necessary background information and knowledge of the maps intended purpose. This led to misinterpretation of map data and incorrect use for fine scale planning. Recent improvements in the knowledge of wildlife behavior relating to vertical structures provided an opportunity to create a more sophisticated Geographic Information System (GIS) based habitat and fragmentation model resulting in an improved planning tool for developers.

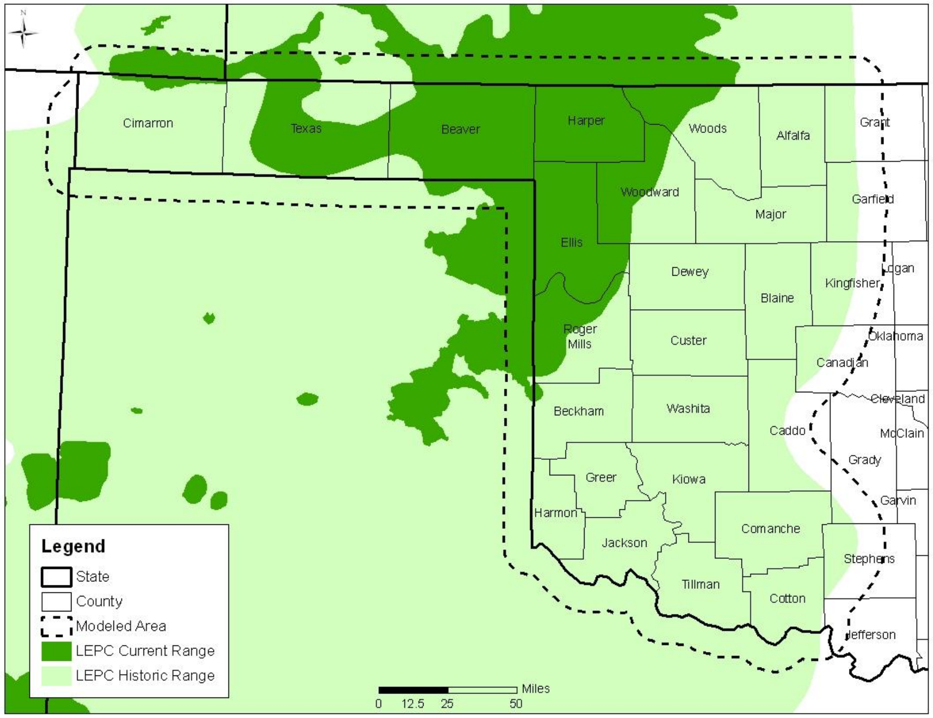

Figure 3. The extent of the modeled area is delineated by the black dotted line (10 miles outside the historical range or state boundary).

Model Overview

The LEPC model is a conceptual spatial model that ranks land relative to its importance for LEPC conservation. The LEPC model produces a spatial grid spanning the historical range of the LEPC in Oklahoma in which each 30m x 30m pixel is numerically ranked (1 to 8). The higher the rank, the more valuable that pixel is to the LEPC. Ranks are determined by comparing each pixel in the grid against a set of eight criteria addressing LEPC occurrence, habitat requirements and threats. Each rank value is associated with a dollar value reflecting the cost of replacing that land if it were destroyed or degraded. The model can be used to evaluate any type of potentially detrimental development (e.g. wind energy farm, road construction, oil and gas wells, transmission line).

METHODS

This section describes the components and design of the model including detailed information on how the model determines importance and dollar values.

All GIS work was conducted in raster format using the Spatial Analyst extension of the ArcMap software package (Environmental System Research Institute (ESRI), Version 9.2, 2005). All data was set to the projected coordinate system of North American Datum 1983, Universal Transverse Mercator Zone 14 North (NAD83, UTM Zone 14N).

Spatial Extent

The model extent includes the area within 10 miles of the LEPC historical range in Oklahoma (Figure 3). The LEPC model was run throughout the species historical range in Oklahoma, not just the current range, because suitable and potentially suitable habitat in the historical range is considered vital for LEPC range and population expansion. The LEPC model was run across the state boundary for two reasons. First, two of the eight model factors are based on spatial habitat models which identified large contiguous patches of landcover types, requiring analysis across state boundaries. Second, developments occurring near the state line will affect habitat in adjacent states. Every effort was made to include the data for each factor in the 10 mile buffered area, however, data for each factor was not available for every state occurring within the 10 mile buffer. Known data deficiencies in the 10 mile buffer include the 5 mile buffer of lek locations in Texas and portions of the managed/protected lands from each state, specifically the location of all state and federal wildlife habitat cost share projects on private land. The LEPC model should only be used for evaluation of projects located in Oklahoma (Figure 2, Figure 3). Any question regarding potential for effects to LEPC in any portion of the adjacent states, should be referred to the appropriate state wildlife management agency (i.e., Kansas Department of Wildlife and Parks, Colorado Division of Wildlife, New Mexico Department of Game and Fish or Texas Parks and Wildlife Department).

Data and Format

All grids analyzed and produced by this model are based on 30m x 30m pixels. The primary reason for using this resolution is because three of the eight model factors (discussed below) are based on spatial analysis of a regional 30m x 30m landcover grid. The source data set(s) used in the model are cited and described in the *Ranking Factors* section of this document. Some of the data sets used in this model will be updated regularly (e.g., Federal Aviation Administration digital obstruction file) or occasionally (e.g., managed lands, leks, landcover) as new data become available. The LEPC model and products will be updated annually, no later than March 1 each year. Thus this product is dynamic and should be consulted regularly for the most current information.

Ranking Process

The LEPC model assigns each pixel a rank of 1 to 8 by comparing each pixel against eight sets of criteria. Each set of criteria is based on a factor (referred to hereafter as *ranking factor)* that addresses one of the following categories: LEPC occurrences, habitat requirements or threats. Criteria are distinct for each ranking factor and are based on published scientific literature or expert opinion from biologists. If a pixel meets the criteria of a ranking factor, it is assigned a value of 1, otherwise 0. This process produces a binary (1 or 0) grid for each ranking factor. The addition of these eight binary grids produces the final result of the model, a grid with values ranging from 1 to 8, where pixels with a value of 8 have the highest value for LEPC conservation (Figure 4). The eight ranking factors are described in detail in below.

Ranking Factors

The eight ranking factors are listed in Table 1 along with a brief description of the criteria against which pixels are evaluated and the assigned pixel values. The numeration (order) of the factors has no effect on the model. A detailed account of each ranking factor follows and includes:

1) their function in the model,
2) the criteria used to evaluate pixels and assign binary values (1 or 0),

3) a justification for including the factor in the model,
4) a description of the data used to evaluate the pixels,
5) the source of the data, and
6) the resultant binary grid as a map.

In the maps, blue pixels have a value of 1 and white pixels have a value of 0. Pixels outside the model extent, represented by the black dotted line, are not valued. Due to the high resolution of the LEPC model, 30m x 30m, the maps provided below are for illustrative purposes only. For an accurate representation of the ranks at a project level, referrer to the LEPC model in GIS or one of the large format maps (34" x 44" .pdf)

Table 1. The eight ranking factors in the model, the criteria against which pixels are evaluated, the category and the assigned values.

Ranking Factor	Pixel Criteria	Category	Pixel Value	
			True	False
1. Historical Range	Within 10-miles of boundary	Occurrence	1	0
2. Current Range	Within boundary	Occurrence	1	0
3. Leks	Within 5-mile radius	Occurrence	1	0
4. Habitat Suitability	Suitable or Potentially Suitable	Habitat	1	0
5. Core Habitat Patch	Within core patch	Habitat	1	0
6. Core Buffer Habitat	Within core buffer	Habitat	1	0
7. Managed/Protected Land	Within 2-km buffer of boundary	Habitat	1	0
8. Avoided Structures	Outside all avoidance buffers	Threats	1	0

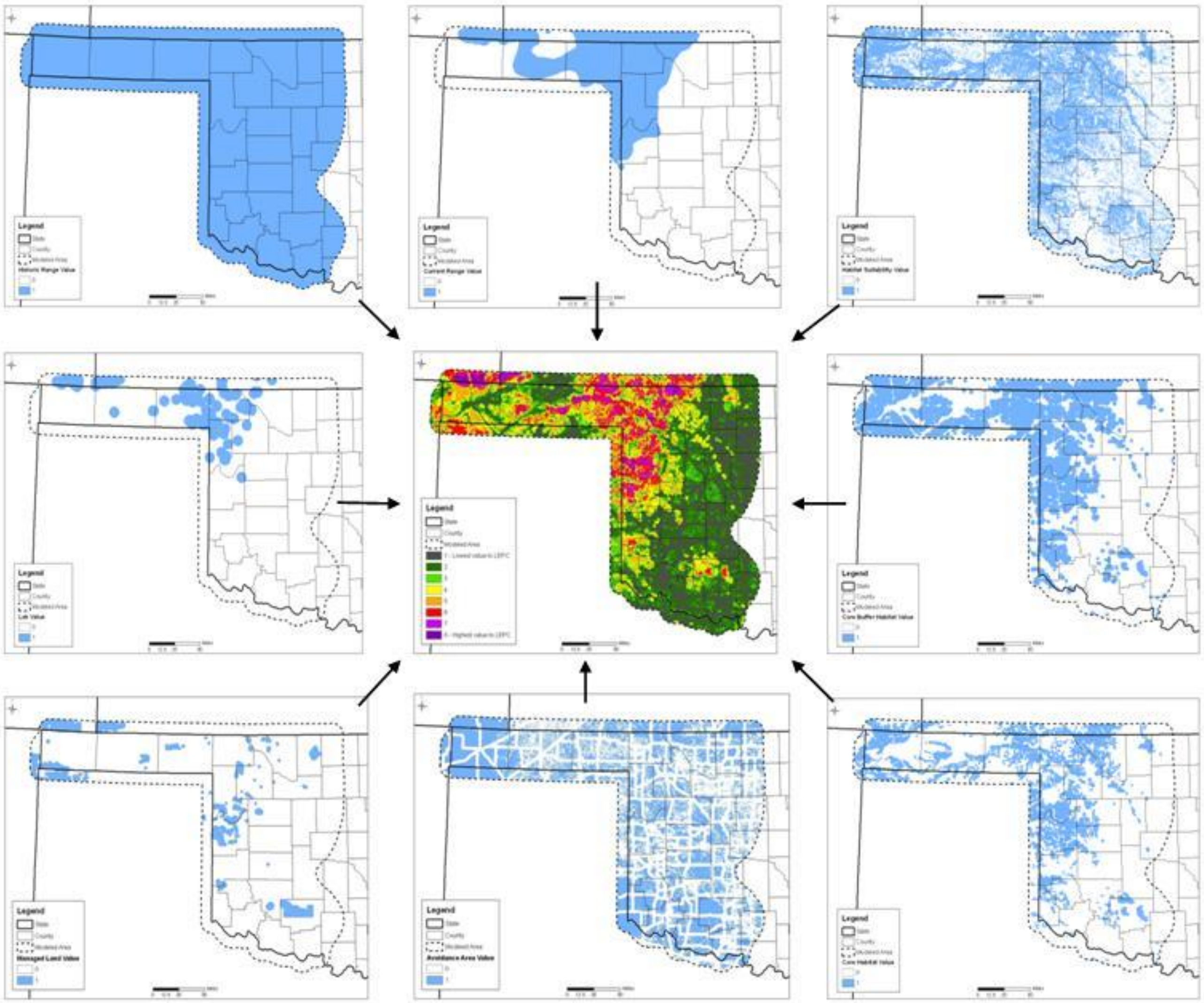

Figure 4. Illustration of the eight binary grids that are added to produce the final ranking grid.

Factor 1: Historical Range

Function: Gives value to land within 10 miles of the Oklahoma historical range of the LEPC regardless of habitat suitability.

Criteria: Pixels within 10 miles of the Oklahoma historical range boundary are given a value of 1; otherwise 0 (Figure 5).

Justification: All land within the historical range boundary is considered valuable for LEPC conservation because it is needed for population growth and range expansion. Habitat destruction or degradation within the historical range would likely impede range expansion and could further fragment populations.

Data Description: The range boundary is based on a compilation of historical accounts of the species' distribution with account dates beginning as far back as the early 1900's (Davis et al. 2008). Sources and dates of these accounts vary by state; see the *Lesser Prairie-Chicken Conservation Initiative* (Davis et al. 2008) for detailed information on how the boundary was developed. The historical range boundary includes 178 counties in five states (Colorado, Kansas, Oklahoma, New Mexico, and Texas). See Figure 2 for a map of the entire historical range.

Data Source: The historical range boundary is as illustrated and described in the *Lesser Prairie-Chicken Conservation Initiative* (Davis et al. 2008) and was modified (expanded) in Colorado to incorporate recent edits from the Colorado Division of Wildlife (Seth McClean, personal communication).

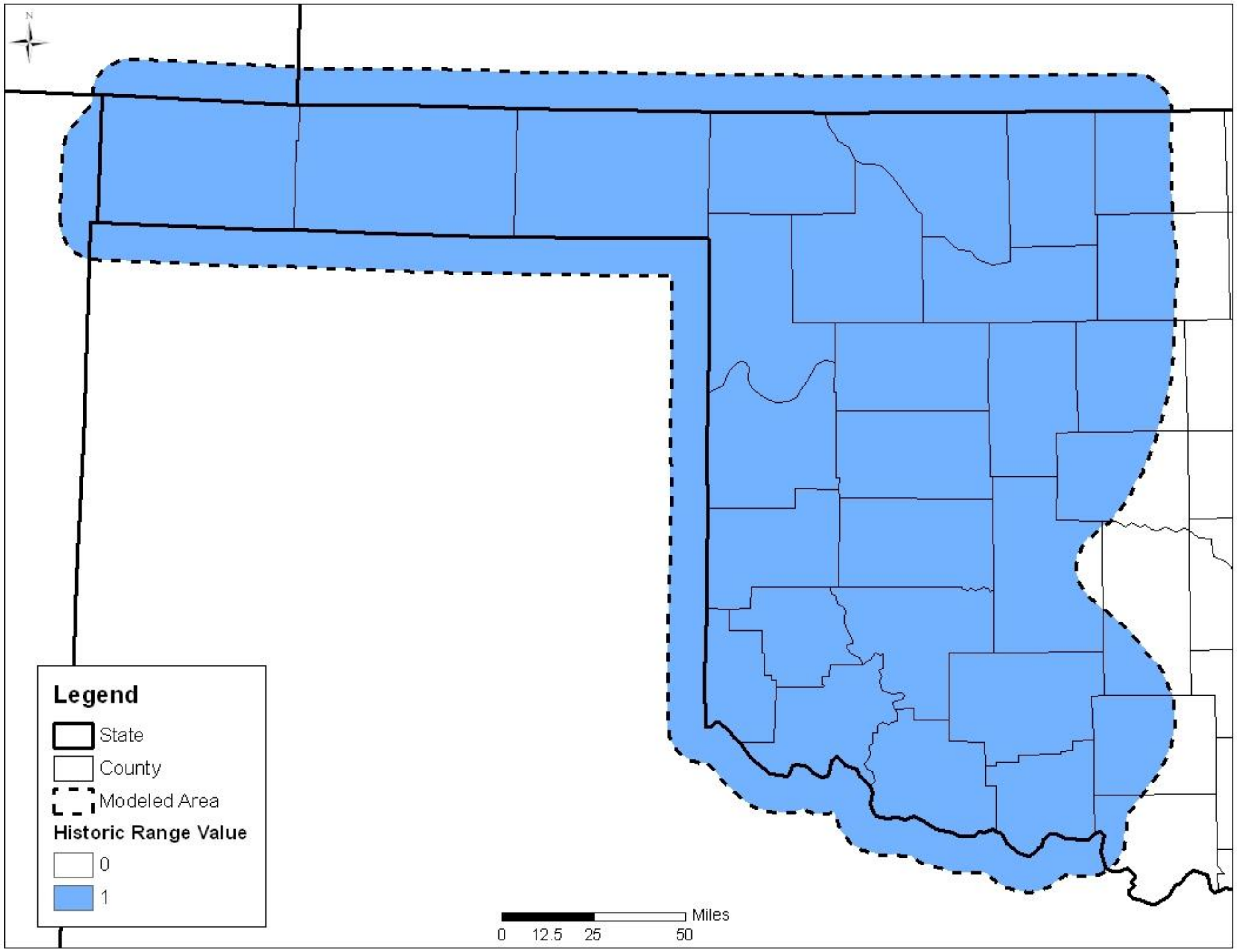

Figure 5. The binary grid for the historical range factor. Blue pixels =1 and white pixels =0. The black dotted line delineates the extent of the modeled area.

Factor 2: Current Range

Function: Gives value to all land within the current range of the LEPC regardless of habitat suitability.

Criteria: Pixels within the current range boundary are given a value of 1; otherwise 0 (Figure 6).

Justification: All land within the current range is considered valuable for LEPC conservation because it is where LEPC are known to occur. Development and disturbance anywhere within the current range, regardless of habitat suitability, has greater potential to affect the LEPC than areas outside the range.

Data Description: The current range boundary includes areas where LEPC currently exist or have occurred in recent years based on lek locations and bird sightings. Areas within 5 miles of a lek are included within the current range boundaries (based on LEPC dispersal distances). It is almost certain that not all occupied areas are known so LEPCs likely occur in areas outside this boundary. The current range boundary will be updated as new sightings occur. See Figure 2 to see the entire current range.

Data Source: The current range is based on the boundary developed by the Lesser Prairie-Chicken Interstate Working Group (LPCIWG) and was edited (extended) in Oklahoma to incorporate recently identified areas of occurrence (individuals and leks) and corridors connecting those areas. The LPCIWG is a partnership of biologists representing natural resource agencies and organizations from the five states within the LEPC range (Colorado, Kansas, New Mexico, Oklahoma, and Texas). Edits made to the current range boundary include the following:

1. The range was expanded southward along the Oklahoma-Texas border, from Ellis County into Roger Mills County, to incorporate recently active LEPC wintering grounds (Don Wolfe, personal communication).
2. The range was expanded to encompass all 5-mile buffers of lek sites (several leks were excluded from the original range). This expanded the range eastward in Woodward County, eastward in Roger Mills County, and westward in Texas County.
3. The range was expanded to the south in Beaver County, to the Texas state border, to incorporate recently active breeding grounds (Don Wolfe, personal communication). The boundary edges now correspond to (reflect) the current range boundary that was delineated for Texas, making the range fluid across the state line.
4. The 'hole' in range in Harper County was closed to prevent further fragmentation of this portion of the range. This change was made specifically for the application of the range boundary to this model, not to indicate that LEPCs occur in this area.
5. The two areas of LEPC range (two distinct polygons) in Texas County were connected, using native vegetation as a guide, to prevent further fragmentation of these areas. This change was made specifically for application of the range boundary to this model, not to indicate that LEPCs occur in this area.

This edited current range boundary is not intended to replace the original LEPC current range boundary developed by the LPCIWG.

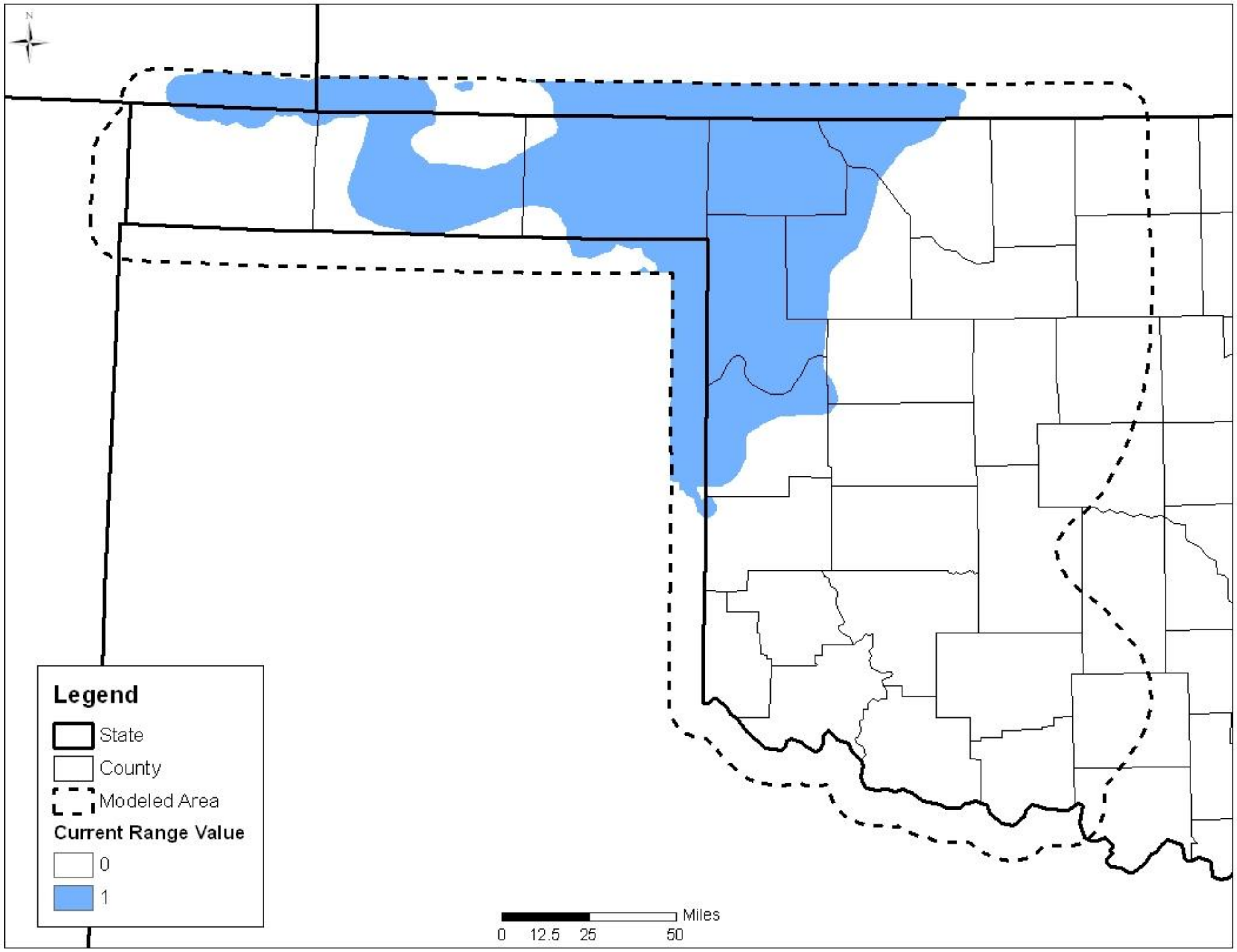

Figure 6. The binary grid for the current range factor. Blue pixels =1 and white pixels =0. The black dotted line delineates the extent of the modeled area.

Factor 3: Habitat Suitability

Function: Gives value to suitable or potentially suitable habitat.

Criteria: Pixels classified as suitable or potentially suitable habitats are given a value of 1; otherwise 0 (Figure 7).

Justification: All suitable and potentially suitable habitat within 10 miles of the historical range is considered valuable regardless of landcover composition or configuration because of its potential for current inhabitation or future inhabitation via population shifts and expansion, and habitat restoration work (i.e., creation of large patches of suitable habitat from previously small and fragmented patches).

Description: Seven habitats are considered suitable for LEPC and three classes are considered potentially suitable (i.e., habitat that would become suitable if managed for the LEPC). Habitat suitability was determined by reviewing published LEPC literature and conferring with local biologists. All suitable habitat types are associated with at least one life-cycle habitat requirement as described in the Lesser Prairie-Chicken Conservation Initiative (Davis et al. 2008). Land in the Conservation Reserve Program (CRP) that was planted to grass is considered potentially suitable habitat. In Kansas, research shows that CRP grassland planted with native species provides suitable habitat to LEPCs (Rodgers and Hoffman 2005). However, CRP in Oklahoma is often planted with non-native species, such as old-world bluestem, so the suitability may be lower (Rodgers and Hoffman 2005) but proper management (e.g., grazing, prescribed fire, re-seeding) could provide suitable habitat. Eastern red cedar and mesquite infested grassland were also considered potentially suitable because, if they were managed appropriately (e.g., tree removal, prescribed fire), they could provide suitable habitat. Habitat names are based on landcover classes in the landcover grid that was analyzed, cited below in *Data Sources*. See Table 2 for a list of habitats.

Table 2. Suitable and potentially suitable habitats.

Suitable Habitat	**Potentially Suitable Habitat**
Mixed-grass prairie	Eastern Red Cedar
Tallgrass prairie	Mesquite
Sandhills prairie	CRP planted to grass
Shortgrass prairie	
Sandsage	
Shinnery	
Wet Meadow	

Data Source: Suitable and potentially suitable habitat classes were identified in a regional 30-m landcover grid developed by PLJV. The landcover grid encompasses all five states in the LEPC range (Colorado, Kansas, Oklahoma, New Mexico, and Texas) and categorizes habitats according to a single classification scheme such that habitat classes are consistent across state boundaries. Detailed information on the development of the PLJV landcover including a list of habitat classes is available in the Habitat Assessment Procedures manual (Playa Lakes Joint Venture 2007).

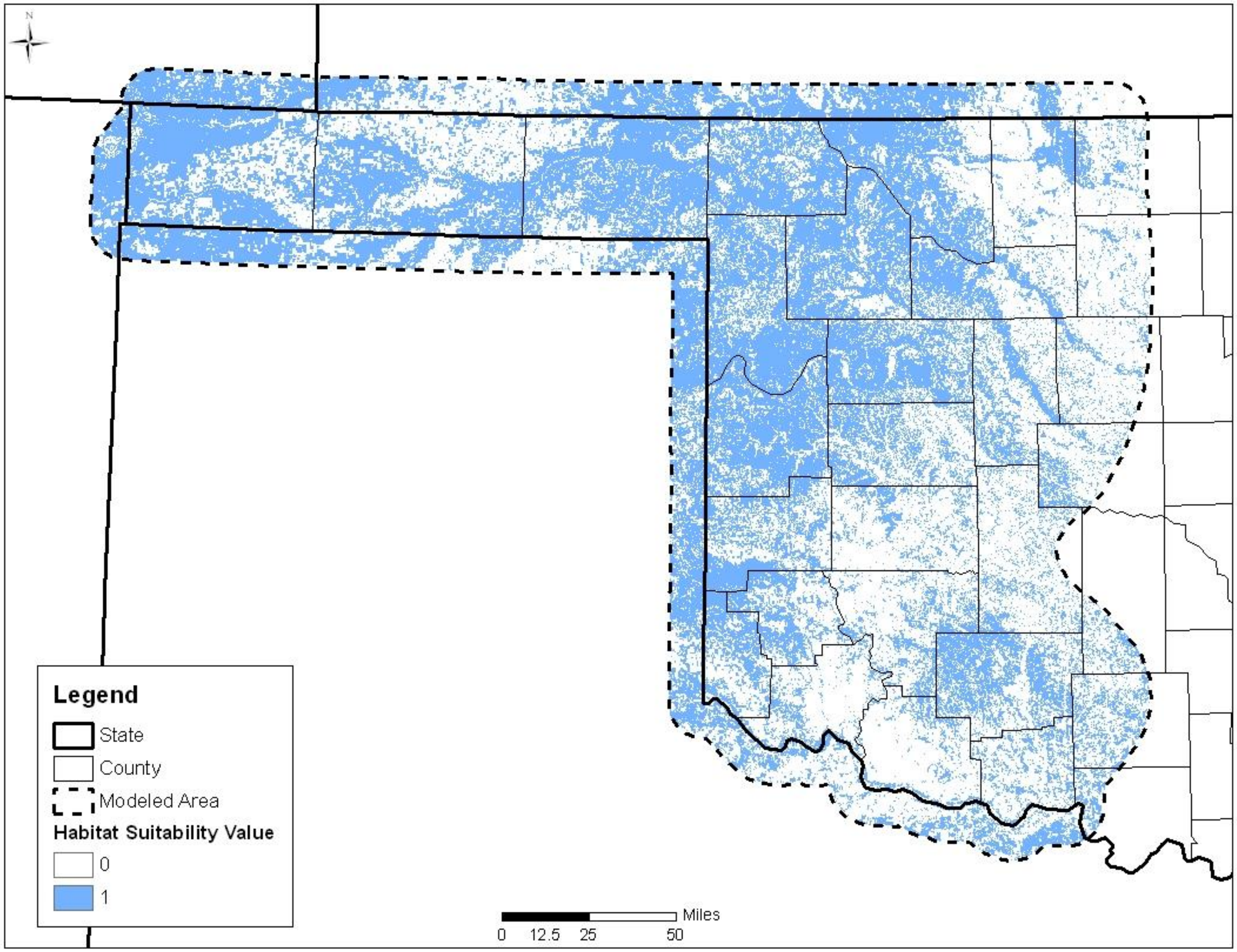

Figure 7. The binary grid for the habitat suitability factor. Blue pixels =1 and white pixels =0. The black dotted line delineates the extent of the modeled area.

Factor 4: Core Habitat

Function: Gives value to large contiguous patches of suitable and potentially suitable habitat.

Criteria: Pixels within core habitat patches receive a value of 1; otherwise 0 (Figure 8). Core habitat always occurs within core buffer habitat (described below) so it will automatically receive one additional point.

Justification: Core habitat patches are considered valuable because published research suggests minimum patch size and configuration criteria for LEPC conservation and recovery (Hagen et al. 2004).

Description: Core habitat delineates large patches of suitable and potentially suitable habitat for LEPC based on minimum patch size and configuration criteria that occur within 10 miles of its historical range in Oklahoma. Delineation of core habitat was based on spatial analysis of landcover composition and configuration as it relates to the habitat needs of LEPC.

Core habitat consists of patches of suitable habitat (mixed grass prairie, sandhills prairie, tallgrass prairie, shortgrass prairie, wet meadow, sand sagebrush, or shinnery) or potentially suitable habitat (eastern red cedar or mesquite *but not CRP*) that are:

1) either more than 2,000ha in area or 500ha – 2,000ha in area and no more than 10km from another patch of at least 500ha (i.e., patches with high connectivity),
2) at least 1600m wide (about 1 mile), and
3) contain gaps of unsuitable habitat no wider than 450m (about 0.25 mile).

Unsuitable habitat is defined as any landcover other than those defined as suitable or potentially suitable such as primary roads, urban/suburban development, cropland, or woodland (see Appendix A for information on treatment of primary roads and developed areas as unsuitable habitat).

Minimum patch size criteria follow recommendations published in *Guidelines for Managing Lesser Prairie-Chicken Populations and their Habitats* (Hagen et al. 2004). Minimum patch width and maximum gap width within patches were based on expert opinion because information specific to such thresholds was not found. See Appendix A for an account of the spatial processing used in identifying core habitat, including assumptions and limitations of this process.

Data Source: Core habitat was identified by running a spatial model (see Appendix A) on a regional 30-m landcover grid developed by PLJV. The landcover grid encompasses all five states in the LEPC range (Colorado, Kansas, Oklahoma, New Mexico, and Texas) and categorizes habitats according to a single classification scheme such that habitat classes are consistent across state boundaries. Detailed information on the development of the PLJV landcover including a list of habitat classes is available in the Habitat Assessment Procedures manual (Playa Lakes Joint Venture 2007).

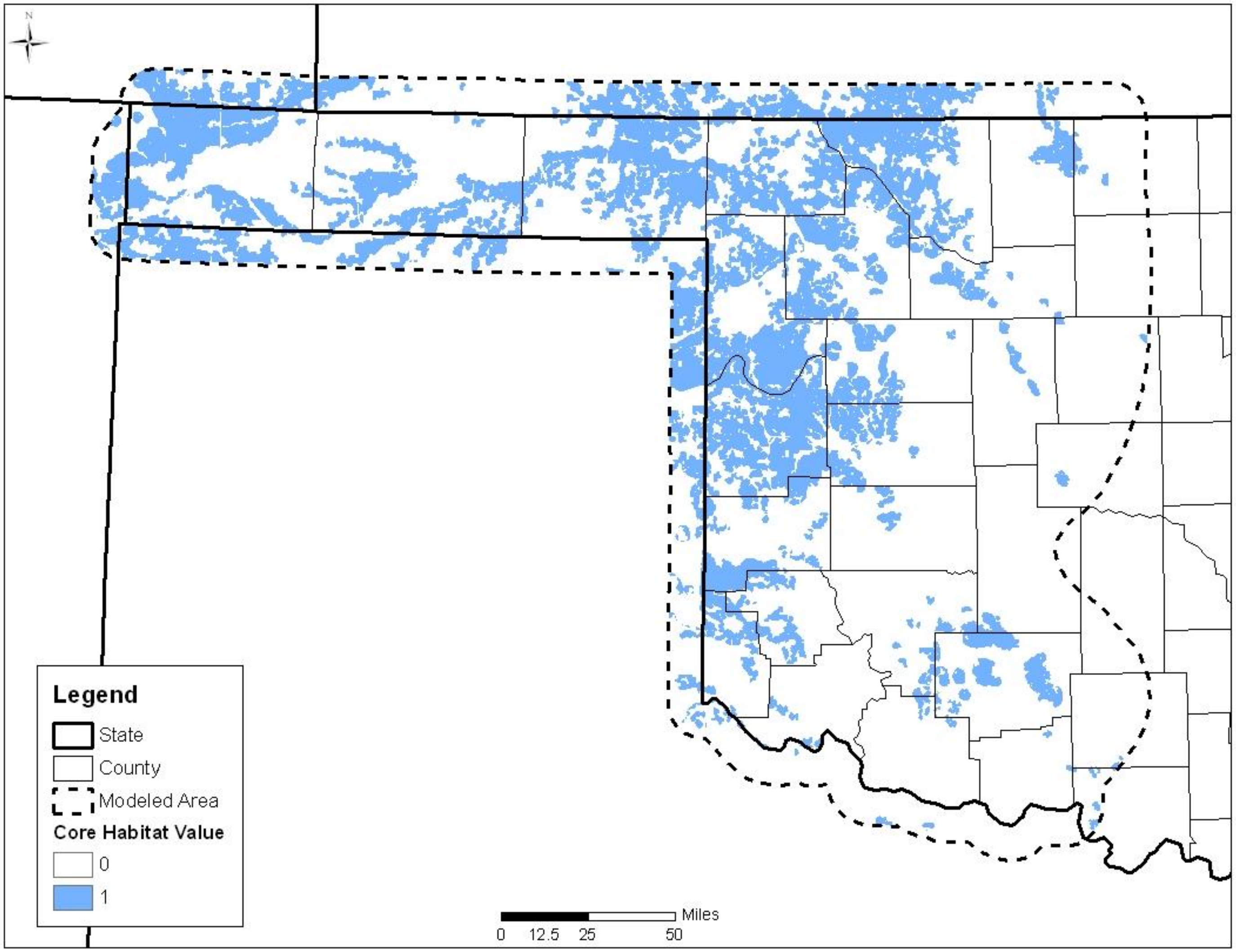

Figure 8. The binary grid for the core habitat factor. Blue pixels =1 and white pixels =0. The black dotted line delineates the extent of the modeled area.

Factor 5: Core Buffer Habitat

Function: Gives value to areas that meet minimum habitat composition ratios considered suitable for LEPC.

Criteria: Pixels within core buffer habitat receive a value of 1; otherwise 0 (Figure 9).

Justification: Core buffer habitat is considered valuable because published research suggests minimum landcover composition ratios are necessary for LEPC conservation and recovery (Hagen et al. 2004).

Data Description: Core buffer habitat represents areas that contain patches of suitable or potentially suitable habitat that are smaller and less contiguous relative to core habitat (i.e., are more interspersed with unsuitable habitats) but still have potential as LEPC habitat, especially if managed appropriately or if additional suitable habitat were created within the area. Delineation of core buffer habitat was based on spatial analysis of landcover composition. See Appendix B for an account of the spatial processing used in identifying core buffer habitat, including assumptions and limitations of this process

Core buffer habitat is as an area of 2,025ha in which there is at least 810ha (40%) of suitable habitat (mixed grass prairie, sandhills prairie, tallgrass prairie, shortgrass prairie, wet meadow, sand sagebrush, or shinnery) or potentially suitable habitat (eastern red cedar, mesquite, or CRP land in grass-type practices), less than 810ha of cropland (including pasture), less than 50ha of woodland other than mesquite or eastern red cedar, and no urban/suburban development or major roads (e.g., state highways, interstates, freeways; secondary roads such as county roads not included).

These criteria are based on recommendations from the LEPC Interstate Working Group in combination with recommendations found in *Guidelines for managing Lesser Prairie-Chicken populations and their habitats* (Hagen et al. 2004).

Data Source: Core buffer habitat was identified by running a spatial model (see Appendix B) on a regional 30-m landcover grid developed by PLJV. The landcover grid encompasses all five states in the LEPC range (Colorado, Kansas, Oklahoma, New Mexico, and Texas) and categorizes habitats according to a single classification scheme such that habitat classes are consistent across state boundaries. Detailed information on the development of the PLJV landcover including a list of habitat classes is available in the Habitat Assessment Procedures manual (Playa Lakes Joint Venture 2007).

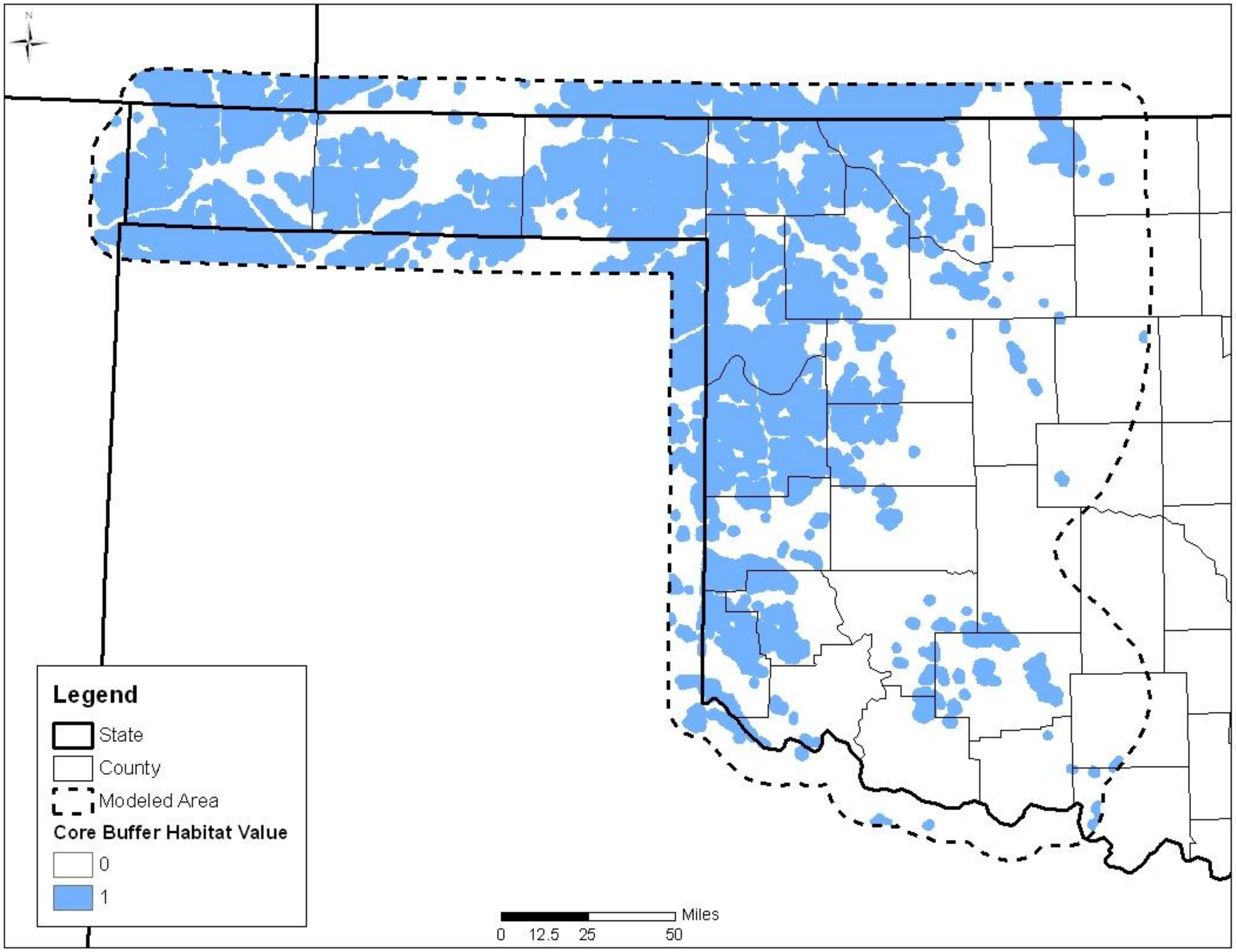

Figure 9. The binary grid for the core buffer habitat factor. Blue pixels =1 and white pixels =0. The black dotted line delineates the extent of the modeled area.

Factor 6: Leks

Function: Gives value to all land within 5 miles of a known lek.

Criteria: Pixels within 5 miles of a lek are assigned a value of 1; otherwise 0 (Figure 10).

Justification: Leks are essential for LEPC reproduction and areas around leks have high concentrations of LEPCs including nesting hens (Suminski 1977, Riley 1978, Gisen 1998, Woodward et al. 2001, Pitman 2003). Research also indicates that disturbance in surrounding areas can cause abandonment of the lek site, reduce breeding success, and lower nest success (Crawford and Bolen 1976, Hunt 2004, Pitman et al. 2005, Davis et al. 2008).

Data Description: A 5-mile buffer was applied to spatially explicit points representing approximate lek locations. All leks were sighted between 1996 and 1998. The USFWS suggests that areas within a 5-mile radius of leks be avoided when siting wind energy facilities (Manville 2004).

Data Source: Lek locations were provided by Oklahoma Department of Wildlife Conservation and the G.M. Sutton Avian Research Center. All leks were confirmed between 1996 and 1998.

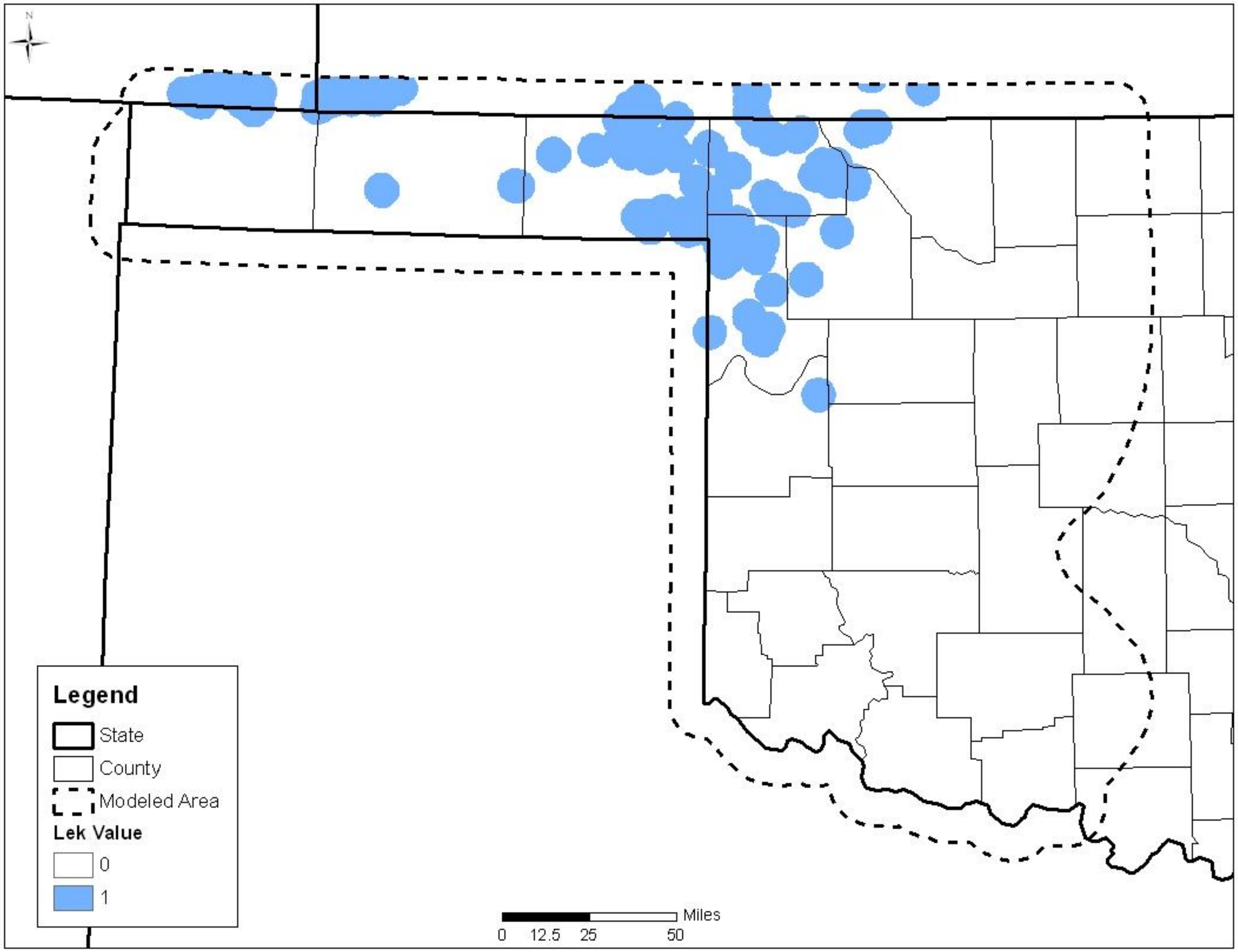

Figure 10. The binary grid for the lek factor. Blue pixels =1 and white pixels =0. The black dotted line delineates the extent of the modeled area.

Factor 7: Managed and Protected Land

Function: Gives value to managed and protected lands that are potential LEPC habitat including all land within 2-km of them.

Criteria: Pixels within 2-km buffer of a managed or protected land area assigned a value of 1; otherwise 0 (Figure 11).

Justification: Managed and protected lands are valuable for LEPC conservation and recovery because they are areas in which habitat management can be controlled and monitored for LEPC by the corresponding owner or manager (e.g., U.S. Forest Service, Agricultural Research Service, USFWS, TNC, ODWC) and are areas where new habitat can be established to create large patches of suitable habitat.

Data Description: Managed and protected lands include lands that are managed by government agencies or private non-profit conservation groups (e.g., TNC) and are considered to have at least some potentially suitable habitat for LEPC. A buffer was applied because research indicates that habitat up to 2-km from a wind turbine may be avoided by the LEPC (Hagen et al. 2004). In other words, development within 2-km of a managed area may render it unsuitable for LEPC despite proper habitat management. The same buffer size is used for wind turbine avoidance buffer, discussed below in *Factor 8*).

Data Source: Spatial boundaries of managed and protected lands are maintained by the U.S. Forest Service, USFWS, ODWC, and TNC.

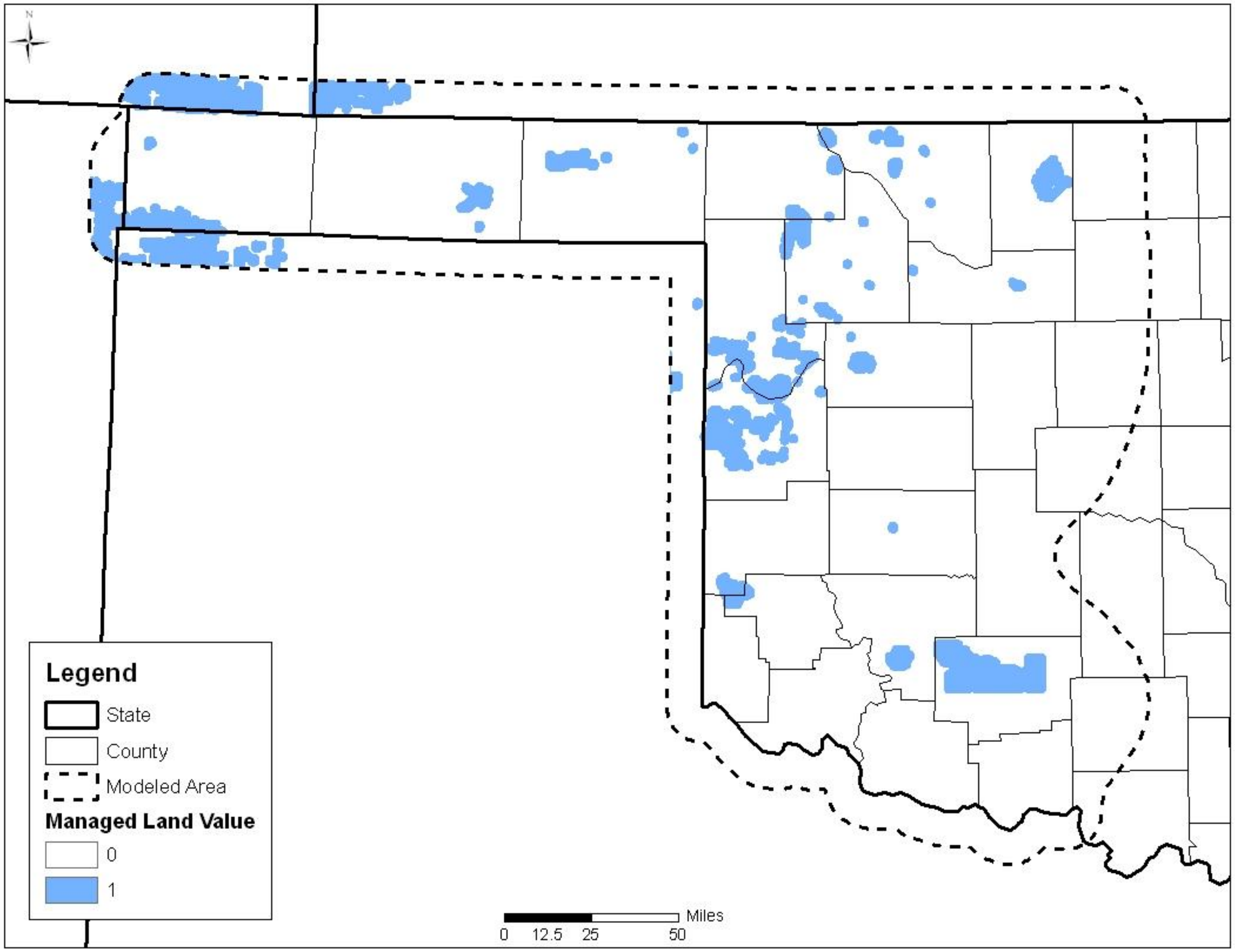

Figure 11. The binary grid for the managed and protected lands factor. Blue pixels =1 and white pixels =0. The black dotted line delineates the extent of the modeled area.

Factor 8: Avoidance Areas

Function: Gives value to all land that is outside LEPC avoidance areas cause by fragmentation, vertical structures, or human activity.

Criteria: Pixels outside LEPC avoidance areas are assigned a value of 1; otherwise 0 (Figure 12).

Justification: Research indicates that LEPC can be negatively affected by habitat fragmentation, human activity, and the presence of vertical structures and may avoid such areas (Robel 2002, Hagen et al. 2004, Robel et al. 2004, Pitman et al. 2005, Chamberlain et al. 2006, Wolfe et al. 2007, Pruett et al. 2009b). Otherwise suitable habitat may be of little value for LEPC conservation and recovery if it occurs near or adjacent to these landscape features. Since some fragmentation is considered "manageable" (i.e., can be offset to some degree through avoidance, minimization and habitat restoration efforts like tree removal, fence marking or fence elimination), only fragmentation that was considered semi-permanent to permanent was included into the fragmentation part of the model. Fragmentation components included in the model are distance factors related to major roads and vertical structures (from the FAA's vertical obstruction file), current oil and gas activity, buildings and transmission lines.

Data Description: Avoidance areas are based on six types of landscape structures to which LEPCs exhibit avoidance behavior (Hagen et al. 2004, Pitman et al. 2005, Table 3). The spatial extents/locations of these features are buffered according to varying structure-specific avoidance distances as published in research (Table 3) and are illustrated in Figure 13. These buffered areas are considered avoidance areas. All avoidance buffers are merged into one data layer representing all five types of avoidance features (Figure 13). Although recent research indicates that avoidance behavior increases with the number of avoided structures present in the landscape (Pruett et al. 2009b), a quantifiable increase is not yet clear; therefore, areas with overlapping avoidance buffers (e.g., an area next to a road buffer overlapping a transmission line buffer) are not treated differently than areas near a single avoidance buffer. All land outside the avoidance buffers is valued at 1 regardless of how many avoidance buffers are nearby.

Table 3. List of avoidance features, associated avoidance buffers, and citation of the buffer distance.

Feature	**Buffer**	**Citation**
Oil/gas well heads	564m buffer applied to point location data	Pitman 2003 *in* Hagen et al. 2004
Wind turbines	2,000m buffer applied to point location data	*Suggestion* of Hagen et al. 2004; not measured (Robel et al. 2004 *suggests* 1.6km)
Electric transmission lines	500m buffer applied to line location data	Pruett et al. 2009b (in press) (Pitman 2003 *in* Hagen et al. 2004 states 1.32km)
Towers and other vertical structures >99ft	500m buffer applied to point location data	Verticals structure buffer size *assumed* to be same as transmission line
Major roads	2,377m buffer of applied to line location data	Pitman 2003 *in* Hagen et al. 2004
Buildings	2,129m buffer applied to point data	Pitman 2003 *in* Hagen et al. 2004

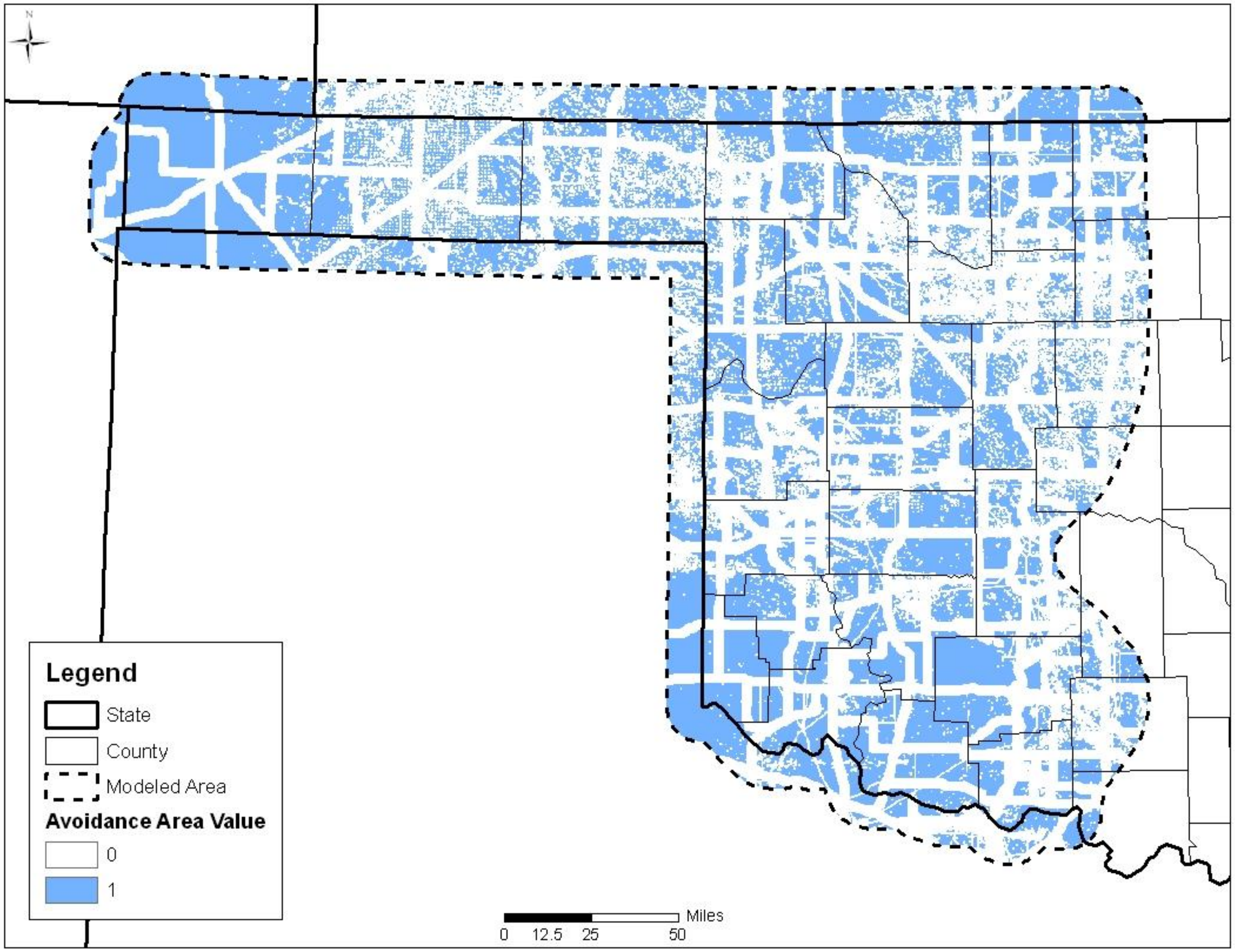

Figure 12. The binary grid for the avoidance areas factor. Blue pixels =1 and white pixels =0. The black dotted line delineates the extent of the modeled area.

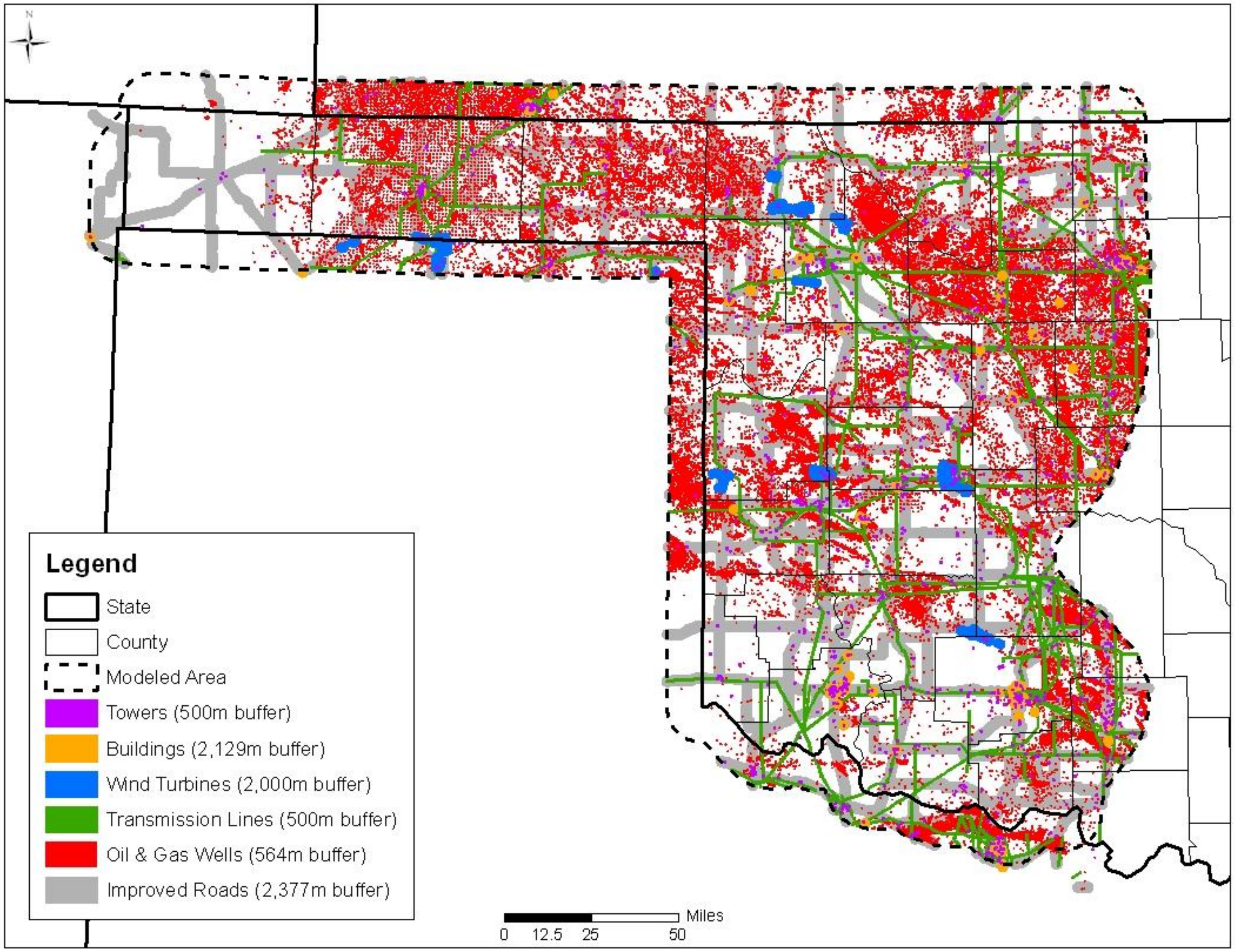

Figure 13. Buffers of the five avoided structure types used to create the avoidance areas grid, by type and buffer size. Each data layer depicts a type of structure which lesser prairie-chickens avoid and the corresponding avoidance distance as a buffer around the structure.

RESULTS

The ultimate result of the model is a 30-m grid spanning the historical range of the LEPC in Oklahoma in which each pixel is assigned a rank (Figure 14). Ranks represent the relative value of the pixel to LEPC conservation, the higher the rank, the more valuable it is to LEPCs. Results will change as new and updated data are acquired. Applications of the results (i.e., the model's resultant grid) are presented in detail in the following section.

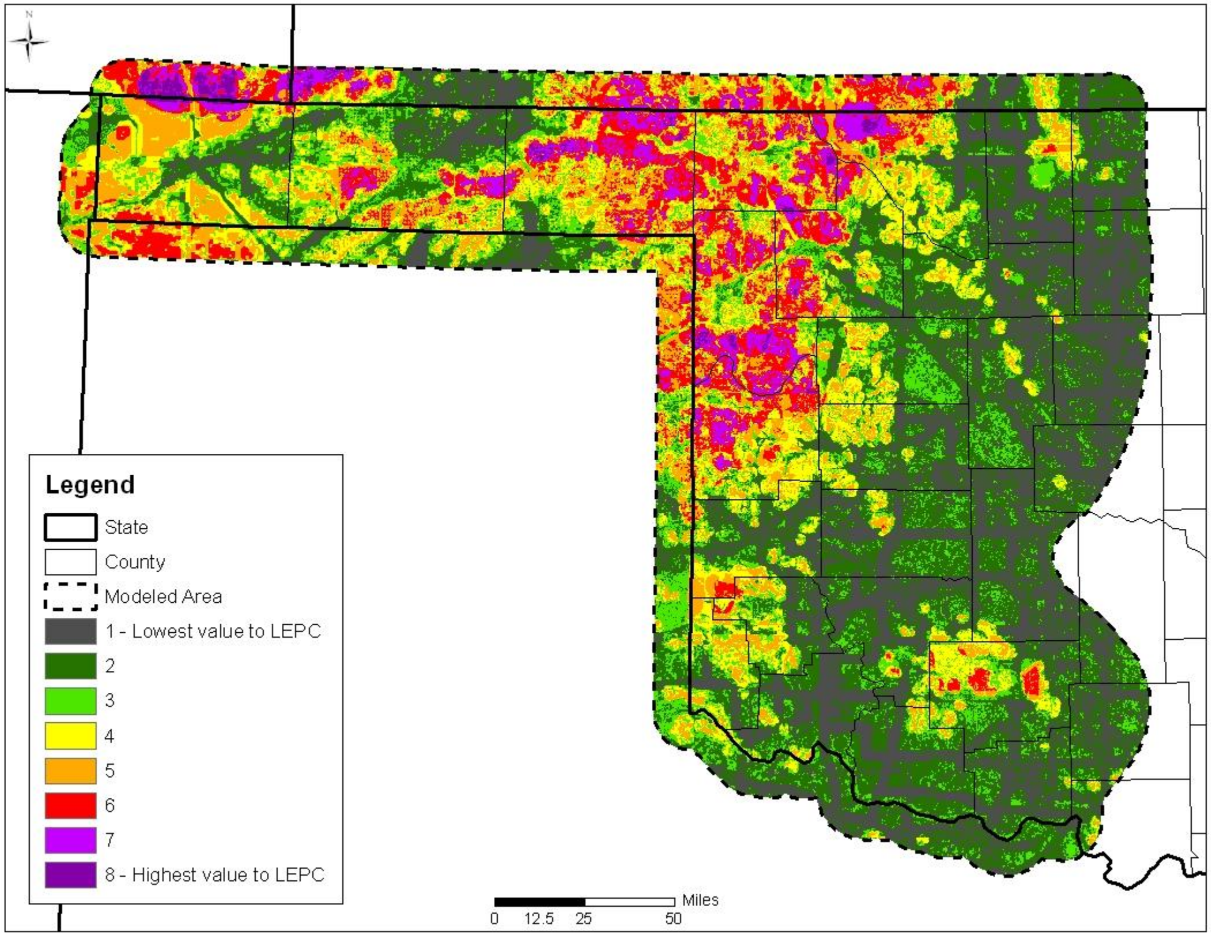

Figure 14. The final LEPC model output resulting from the addition of the eight binary factor grids. The higher the pixel value, the greater its value for lesser prairie-chicken conservation.

DISCUSSION

Grasslands of North America's Great Plains are some of the most imperiled ecosystems in the world (Samson and Knopf 1994). Some of the fragmenting factors to grassland ecosystems are land use practices that do not incorporate ecological processes like historical grazing and fire regimes, extensive grassland conversion to croplands and a variety of other anthropogenic related activity (Knopf and Samson 1997, Rich et al. 2004). To conserve intact grassland systems, conservation planning models based on umbrella species will benefit multiple taxa that need smaller fractions of the umbrella species' habitat requirements. One such species, the lesser prairie-chicken, is restricted to these grassland systems of the southern Great Plains (Rich et al. 2004, Hagen and Giesen 2005).

However, the lesser prairie-chicken does not represent all potential impacts to western Oklahoma. For example, playa lakes are important stop over locations for migrating birds (e.g. federally listed whooping cranes) but are often found in extensive cropland landscapes. Bats and bat caves are independent of intact grasslands but can be devastated by vortexes created by wind turbines or fatal collisions with wind turbines themselves. It will remain important that any development activity must consider all potential impacts to natural resources.

Not all impacts can be avoided, but developers can use the LEPC model to avoid or minimize their impacts substantially. Developers can use the LEPC model to identify areas where conservationist's interests and development potential do not overlap, like the "Where Wind Could Go and Have Reduced or No Effect on the LEPC". The ultimate goal of the LEPC model is to increase the effectiveness of limited resources available to conservationists, while simultaneously decreasing the impacts from ongoing and planned development actions within the range of the LEPC.

APPLICATIONS

Use and implementation of this model is intended to be beneficial for both developers and LEPC conservation efforts as it can be used to conserve LEPCs by both reducing negative effects (via development in LEPC sensitive landscapes) and by maximizing positive results (via effective habitat acquisition and management). Specifically, the model can be applied in three separate but related ways:

1. Proactive planning and site evaluation that locates areas for development which avoid or minimize potential adverse effects to LEPC
2. Estimating recommended contributions to the voluntary LEPC Habitat Conservation Fund for proposed project sites, and
3. Identifying areas important for targeted LEPC conservation efforts, including land acquisition, conservation easements and management agreements.

Each of these applications is discussed in detail in subsequent sections.

Planning and Evaluation of Developments

The model can be used to locate areas for development that minimize potential adverse effects on LEPCs. The ranks produced by the model reflect an area's value to the LEPC relative to its habitat requirements and the extent of influence from existing fragmentation: the higher the rank, the greater the value to the LEPC. Therefore, when considering areas for development, target areas with low ranks and avoid or minimize areas with high ranks. Using the LEPC model and ESRI's ArcGIS software (ArcInfo license and Spatial Analyst Extension required), developments can be planned and evaluated for the potential to affect LEPC. Proactive planning could include evaluating alternative placement of linear developments such as roads and power lines (i.e., least cost path or least cost corridor) or initial site suitability screening done in coordination with additional public or proprietary datasets. All developments submitted for review will be evaluated with a similar approach, to determine recommended contributions to the voluntary LEPC Habitat Conservation Fund. A detailed, step-by-step workflow has been described for reference (Appendix C).

Specific Example of Planning and Evaluation of Development Potential: Where Wind Energy Could Go and Have Reduced or No Effect on LEPC

The placement of wind turbine facilities and the associated infrastructure is of great consequence for wind industry and natural resource managers (Pruett et al. 2009b). The LEPC model was developed to address LEPC conservation; however developers should consider other resource issues, including, but not limited to those identified in Appendix D. Oklahoma's LEPC modeling group has worked with wind industry to identify areas on the landscape that are compatible for conservation of an area sensitive species and wind development. As a guide for wind industry in siting projects, the "where wind can go and have reduced or no effect on LEPC" product is a first step to identify highly fragmented landscapes where effects to LEPC will be greatly limited and wind potential is high. However, the "where wind can go and have reduced or no effect on LEPC" is only a first step to isolate effects of potential wind farm locations. Other resource conflicts (e.g., whooping cranes, bat caves, playa lakes, etc.) will need to be evaluated. Using additional models or data that prioritize areas for a given industry's resource needs, in combination with the LEPC model, can quickly and efficiently identify areas that meet development needs and avoid or minimize effects to the LEPC.

Using the LEPC model and criteria provided by wind industry, the "where wind energy could go and have reduced or no effect on LEPC" product combines areas of LEPC least importance (LEPC model ranks 1, 2 and 3) identified in the LEPC model with areas of highest wind resource potential (depends on wind model, see below for specifics). Areas within wind models designated class 3 or greater are believed to be suitable for most wind energy developments (Elliott et al. 1986). We used two different wind resource potential models available to us at the time of development of the LEPC model, the Oklahoma Wind Power Initiative's 50 meter Wind Resource Neural Network model (http://www.seic.okstate.edu/owpi) and the U.S. Department of Energy's 50 meter Annual Wind Power model (http://www.windpoweringamerica.gov/maps_template.asp), to develop the "where wind energy could go and have reduced or no effect on LEPC" product. Specifically, using a criteria of wind class 3 or greater with the respective wind energy resource model, LEPC model rank 3 or less, and a contiguous area of 5,000 acres or more (Wayne Walker, personal communication), the "where wind energy could go and have reduced or no effect on LEPC" products show representative areas that are of the highest importance within wind energy resource model, lowest importance within the LEPC model and are of sufficient contiguous acreage to be a feasible commercial wind energy development. Using the Oklahoma Wind Power Initiative wind potential neural network model and the LEPC model we identified 30 sites that are ≥ 5,000 contiguous acres each, totaling 6,319,594 acres in all (Figure 15), where wind potential is desired and there is little impact to lesser prairie-chickens. From the U.S. Department of Energy's 50 meter Annual Wind Power model we identified 25 sites that are ≥ 5,000 contiguous acres each totaling 6,902,933 acres in all (Figure 16). There are many places on the landscape where the needs of both developers and conservationists can be accommodated.

The "where wind could go and have reduced or no effect on LEPC" product should be seen as a guide and not a specific site planning tool. There are other issues to consider in siting wind energy developments. One of the biggest limitations of the "where wind could go and have reduced or no effect on LEPC" product are the area calculations or potential wind farm locations. The 5,000 acre areas are calculated based on connectivity of 30 meter pixels (i.e. sometimes the only connection between two areas is a pixel). Wind developers are encouraged to conduct analyses that identify areas with the least LEPC importance (i.e., LEPC model rank 3 or less) and are surrounded by the lowest rank values. All areas identified from the analysis that were within the modified LEPC current range were excluded from the final output to enable habitat connectivity for LEPC. Additionally, care should be taken in interpreting the output of the "where wind energy could go and have reduced or no effect on LEPC" near state boundaries, as the wind resource models available for use in this approach are only available for a given state and do not include any buffer, as does the LEPC model.

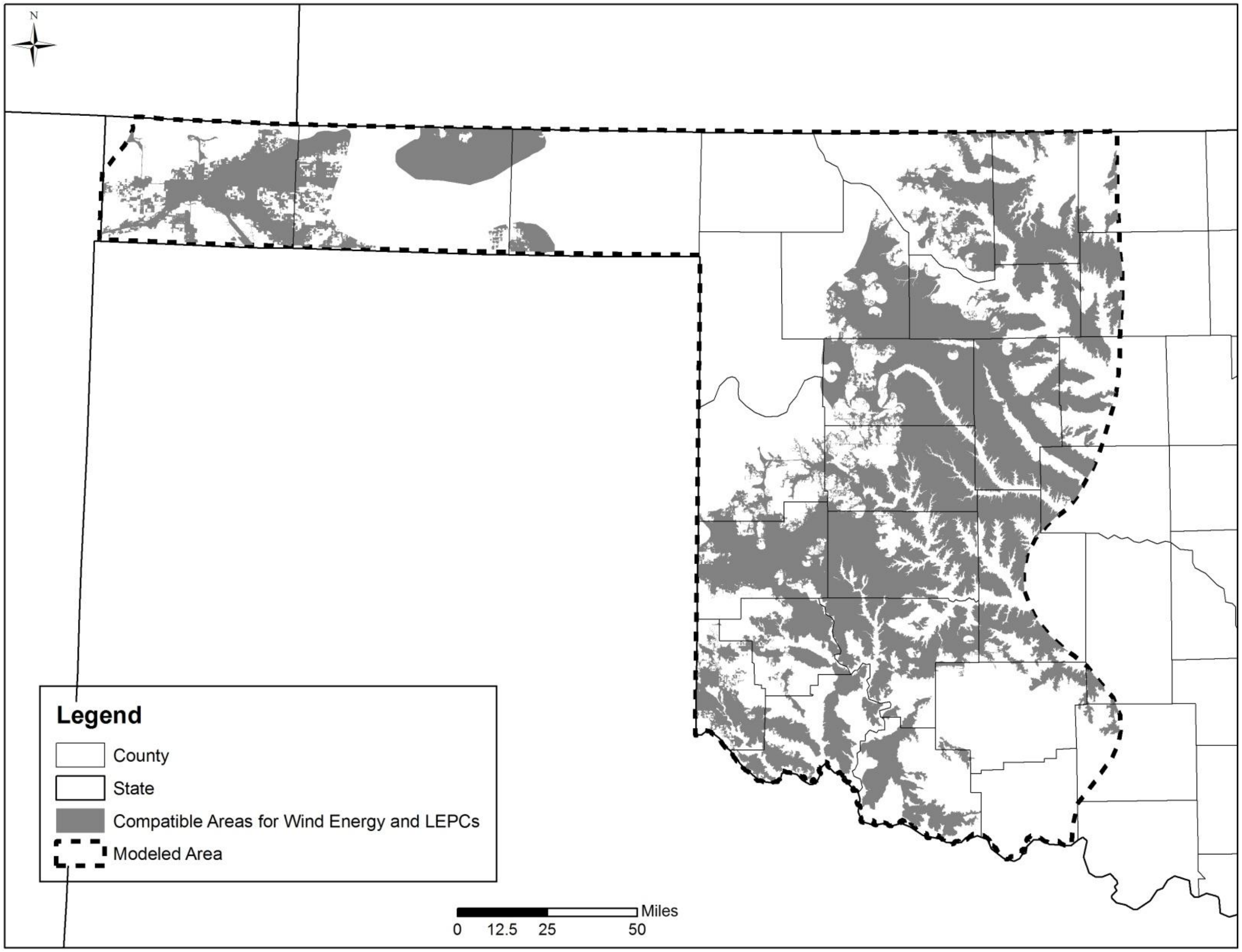

Figure 15. Where wind energy could go and have no effect on LEPC conservation using the Oklahoma Wind Power Initiative's wind potential neural network model.

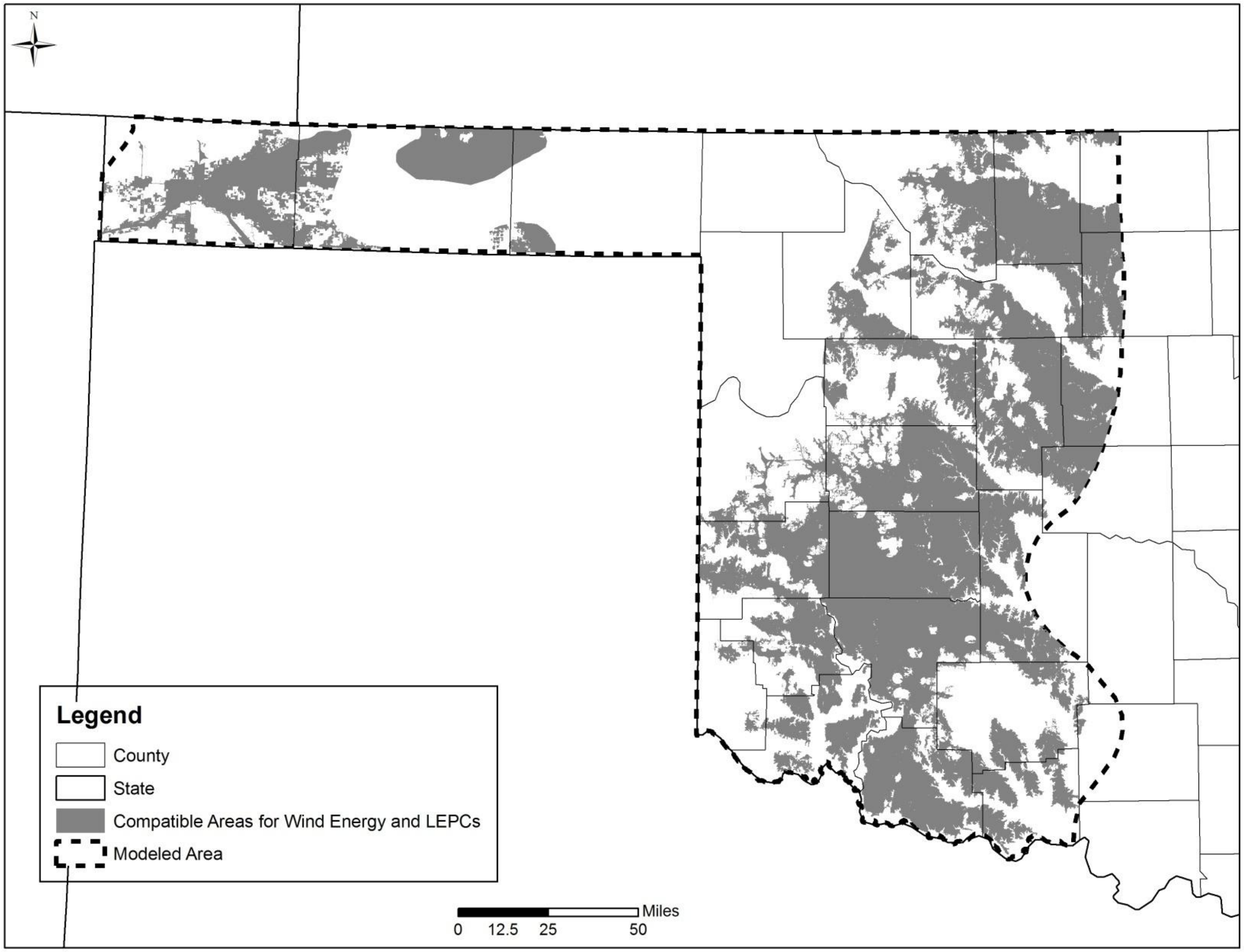

Figure 16. Where wind energy could go and have reduced or no effect on LEPC conservation using the U.S. Department of Energy's 50 meter Annual Wind Power model.

Voluntary LEPC Habitat Conservation Fund and Mitigation Process

Voluntary contributions to the LEPC Habitat Conservation Fund (i.e., mitigation) for development projects (e.g., oil or gas wells, transmission line, wind energy) can be estimated using the LEPC model. A cost has been assigned to each of the model ranks (1-8), representing the estimated dollar value per 30m pixel to mitigate the effects of development on the LEPC (Table 4).

Discussions regarding voluntary contribution to the LEPC Habitat Conservation Fund should be initiated with ODWC for any actions that meet all of the following criteria:

1. is a development activity potentially resulting in effect to LEPC,
2. is proposed to occur within areas of the LEPC model that include model pixels valued four or greater, and
3. occurs within Cimarron, Texas, Beaver, Harper, Woods, Ellis, Woodward, Roger Mills and Beckham counties, Oklahoma.

As additional information and more detailed analyses (e.g., Population Viability Analysis) become available, the areas where mitigation is requested may change at the time of annual updates of the model. The voluntary LEPC habitat conservation fund and mitigation process is described below including information on the purpose of mitigation, how the process is intended to work and how recommended contributions to the fund were calculated.

The voluntary LEPC habitat conservation fund is being established in an attempt to offset potential adverse effects of human development activity to the LEPC and LEPC habitat. The effects of development are assumed to be indefinite and the resulting loss of habitat and the number of LEPC that could have been produced on that habitat are accounted for cumulatively, until replaced through habitat management or conservation. Ongoing conservation actions strive to sustain or increase habitat, complexes of habitats and subsequently, the number of individuals in populations of the LEPC. The loss of habitat and subsequent reduction in population results in a decreased ability for the LEPC to rebound from declining populations during population fluctuations, natural or otherwise. This voluntary LEPC habitat conservation approach, a scaling tool (see Figure 17), attempts to account for the effect of developments on LEPC and LEPC habitat by using habitat as a surrogate for the number of LEPC (i.e. number of birds per unit area) and accounting for a given loss of LEPC over time, until replaced through strategic conservation of suitable habitat.

While the LEPC is the basis for concern and the development of the LEPC model and voluntary LEPC Habitat Conservation Fund, many other species that require all or a portion of related habitats will benefit from the conservation actions that are planned as a part of this program. Some of the numerous additional species that will potentially benefit in all or a portion of the LEPC range from the conservation and management of LEPC habitat in Oklahoma include Bell’s vireo, Cassin’s sparrow, dickcissel, eastern meadowlark, grasshopper sparrow, lark bunting, lark sparrow, loggerhead shrike, northern bobwhite, northern harrier, painted bunting, scaled quail, scissor-tailed flycatcher, Swainson’s hawk, western kingbird (PLJV Hierarchical All Bird System database), Texas horned lizard, black-tailed prairie dog, pronghorn and mule deer.

Recommended contributions to the voluntary LEPC Habitat Conservation Fund are based on non-scalable and scalable costs (Table 4). Non-scalable costs ($358.57 per acre) include estimated costs per acre to establish initial management infrastructure ($7.27/acre) and provide overhead and management costs for 30 years ($351.30/acre). These costs are independent of the relative value in the model (model rank) and are based on current estimated costs per acre for ODWC.

Scalable costs include those costs to: 1) purchase and restore LEPC suitable and potentially suitable habitat ($985.00 per acre), 2) implement LEPC perpetual conservation agreements ($492.50 per acre) and/or 3) implement voluntary LEPC conservation management agreements with private landowners ($143.19 per acre; Table 5), over a twelve year period (see assumption 5 below). The scalable cost mitigation process was built based on the costs to replace LEPC model rank eight pixels (i.e., the highest value in the LEPC model) and then scaled down equally across the remaining seven model classes. The final cost per acre is calculated by adding non-scalable and scalable costs for each class. This process results in a declining cost per acre as the importance to the LEPC declines in the model (see assumption 2 below). Costs per acre are converted to cost per 30m pixel for evaluation in the model.

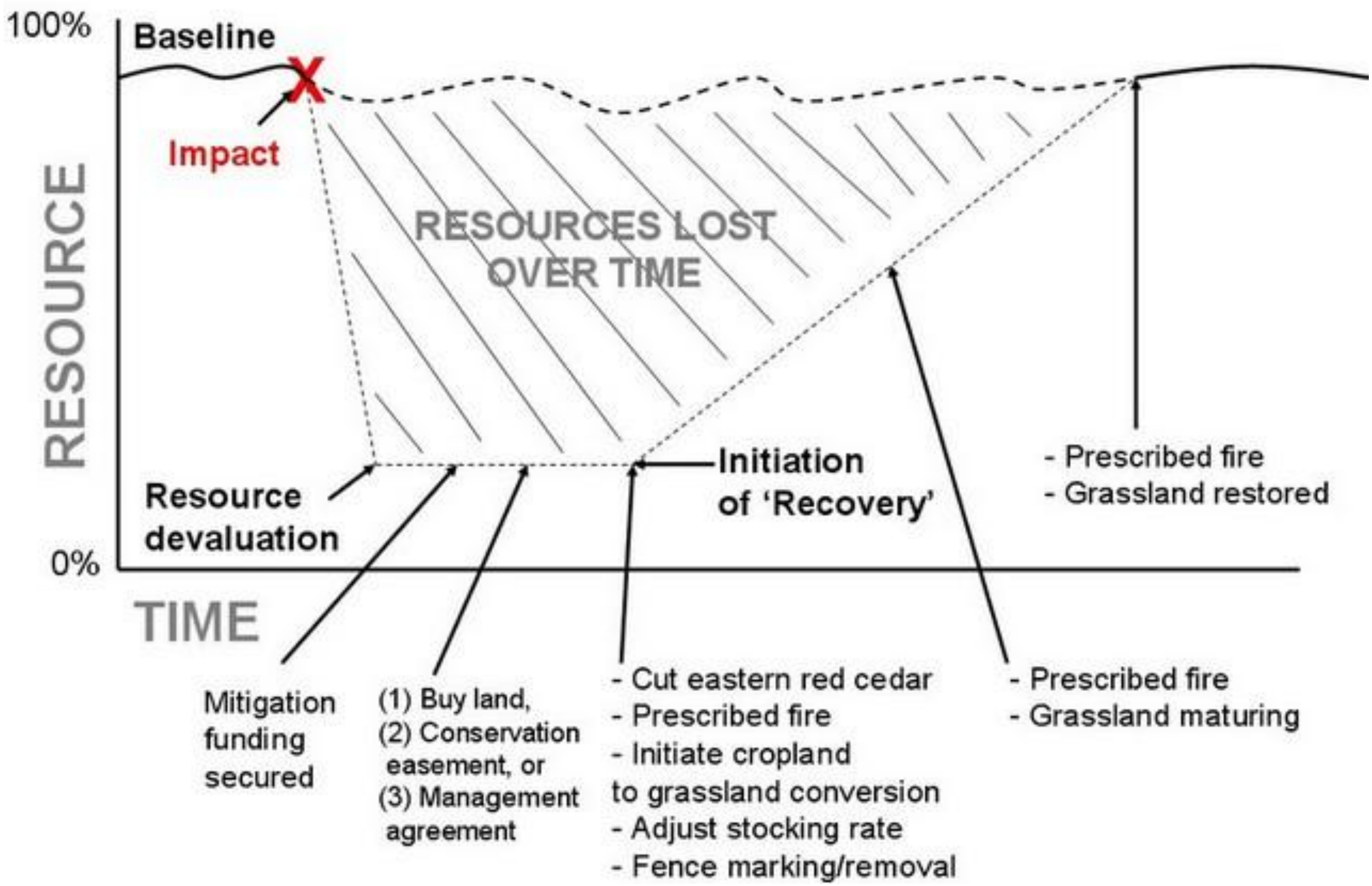

Figure 17. Illustration of scaling tool concept used to develop the voluntary LEPC habitat conservation mitigation process

Assumptions used in the voluntary LEPC Habitat Conservation fund for calculating the recommended contribution amount include the following:

1. The concept of mitigation is based on the principle that wildlife resources are renewable and thus can be replenished through acquisition and management of suitable / potentially suitable lands, resulting in the ability to assess a cost-per-unit area based on the relative value in the model (model rank).

2. The voluntary mitigation calculations process was designed under a "worst-case scenario" from a cost perspective, illustrating the logistical and technical difficulty and costs to replace the best LEPC habitat, starting with the costs to replace class eight pixels (i.e., the highest value in the LEPC model) lost to development and then scaled down equally across the remaining seven model classes as importance to the LEPC declines in the model.

3. The estimated current maximum density of LEPC in Oklahoma is 10 birds per square mile (Don Wolfe, personal communication). For the purpose of mitigation calculations, this density of LEPC was assumed to occur within class 8 of the LEPC model (i.e., the highest value LEPC landscapes).

4. Annual LEPC mortality within a population was assumed to be approximately 45% (0.446 is the average first year mortality in both sexes; Wolfe et al. 2003), with an increasing population having a 1% growth rate above mortality (i.e., a minimally increasing population). This is a simplification of the complex and dynamic relationship of this species mortality/survivorship rates, which can vary significantly by habitat type, age class and sex.

5. It is assumed it will take up to 12 years to effectively implement mitigation actions to offset effects associated with a given development. This assumption is based on the reported expansion of LEPC in Kansas and the time lag for expansion of LEPC populations under implementation of native grass plantings through the Conservation Reserve Program in Kansas (Davis et al. 2008). This time frame allows for the uncertainty associated with implementing the various aspects of a voluntary conservation program in a state where ownership is characterized as primarily private ownership. The lands acquired, placed in easements or management agreements will require a wide range of inputs to restore or enhance the habitat to benefit the LEPC. Some of these practices could be as simple as adjusting stocking rate and implementing prescribed fire, while other practices are much more complex and difficult (i.e., initial success is not guaranteed), such as converting introduced pasture and cropland to native grasslands and shrublands.

6. The acres of suitable and potentially suitable habitat needed for mitigation is calculated from the area affected, as determined by the literature based avoidance distance (Table 3), and accounting for the assumed population of LEPC (10

birds / acre at class eight in the model) plus the total number of birds that could have been produced at the site out to 12 years, without the effects of the development (calculated assuming a continuous 45% mortality and 1% population growth above the mortality rate; see assumption 4).

7. The cumulative number of acres (i.e., total birds effected during the 12 year period) was adjusted starting in year five to account for an assumed gradual increase in the population of LEPC at a mitigation site, through year 12. As management practices are implemented and subsequently mature, habitat quality, and subsequent populations of LEPC, would increase. This approach was initiated based on the reported expansion of LEPC in Kansas as related to the time lag for expansion of LEPC populations under implementation of native grass plantings through the Conservation Reserve Program (CRP) (Davis et al. 2008). In other words, it took five years for CRP grassland habitat to become suitable LEPC habitat and another seven years for LEPC's populations to fully expand into that habitat.

8. The three tiered implementation approach assumes that mitigation of a given development project can be achieved with a general spending target of 40% for fee title land acquisition, 20% for voluntary perpetual conservation easements, and 40% for voluntary conservation management agreements. It should be understood that the described actions are target percentages and depending on opportunity, actual conservation actions may not occur at the described amounts. As opportunities allow, all of the previous approaches will be preferentially implemented in one of seven target Oklahoma counties: Cimarron, Texas, Beaver, Harper, Woods, Ellis, Woodward, Roger Mills and Beckham.

9. Updates of the model mitigation values (except fair market values of land acquisition) will use the Consumer Price Index (CPI, http://www.bls.gov/schedule/archives/cpi_nr.htm#2009). We based our figures on a November 2008 to November 2009 change. A figure of 1.8% was used to adjust the 2010 OLEPCSPT.

10. The cost of fee title land acquisition at the time of the original LEPC Model publication (May 1, 2009) was assessed using the highest fair market value of land within Oklahoma counties occupied by the LEPC. The model now uses the highest fair market value from a database of three year weighted averages of land sales within Oklahoma counties occupied by the LEPC. For the 2010 version of the model, this value is $985.00 per acre from Woodward County, Oklahoma (Oklahoma State University Agricultural Economics, Oklahoma Agricultural Land Values Three-Year Weighted Average, http://agecon.okstate.edu/oklandvalues/county.asp). The assumed cost for conservation easements is 50% of the aforementioned fee title land acquisition value, $492.50 per acre. The assumed cost for management agreements is $143.19 per acre (Table 5). These values will be reviewed annually and adjusted as necessary to ensure any contributions to the voluntary LEPC habitat conservation fund will result in the greatest likelihood of mitigation success.

11. The cost of mitigation can be reduced for every year that contributions are made to the voluntary LEPC habitat conservation fund prior to the effects of development occurring. In other words, initiating conservation actions beneficial to the LEPC, made with funds voluntarily contributed to the LEPC habitat conservation fund prior to a proposed development's effects occurring, allows for preemptive conservation at mitigation sites, reducing the amount of time to offset effects from the proposed development. Additionally, sites may warrant reduction in the cost of mitigation based on site visits and additional analyses at ODWC's discretion. Contributions to the voluntary LEPC Habitat Conservation Fund are recommended for actions affecting model pixels with a rank of four or greater.

Table 4. Oklahoma Voluntary LEPC Habitat Conservation Fund Cost Matrix

Model Class	Non-scalable Costs[1]	Scalable Costs[2]	Cost / Acre	Cost / 30 m Pixel
8	$358.57	$3,385.96	$3,744.54	$832.77
7	$358.57	$2,962.72	$3,321.29	$738.64
6	$358.57	$2,539.47	$2,898.05	$644.51
5	$358.57	$2,116.23	$2,474.80	$550.38
4	$358.57	$1,692.98	$2,051.55	$456.26
3	$358.57	$1,269.74	$1,628.31	$362.13
2	$358.57	$846.49	$1,205.06	$268.00
1	$358.57	$423.25	$781.82	$173.87

[1] Non-scalable costs include those costs per acre to establish initial management infrastructure and provide for overhead and maintentance for 30 years. These costs are independent of the relative value in the model.

[2] Scalable costs include the costs per acre to (1) purchase and restore LEPC suitable and potentially suitable habitat, (2) implement LEPC perpetual conservation agreements, and/or (3) implement LEPC conservation management agreements with private landowners.

Table 5. Management Agreement Cost Matrix

Conservation Practice	Range or Description	Average Cost	Unit	% of Cost Included	Cost Per Acre + 1.8% CPI
Fence Removal	$200 / 0.25 mile to remove 2 miles for every 640 acres	$2.50	acre	100	$2.55
Fence Marking	$200/mile + 4 person hours ($6.55/hour) to mark 4 miles for every 640 acres	$1.40	acre	100	$1.43
Wind Rights	Secure wind rights	$5.00	acre	100	$5.09
Prescribed Burning	$8.50 - $20 / acre for prescribed burning	$14.00	acre	100	$14.25
Fire Guards	$60 - $712 / acre for fire guard construction	$320.00	acre	0.76	$2.47

Tree Removal	$45 - $275 / acre for clipping, cutting and dozing	$121.00	acre	53	$65.28
Planting Native Grass (Croplands)	prepare + drill + seed	$90.00	acre	32	$29.32
Converting Introduced Pasture	till + cover + spray + seed	$218.00	acre	8	$17.71
Unquantifiable or Infrequent Costs	terrace removal, grazing deferments, unknown fences, mesquite and salt cedar tree removal, stock pond removal, cattle guard construction, etc.	$5.00	acre	100	$5.09
				TOTAL	**$143.19**

Table 6. Scalable Cost Matrix For An Entirely Class 8 Area

Variables	Mitigation Matrix Component	Equations for Year 1	Equations for Year 2, 3, …,12	Year 1	Year 2	…..	Year 12
A	Density (birds / square mile)	10	current year B / 640	10	10.1	…..	11.1567
B	Density (birds / acre)	A / 640	current year D / C	0.015625	0.015781	…..	0.017432
C	Hypothetical Project Area Affected (acres)	C	C	15,000.0	15,000.0	…..	15,000.0
D	Original Population Size (1% growth)	current year C * B	D - E + F from previous year	234.38	236.72	…..	261.48
E	Population Mortality (0.436)	current year D * 0.436	current year D * 0.436	102.19	103.21	…..	114.01
F	Population Recruitment (0.446)	current year D * 0.446	current year D * 0.446	104.53	105.58	…..	116.62
G	Cumulative Recruitment	current year F	sum across F starting year 1 to current year	104.53	210.11	…..	1,325.72
H	Cumulative Recruitment + Original Population	current year G + D	current year G + year 1 D	338.91	444.48	…..	1,560.09
I	Adjustment Factor 1/8 per Year	-	starting year 5, use 1/8 adjustment factor (0.125); add 1/8 each year up to year 12	-	-	…..	1.00
J	Recovering Population Adjustment	-	starting year 5, current year F * I	-	-	…..	116.62
K	Final Adjusted Population	-	starting year 5, current year G + year 1 D - current year J	-	-	…..	1,443.47
L	Mitigation Acres Needed	current year H / B	current year K / year 1 B	21,690.0	28,446.9	…..	92,382.1
M	Mgmt. Agreement Acres (40%)	current year L * 0.4	current year L * 0.4	8,676.0	11,378.8	…..	36,952.8
N	Mgmt. Agreement Cost per Acre ($143.19)	current year M * $143.19	current year M * $143.19	$1,242,316.44	$1,629,324.64	…..	$5,291,278.53
O	Cons. Easement Acres (20%)	current year L * 0.2	current year L * 0.2	4,338.0	5,689.4	…..	18,476.4
P	Cons. Easement Cost per Acre ($492.50)	current year O * $492.50	current year O * $492.50	$2,136,465.00	$2,802,019.65	…..	$9,099,639.21
Q	Fee Title Acquisition Acres (40%)	current year L * 0.4	current year L * 0.4	8,676.0	11,378.8	…..	36,952.8

R	Fee Title Acquisition Cost per Acre ($985.00)	current year Q * $985.00	current year Q * $985.00	$8,545,860.00	$11,208,078.60	…..	$36,398,556.82
S	Hypothetical Project Cost per Acre	current year T / C	current year T / year 1 C	$794.98	$1,042.63	…..	$3,385.96
T	Total Cost	current year N + P + Q	current year N + P + Q	$11,924,641.44	$15,639,422.89	…..	$50,789,474.56

Note – Total cost calculations are based on rounded figures, and are

All funds contributed to the voluntary LEPC Habitat Conservation Fund will be used in one of three approaches in an attempt to offset the effects from a given development and to address conservation of the LEPC. These approaches include, (1) fee title land acquisition within the current or likely range of the LEPC, (2) voluntary perpetual conservation easements to be administered by a non-governmental organization, and (3) voluntary conservation management agreements with private landowners to benefit the LEPC. Voluntary conservation management agreements will be executed through existing state, federal and non-governmental organization's private lands cost share programs (these programs may need to be modified to meet the needs and intentions of this effort). Actions under management agreements may include, but are not limited to, prescribed fire, grazing management incentives, fence removal or marking, native grass reestablishment, and removal of invasive plants. The model, in conjunction with other relevant information, will be used to prioritize multiple concurrent opportunities.

All discussions regarding mitigation should be initiated with the ODWC. The authority for final decision regarding the use of the model and subsequent voluntary mitigation resides with ODWC because they are the state agency that has the constitutional and statutory authority for management and conservation of the LEPC. All contributions to the voluntary mitigation fund will be leveraged to the greatest extent possible, through various state, federal and other grants sources. Other leveraging opportunities will be investigated and utilized to the greatest extent possible.

A voluntary LEPC Habitat Conservation Fund summary report will be prepared annually for those years that contributions are made to the fund. This report will detail the amount of voluntary contributions, additional funding procured (including matching funds), expenditures, balances, and the nature, extent and location of all on-the-ground work accomplished during the report period. This report will be made available through ODWC's LEPC model website.

Identifying Priority LEPC Conservation Landscapes

The model can be used to locate areas that will maximize beneficial LEPC conservation actions, including land acquisition, conservation easements and habitat management. The ranks produced by the model reflect an area's value to the LEPC relative to its habitat requirements and the extent of influence from existing fragmentation; the higher the rank, the greater the value to LEPC. This process allows for prioritization of limited agency and non-governmental resources, resulting in maximized efficacy for a given LEPC conservation action. Therefore, when considering areas for LEPC conservation actions, target areas with high ranks and avoid or minimize areas with low ranks. Developments should further emphasize avoiding areas identified as important to the LEPC, as planned and ongoing conservation work will be targeting work in these areas to the maximum extent possible.

LIMITATIONS

A GIS model is only as accurate as the data it contains. This map and the associated data layers are intended as general guidelines to consider when exploring the potential effect of development on LEPC. This map is not definitive in locating LEPC occurrence, its habitat, or measuring potential effects from energy development. This map will be regularly revised to incorporate new and better data or analyses that have become available since the last update.

The LEPC model is intended to be used as a guide to avoid, minimize or mitigate the potential effects to the most intact landscapes within Oklahoma's portion of lesser prairie-chicken historical range. The current model and associated products do not account for lesser prairie-chicken population viability or potential corridors for habitat connectivity.

As with most GIS data, deficiencies exist and users must be aware of these deficiencies when utilizing the data. For example, the OK-GAP data was constructed from 1991-1993 Landsat Thematic Mapper imagery. The respective landscape is rapidly changing and any changes since 1991-1993 may not be fully represented in the model. As for species information, not all LEPC lek locations are documented. The remaining data layers were constructed using datasets from other organizations. The errors associated with these datasets can be referenced by reviewing the documentation and metadata associated with each specific dataset.

Spatial Data Accuracy

The data illustrated in this model are limited by the quality of their underlying source data.

<u>LEPC Occurrence Data</u>

Both LEPC range boundaries (used for ranking factors 1 and 2) are based on expert knowledge of LEPC occurrence but their true accuracy is unknown. Lek location data do not represent a census of LEPC leks or bird sightings; unknown leks likely exist and these locations will be added as they become available.

Habitat Data

Identification of suitable and potentially habitat, core habitat patches, and core buffer habitat (used for ranking factors 4 – 6) is limited by both the appropriateness of criteria applied to the spatial analyses, as well as the accuracy of the landcover on which these analyses were performed. An accuracy assessment of the PLJV landcover has not yet been conducted so its accuracy is unknown; however, information on the accuracy of the source data (e.g., state GAP layers) for the PLJV landcover is available upon request or maybe found at, http://gapanalysis.nbii.gov/portal/community/GAP_Analysis_Program/Communities/Maps,_Data,_&_Reports/.

Structure Data

This data has been reviewed by the FAA's National Aeronautical Charting Group (NACG) and most have been assigned an accuracy code, indicating the reliability of its vertical height and horizontal position. More information can be found in the DOF_README.pdf, located at, http://naco.faa.gov/index.asp?xml=naco/catalog/charts/digital/daicd.

Product Use and Application

Industry professionals and consultants should always contact and seek recommendations from statutorily responsible state and federal natural resource agencies as soon as possible in the development planning process, prior to finalizing development and mitigation plans, since site-specific conditions may vary.

DATA DISTRIBUTION AND UPDATES

The LEPC model output, representative maps and this descriptive paper of the LEPC model and the “Where Wind Could Go and Have Reduced or No Effect on the LPEC” products will be distributed through the internet at the ODWC’s website, (*http://www.wildlifedepartment.com/lepcdevelopmentplanning.htm*). By providing the data in GIS formats, users having complete GIS capabilities can perform further analysis or inquiries with the LEPC model. Maps depicting the LEPC model and the “Where Wind Could Go and Have Reduced or No Effect on the LEPC” products will be distributed as Adobe Portable Document Format (.pdf).

The LEPC model and associated products will be updated annually and made available at the ODWC’s LEPC model website, no later than March 1 each year.

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APPENDIX A

Description of PLJV's Core Habitat Spatial Analysis

Process

To identify core habitat patches we used PatchMorph (Girvetz 2007), "an improved patch delineation algorithm …which can delineate patches across a range of spatial scales based on three organism-specific thresholds: (1) land cover density threshold, (2) habitat gap maximum thickness (gap threshold), and (3) habitat patch minimum thickness (spur threshold)." PatchMorph is an extension for ESRI ArcMap (ESRI 2005) and its function and application are published in Landscape Ecology (Girvetz and Greco 2007). The habitat gap maximum thickness was set to 450m (i.e., gaps of unsuitable habitat could be no larger than 450m wide) and the habitat patch minimum thickness was set to 1600m (i.e., resultant patches must be at least 1 mile wide). A landcover density threshold was not applied because trial analyses revealed little change in resultant patches when the landcover was analyzed with and without the density threshold. Using the landcover density threshold trimmed thin slices of habitat from along the edges of patches, essentially creating a small buffer between suitable and unsuitable habitat that was insignificant for the scale this analysis.

To account for fragmentation caused by primary roads, which are less than 450m wide, habitat patches were clipped to the boundaries of 'large blocks'. A large block is a 2,000ha parcel of land that consists of at least 810ha of suitable or potentially suitable habitat (see above for list), less than 810ha of cropland (including pasture), ≤50ha of woodland (other than mesquite and eastern red cedar, which are considered potential habitat if managed), and no primary roads or urban/developed areas. Large blocks were identified through a separate spatial model that was designed to delineate areas on the landscape that had potential for habitat management for LEPC conservation (see CORE BUFFER HABITAT below for details on large block delineation). Large blocks encompass core habitat patches but also contain smaller and more fragmented areas of suitable habitat where conservation work may show benefit to LEPCs. By clipping the patches to the large blocks, fragmentation cause by primary roads and small developed areas is addressed (i.e., these landcover types cannot occur in core habitat patches). This process also eliminated patches that did not occur within large blocks – these were small isolated habitat patches that likely hold little value for LEPCs.

Next, patches less than 500ha were removed because they were considered too small (Hagen et al. 2004). Patches 500ha-2,000ha were tested for proximity to the nearest patch and those that were more than 10km from the nearest patch were removed because they were considered too small and isolated (Hagen et al. 2004). Thus, remaining patches (core habitat) were large patches of suitable habitat (>2,000ha) or smaller patches of suitable habitat (500ha-2,000ha) with high connectivity (≤10km apart).

Discussion

This analysis produces course-scale delineation of core habitat for LEPC. Core habitat represents large patches of suitable habitat with relatively low fragmentation and high connectivity. Fragmentation, according to this analysis, occurs when areas of unsuitable habitat more than 450m wide (about 0.25 miles) occur within patches of suitable habitat or when primary roads or urban/developed areas intersect patches. Fragmentation caused by primary roads was accounted for by clipping patches to large blocks (see *Spatial Analysis* section). Potential fragmentation from secondary roads, which are less than 450m wide, was not accounted for so they do not contribute to fragmentation in this analysis. Some scientific literature suggests that LEPCs may avoid secondary roads (Hagen et al. 2004); thus, secondary roads may fragment otherwise suitable habitat. Conversely, LEPCs have been observed near or next to secondary roads. This conflicting information, in combination with the course-scale approach to the analysis, led PLJV to treat secondary roads as non-fragmenting landcover. We suggest that when evaluating smaller, more site-specific areas for its value as LEPC habitat, it may be beneficial to consider secondary roads as fragmenting landcover.

APPENDIX B

Description of PLJV's Core Buffer Habitat Spatial Analysis

Process

Core buffer habitat was identified through a moving window analysis (in ERDAS IMAGINE Modeler; Leica 2006) of the seamless landcover mentioned above. A moving window analysis is a spatial evaluation of a grid composed of pixels. In this case, each pixel represents a type of landcover. The size of the 'window' is defined by set number of pixels (e.g., a 10x10 pixel window on a 30m-scale grid is akin to a 3,000m^2 window). Every possible window, starting from the upper left corner of the grid, is evaluated against a set of criteria and results are exported as another grid. Below are the settings and criteria used for the moving window analysis designed to find core buffer habitat. These criteria are based on recommendations from the LEPC Interstate Working Group in combination with recommendations found in Hagen et al. (2004).

Window size: 2,025ha

Parameters:

- ≥ 810 ha of suitable habitat (mixed grass prairie, sandhills grassland, tallgrass prairie, shortgrass prairie, wet meadow, sand sagebrush, or shinnery) or potentially suitable habitat (eastern red cedar, mesquite, CRP land in grass-type practices)
- ≤ 810 ha of cropland (including pasture)
- ≤ 50 ha of woodland (excluding mesquite and eastern red cedar)
- 0 ha of urban or primary roads

The resulting core buffer habitat was then converted from a grid into vector (polygon) format and was overlaid with the core habitat patches. Core habitat patches were then clipped to the boundaries of the core buffer habitat to restrict core habitat from primary roads and to eliminate small isolated core habitat (i.e., core habitat that did not have buffer habitat). Core buffer habitat encompasses all core habitat.

Discussion

This analysis produces course-scale delineation of core buffer habitat for LEPC to be used in combination with core habitat. Core buffer habitat represents areas within 10 miles of the historical LECP range in Oklahoma that have smaller and more fragment patches of suitable habitat, as compared with core habitat, but are areas where habitat management has high potential to benefit LEPC. The moving window analysis does not directly measure the amount of habitat fragmentation that occurs within a window. It simply locates areas that meet a set ratio of landcover composition based on total area. However; fragmentation caused by the presence of primary roads and urban areas is addressed because the area threshold was set to zero. In other words, in this analysis, the amount and sources of fragmentation that occurs within core buffer habitat varies but no core buffer habitat contains primary roads or urban areas. Potential fragmentation from secondary roads was not directly limited through the criteria thresholds so the potential level of fragmentation from these roads varies through the core buffer habitat. Some scientific literature suggests that LEPCs may avoid secondary roads (Hagen et al. 2004); thus, secondary roads may fragment otherwise suitable habitat. Conversely, LEPCs have been observed near or next to secondary roads. This conflicting information, in combination with the course-scale approach to the analysis, led PLJV to treat secondary roads as non-fragmenting landcover. We suggest that when evaluating smaller, more site-specific areas for its value as LEPC habitat, it may be beneficial to consider secondary roads as fragmenting landcover.

APPENDIX C

Planning and Evaluation of Developments using ArcGIS

The following section describes the approach, using ESRI's ArcGIS software (ArcInfo license and Spatial Analyst Extension required), that will be used to evaluate projects and determine recommended contributions to the voluntary LEPC Habitat Conservation fund.

To evaluate a given development project in ArcGIS using the LEPC model, spatial data (e.g., shapefile) detailing the location of proposed structures and associated development infrastructure (e.g., oil and gas well head, road, transmission line, wind turbine, etc.) must be available. This data must all be in the same projected coordinate system as the LEPC model, North American Datum 1983, Universal Transverse Mercator Zone 14 North (NAD83, UTM Zone 14N).

1. An ArcMap project is created and includes some basic datasets for reference (Figure 18).

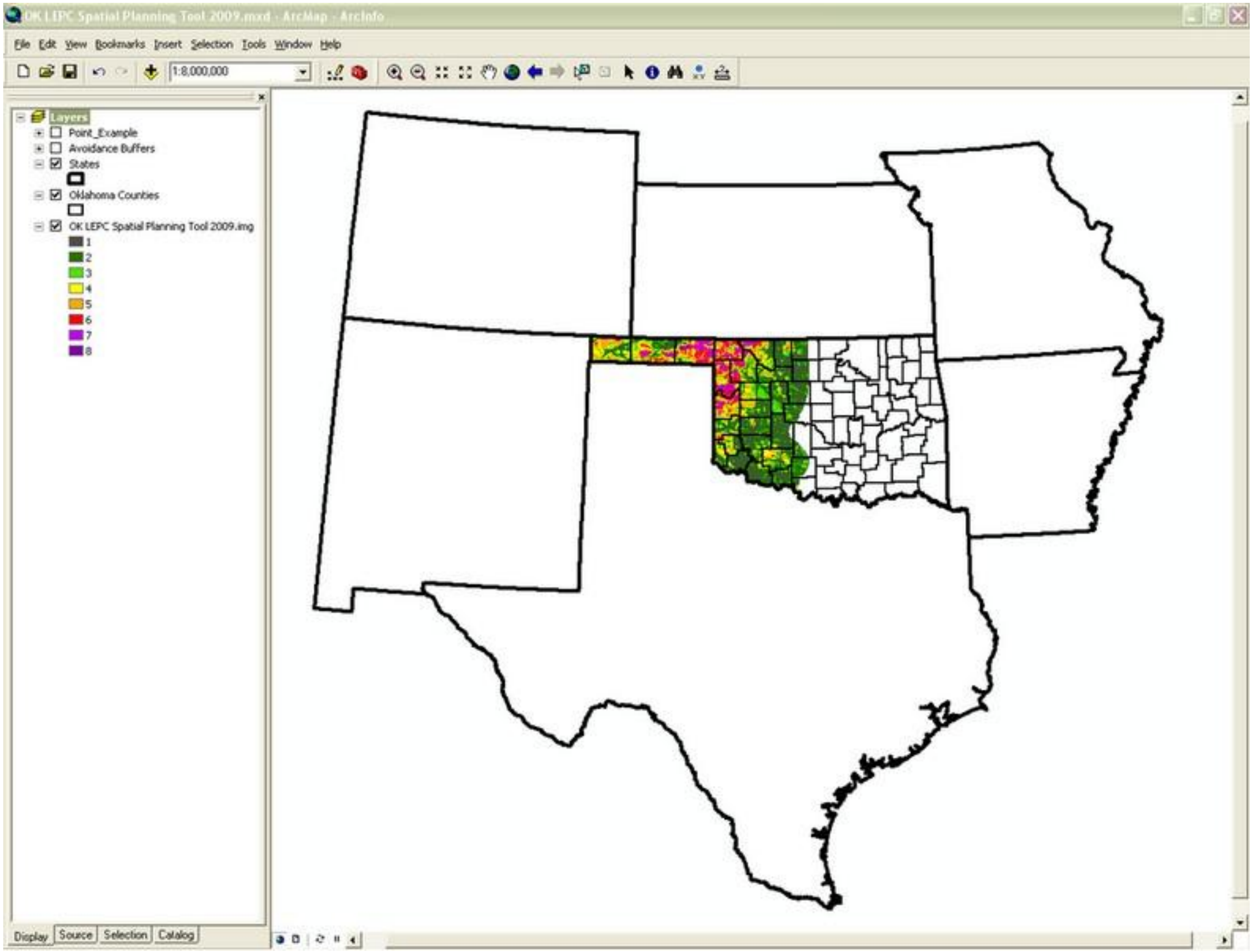


Figure 18. Project analysis overview

2. The ArcMap project is zoomed in, to the general project area (Figure 19)

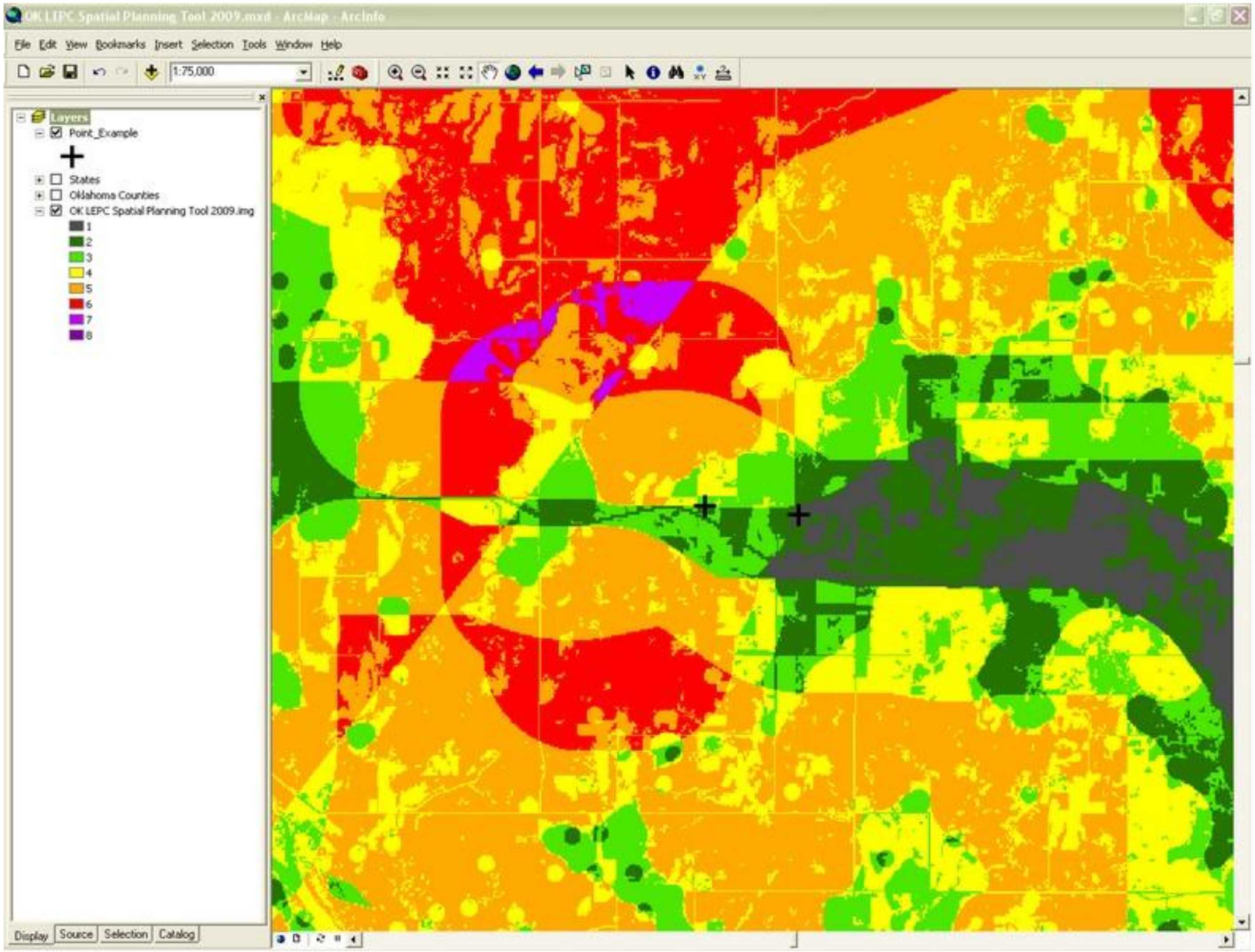


Figure 19. Point Example

3. Next, a buffer of a specific distance is applied to the development feature to represent the effect to LEPC (i.e., avoidance area) from a given development type (refer to Table 3 under Methods for a list of avoidance distances). For this example, a one mile buffer is applied to two points to illustrate the concept. Specifically, activate the ArcToolbox window within ArcMap; navigate to the “Analysis Tools” toolbox, to the “Proximity” toolset and then to the “Buffer” tool. Next, define (a) the “Input Features”, which is the shapefile depicting the location of development features of interest (e.g., Point_Example), (b) the name and location under the “Output Feature Class”, (c) the “Distance” as a “Linear unit” (e.g., 1 Mile), (d) the “Dissolve Type” as ALL (Figure 20). Left mouse click the “OK” option. The output, with adjustment for visibility (i.e., setting the interior color of the polygon to none and increasing the outline width for increased visibility) should look comparable to the image in Figure 21.

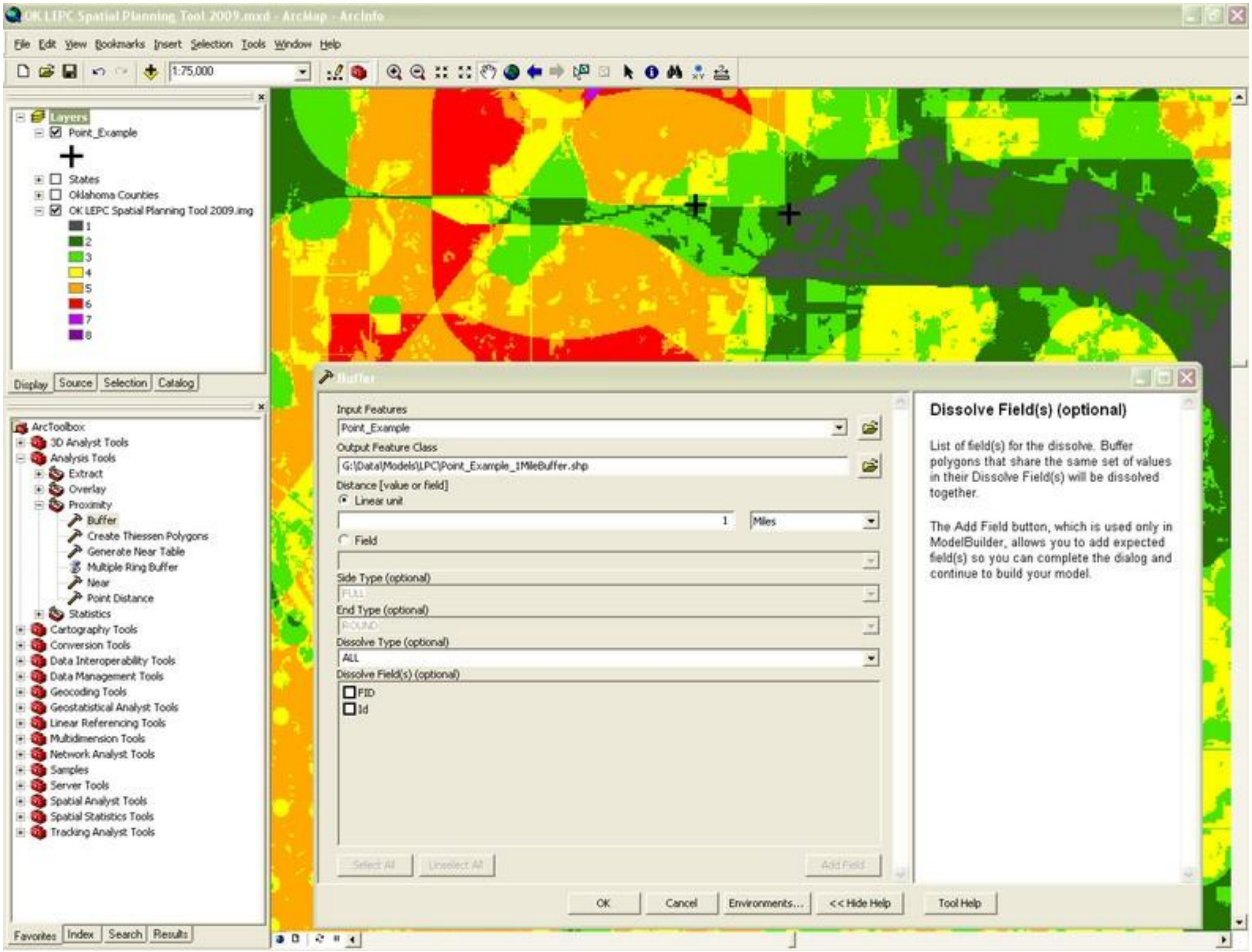


Figure 20. Buffer process

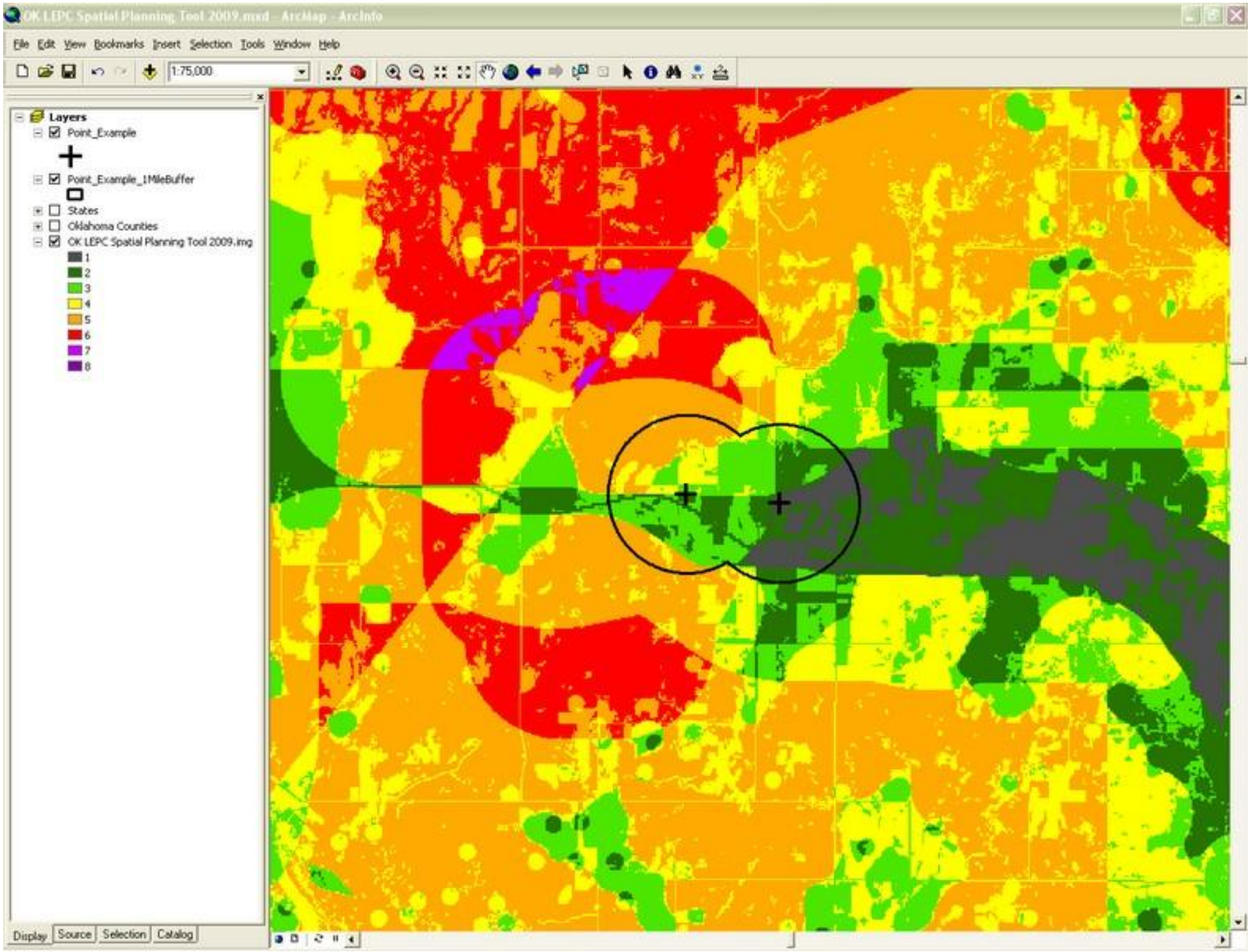


Figure 21. Buffer output

4. Access the “Spatial Analyst” toolbar in ArcMap. Left mouse click on the dropdown arrow to the right of “Spatial Analyst” and left mouse click on “Options”. Under the “General” tab, select a “Working directory” to store the analysis about to be performed. Next select the buffer polygon created in step 3 as the “Analysis mask” (e.g., Point_Example1MileBuffer). Ensure the “Analysis Coordinate System” is set to the first option (i.e., “Analysis output will be saved in the same coordinate system as the input (or first raster input if there are multiple inputs).) and that the box next to “Display warning message if raster inputs have to be projected during analysis operation” is checked (Figure 22).

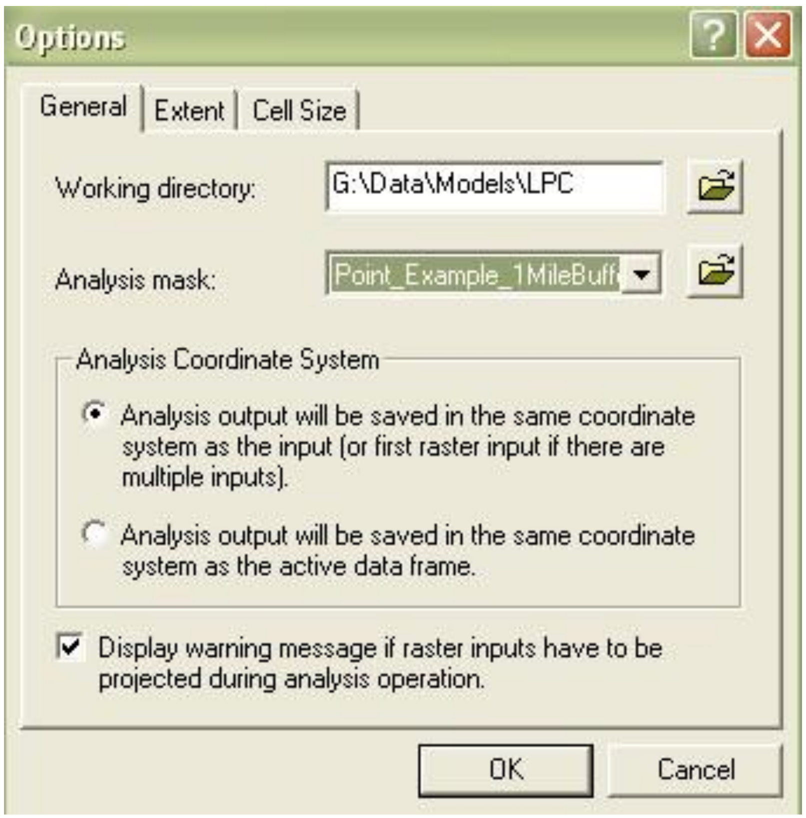


Figure 22. Spatial Analyst options

5. Access the “Spatial Analyst” toolbar in ArcMap. Left mouse click on the dropdown arrow to the right of “Spatial Analyst” and left mouse click on “Raster Calculator…”. To begin building an expression in the Raster Calculator (a) locate the “Layers:” box, (b) double left mouse click on the LEPC model raster (e.g. OK LEPC Spatial Planning Tool 2009.img), (c) left mouse click on the “+”, and (d) left mouse click on “0” (Figure 23). Left mouse click on “Evaluate” option and wait for the analysis to finish. If executed correctly, a “Calculation” should be added to the ArcMap project that is a raster file occurring within the buffered area produced in Step 3. To ensure no confusion regarding color schemes, adjust the “Calculation” to match the LEPC model color scheme. This can be accomplished quickly by, (a) right mouse clicking on “Calculation” in the table of contents, (b) left mouse clicking on “Properties”, (c) left mouse clicking on the “Symbology” tab, (d) left mouse clicking on the “Import…”, (e) choose the LEPC model raster file and left mouse clicking “OK”. Before closing the “Layer Properties” box, select the colors not represented in the “Calculation” and left mouse click “Remove”. Finally, left mouse click “OK” in the “Layer Properties” box. The “Calculation” color scheme should now match the original model color scheme (Figure 24).

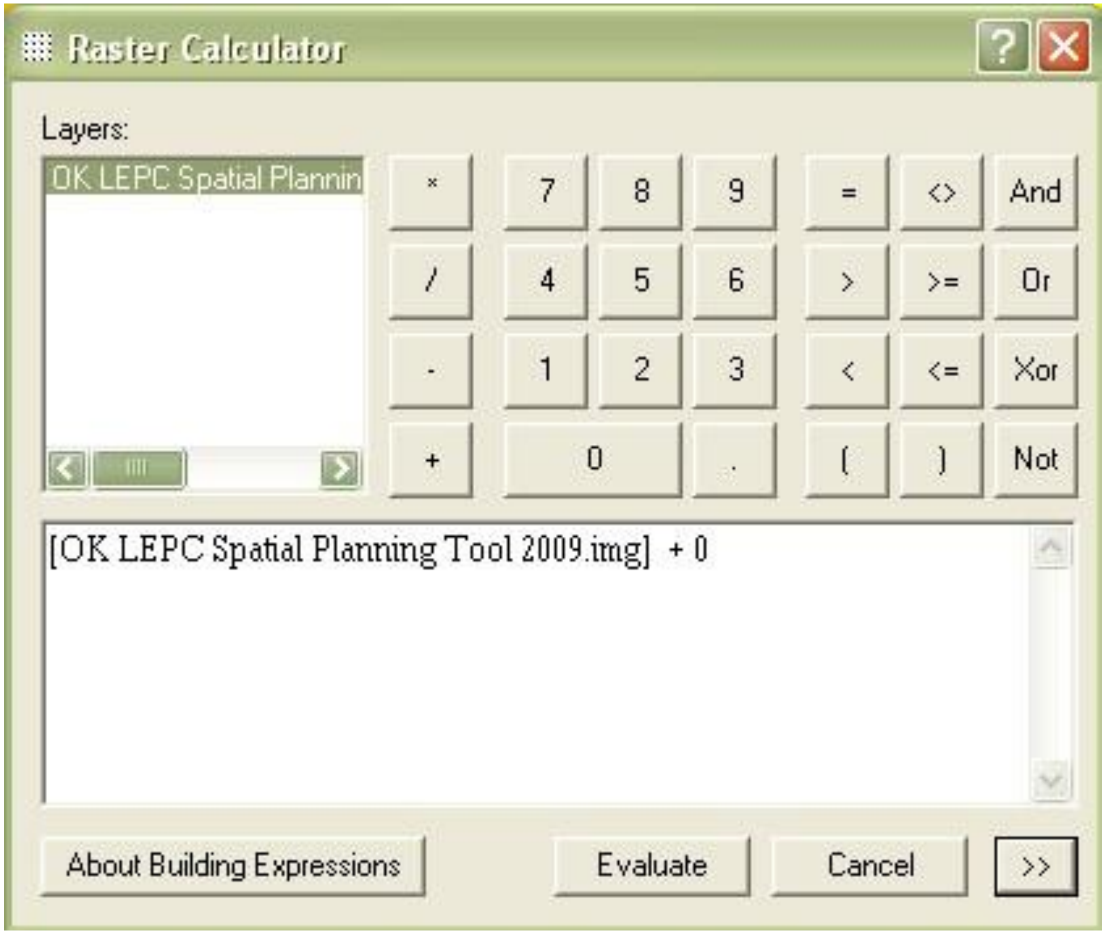


Figure 23. Raster Calculator expression

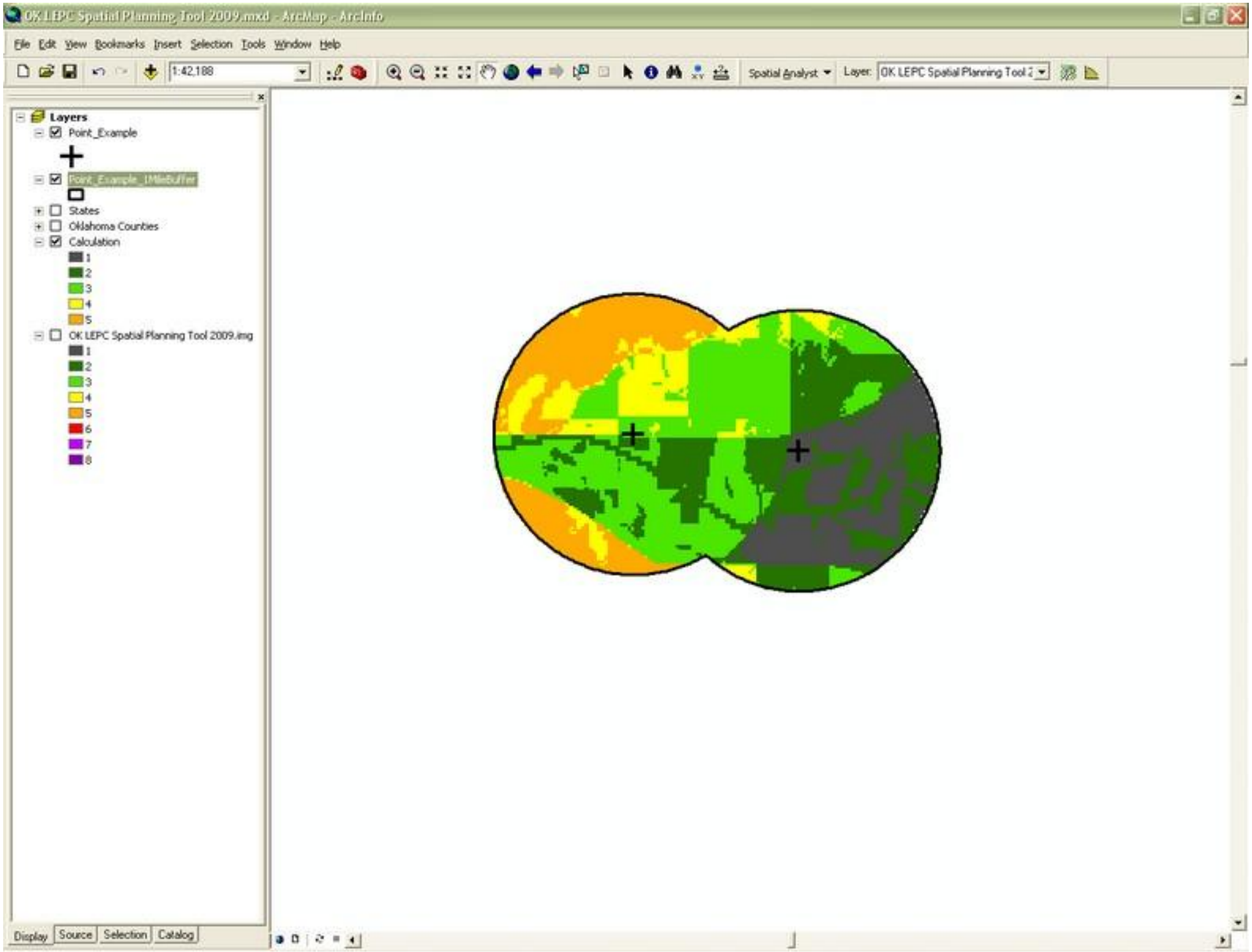


Figure 24. Raster Calculator "clipped" analysis area

6. Access the “Spatial Analyst” toolbar in ArcMap. Left mouse click the dropdown arrow next to the “Layer:” box. Choose the “Calculation” raster file. Left mouse click the “Histogram…” button. After the “Histogram of Calculation” figure appears in ArcMap, right mouse click on the figure and left mouse click on “Properties”. To adjust the histogram for display purposes, (a) select the “Series” tab, (b) set the “Value field:” to “COUNT”, (c) the “x field” to “VALUE” and “Value”, (d) the “x label field” to “COUNT”, (e) uncheck the “Add to legend” and (f) check “Show labels (mark)” box (Figure 25). Under the “Appearance” tab, change the title to read, “Histogram of Calculation: Field = Count”.

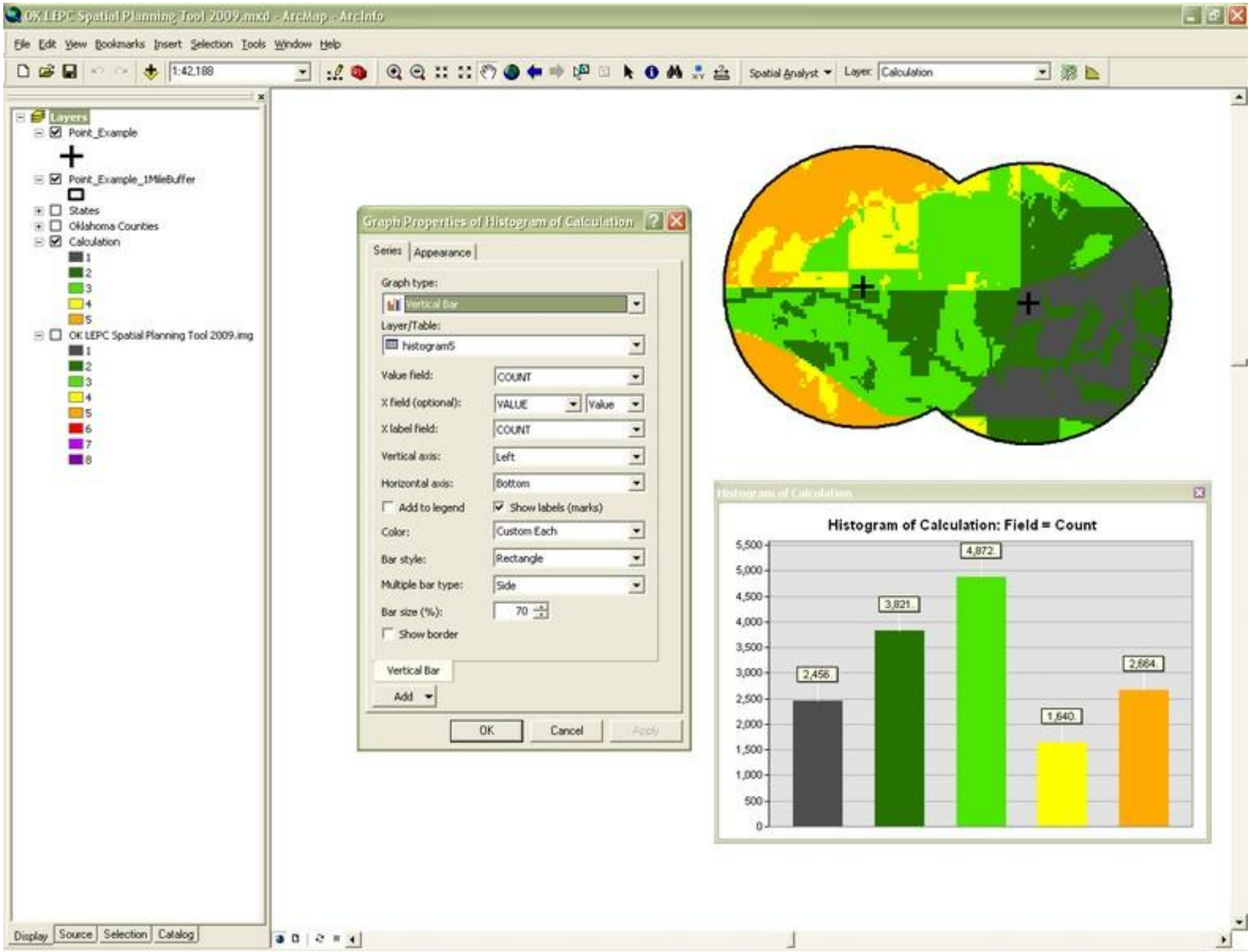


Figure 25. Histogram of calculation

7. To determine the recommended contribution to the voluntary LEPC Habitat Conservation fund, export the attribute table from the “Calculation” raster and open it in Microsoft Excel. To begin the process, (a) right mouse click on “Calculation”, (b) left mouse click “Open Attribute Table”, (c) left mouse click “Options”, (d) left mouse click “Export” and define the export as “All records” and choose a location for the .dbf file. Now open the .dbf file in Microsoft Excel and add a series of columns to those already in the file (VALUE and COUNT), (a) COST PER 30 METER PIXEL, (b) PROJECT COST BY CLASS, and (c) TOTAL PROJECT COST. Using the cost matrix provided in Table 4, place the corresponding cost per 30 meter pixel to the LEPC model value as exported from the “Calculation” attribute table. Multiply the corresponding model value count by the cost per 30 meter pixel, for each of the values from this example. Finally, sum all of these values to calculate the recommended contribution to the voluntary LEPC Habitat Conservation fund for the entire project (Table 7).

Table 7. Appendix C Development Cost Matrix Example

Model Class	Cost / 30 m Pixel	Count of Pixels by Rank	Recommended Contribution
8	$832.77	0	$0.00
7	$738.64	0	$0.00
6	$644.51	0	$0.00
5	$550.38	2,664	$1,466,212.32
4	$456.26	1,640	$748,266.4
3	$362.13	4,872	$0.00
2	$268.00	2,821	$0.00
1	$173.87	2,456	$0.00
TOTAL			**$2,214,478.72**

APPENDIX D

Additional Spatial Tools and Wildlife Planning Resources

Note: the following represents a partial list of planning tools known to the authors of the LEPC model as of March 2010. It does ***not*** represent all natural resource concerns relating to energy production or other types of development, nor does it preclude the need to consult with appropriate state and federal wildlife management agencies to evaluate sites prior to construction.

Maps

Oklahoma Natural Resources: Wind, Wildlife, Untilled Landscapes, and Protected Areas Map D.1
http://www.ocgi.okstate.edu/owpi/documents/OKwindwildlife.pdf (map)
http://www2.ocgi.okstate.edu/website/wildwind/viewer.htm (viewer)
Description: A map created by TNC in 2004 that depicts generalized areas of conservation sensitivity in Oklahoma, including bat caves, whooping crane stopover sites, protected areas, untilled prairies, landscapes of conservation significance, and prairie grouse distribution. An early effort at creating a spatial planning tool for wind energy development. The LEPC information contained in this map is superseded by the LEPC model.

Lesser Prairie-Chicken and Wind Energy Map Map D.2
http://www.pljv.org/cms/wind-energy
Description: A spatial model developed by PLJV to identify areas of potentially suitable habitat for LEPC. The methods for delineating core habitat and core habitat buffer areas were used in developing the LEPC model. Spatial data layers for this map are available upon request.

Township Wetland Density Map Map D.3
http://www.pljv.org/cms/wind-energy
Description: A map created by PLJV to provide wind industry professionals and others interested in the conservation of birds insight into where development of wind farms and their associated infrastructure may have negative impacts on birds inhabiting and using wetlands. This map highlights townships, 36mi^2 parcels of land as defined by the Public Land Survey System (PLSS), across the Shortgrass and Mixed-grass Prairie Bird Conservation Regions that have high densities of wetlands. Spatial data layers for this map are available upon request.

Whooping Crane Migration Route and Distribution of Playa Lakes in Oklahoma Map D.4
Description: A map created by authors of the LEPC model depicting a generalized migration route of the federally endangered whooping crane in Oklahoma, along with locations of playa lakes in the Panhandle and northwest regions of the state.

Map of Federally-Listed Aquatic Species Watersheds of Oklahoma **Map D.5**
http://www.fws.gov/southwest/es/oklahoma/Documents/ListedAquaticsMapOct08.pdf
Description: A map created by USFWS depicting 11 digit Hydrologic Unit Code (HUC) watersheds within 10 miles of water bodies occupied by federally-listed species.

Map of Federal Candidate Aquatic Species Watersheds of Oklahoma **Map D.6**
http://www.fws.gov/southwest/es/oklahoma/Documents/CandidateAquaticsMapOct08.pdf
Description: A map created by USFWS depicting 11 digit Hydrologic Unit Code (HUC) watersheds within 10 miles of water bodies occupied by federal candidate species.

Map of Federally-Listed Aquatic Dependent Species Watersheds of Oklahoma **Map D.7**
http://www.fws.gov/southwest/es/oklahoma/Documents/ListedAquaticDepMapOct08.pdf
Description: A map created by USFWS depicting 11 digit Hydrologic Unit Code (HUC) watersheds within 10 miles of water bodies occupied by federally-listed aquatic dependant species.

Map of Watersheds Adjoining Oklahoma's National Wildlife Refuges and Hatchery **Map D.8**
http://www.fws.gov/southwest/es/oklahoma/Documents/OKNWRMapOct08.pdf
Description: A map created by USFWS depicting 11 digit Hydrologic Unit Code (HUC) watersheds within 10 miles of National Wildlife Refuges and National Fish Hatcheries.

Interactive map viewers (national)
U.S. Fish and Wildlife Service – Critical Habitat Portal
http://crithab.fws.gov/
Description: An online service for information regarding Threatened and Endangered Species final Critical Habitat designation across the United States.

U.S. Fish and Wildlife Service – National Wetlands Inventory
http://www.fws.gov/wetlands/Data/index.html

Description: An online mapper designed to promote greater awareness of wetlands map data applications and to deliver easy-to-use, maplike views of America's wetland resources in a digital format. This product was developed in collaboration with the U.S. Geological Survey (USGS), Water Resource Division.

Other information

Bats and Wind Energy Cooperative

http://www.batsandwind.org/

Description: The Bats and Wind Energy Cooperative (BWEC) is an alliance of state and federal agencies, private industry, academic institutions, and non-governmental organizations that cooperates to develop solutions to minimize or, where possible, prevent mortality of bats at wind power turbines.

U.S. Fish and Wildlife Service – Oklahoma Ecological Services Field Office

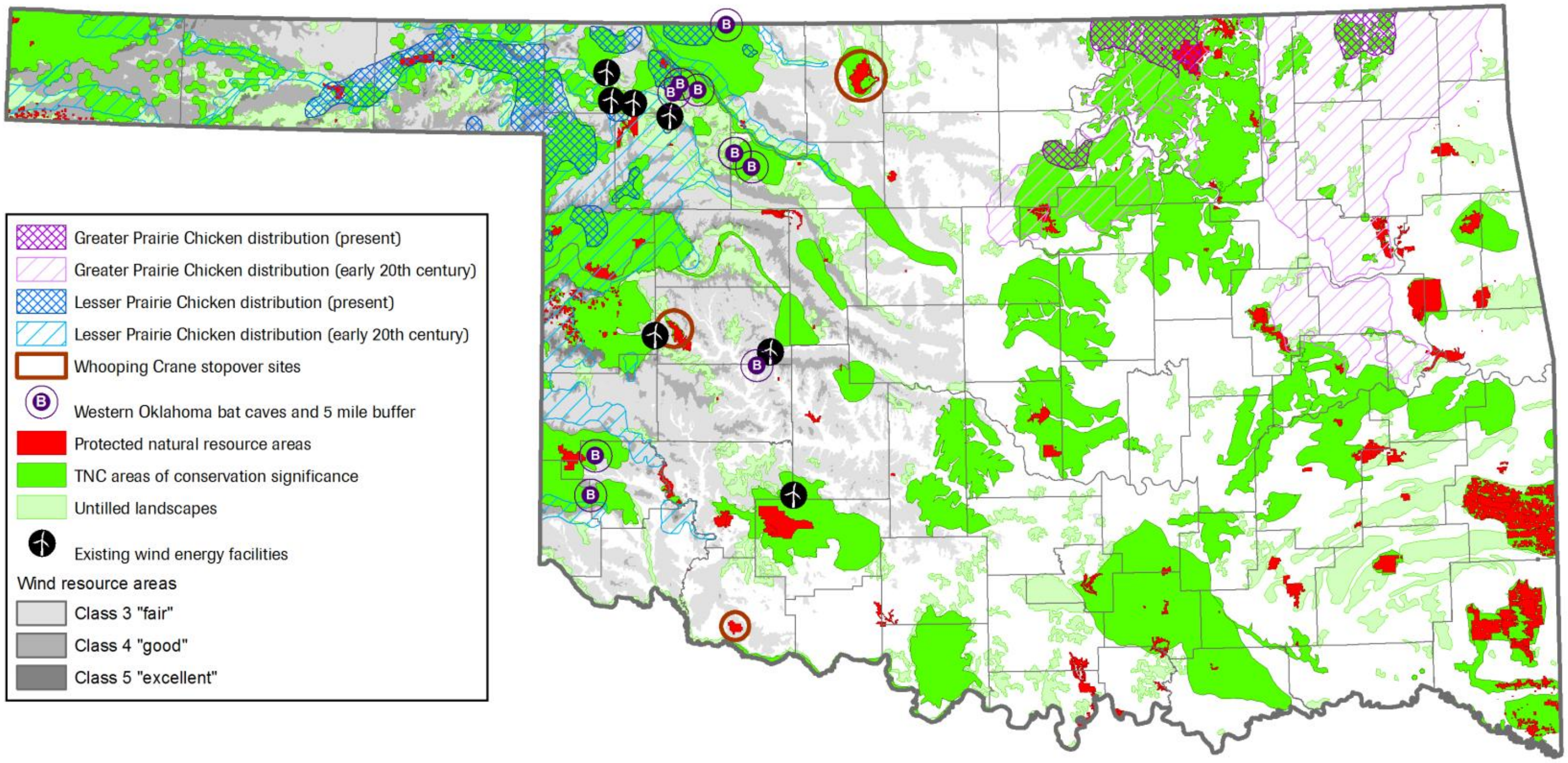
http://www.fws.gov/southwest/es/oklahoma and http://www.fws.gov/southwest/es/oklahoma/windpower.htm

Description: This office of the USFWS has a variety of responsibilities related to the conservation of federal trust resources such as endangered species, migratory birds, interjurisdictional fishes, and their habitats throughout Oklahoma and portions of northern Texas.

Oklahoma Natural Resources:
Wind, Wildlife, Untilled Landscapes, and Protected Areas

The Nature Conservancy
Protecting nature. Preserving life.™
Oklahoma Chapter January 2009

This map depicts general areas of conservation sensitivity and is intended to provide general guidance for wildlife appropriate siting of wind farms, transmission lines and other landscape-altering structures. Interactive version available online at http://www.seic.okstate.edu/owpi/



Present Greater and Lesser Prairie Chicken distributions:
The Nature Conservancy, Oklahoma Chapter GIS,
with comments from the Sutton Avian Research Center and
the Oklahoma Department of Wildlife Conservation.
January 2005

Early 20th century prairie chicken distributions:
Digitized from Duck, L.G. and J.B. Fletcher. 1943.
Lesser and Greater Prairie Chicken distribution and densities
in A Survey of the Game and Furbearing Animals of Oklahoma.
Oklahoma Game and Fish Commission.

Protected natural resource areas:
State parks, wildlife management areas,
National parks, grasslands/forests, wildlife refuges;
and Nature Conservancy preserves.
The Nature Conservancy, Oklahoma Chapter GIS,
January 2009

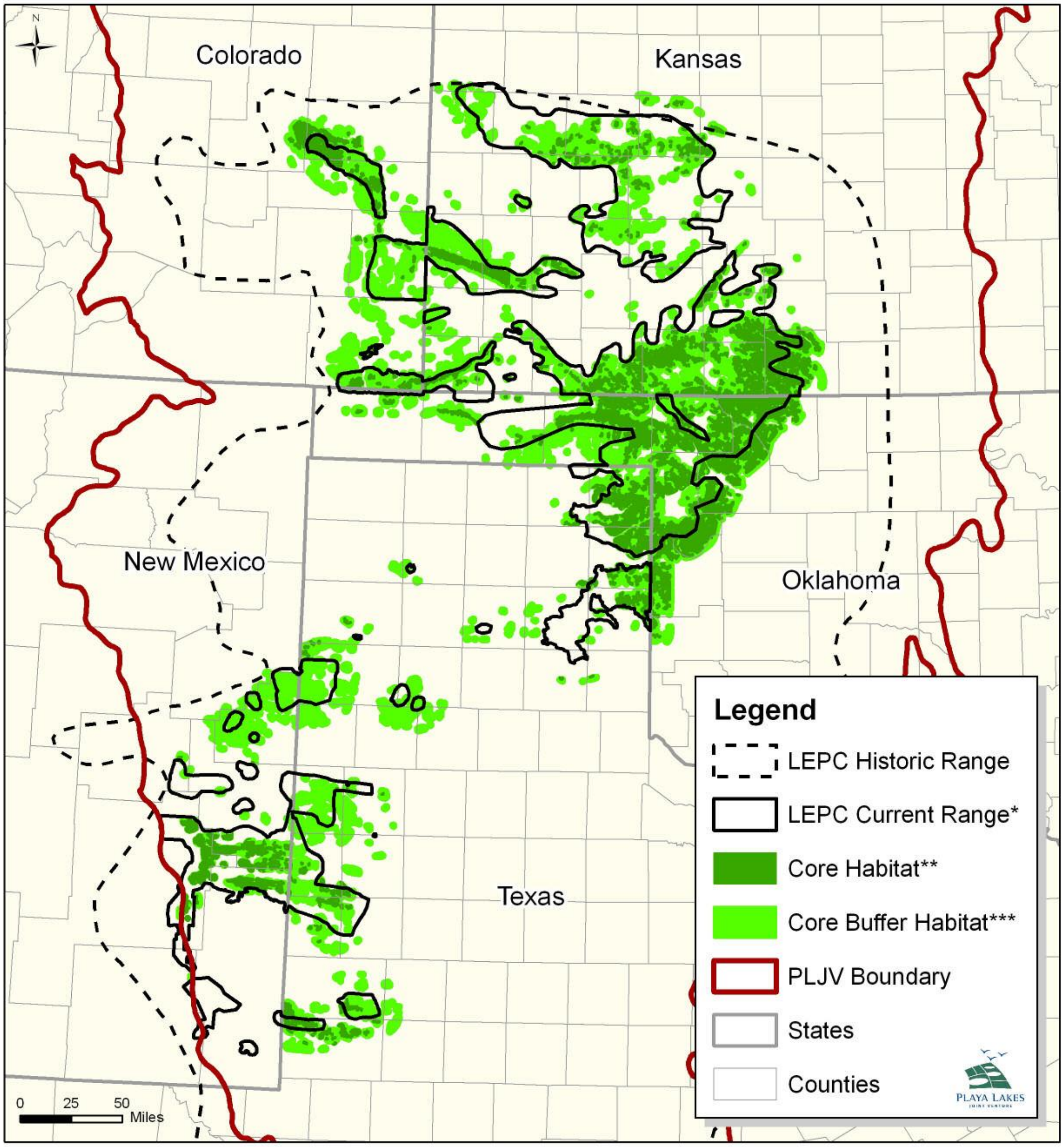
Untilled landscapes:
Central and Western Oklahoma -
Ostlie, Wayne. 2003. Untilled Landscapes of the Great Plains.
The Nature Conservancy, Midwest Science Center.
Eastern Oklahoma -
The Nature Conservancy, Oklahoma Chapter GIS,
January 2005

Western Oklahoma bat caves:
The Nature Conservancy, Oklahoma Chapter GIS,
January 2005

Whooping Crane stopover sites
Modified from U.S. Fish and Wildlife Service
Whooping Crane sightings, 1947-1999
The Nature Conservancy, Oklahoma Chapter GIS,
February 2005

Wind resource areas:
Oklahoma Wind Power Initiative
www.ocgi.okstate.edu/owpi
August 2005

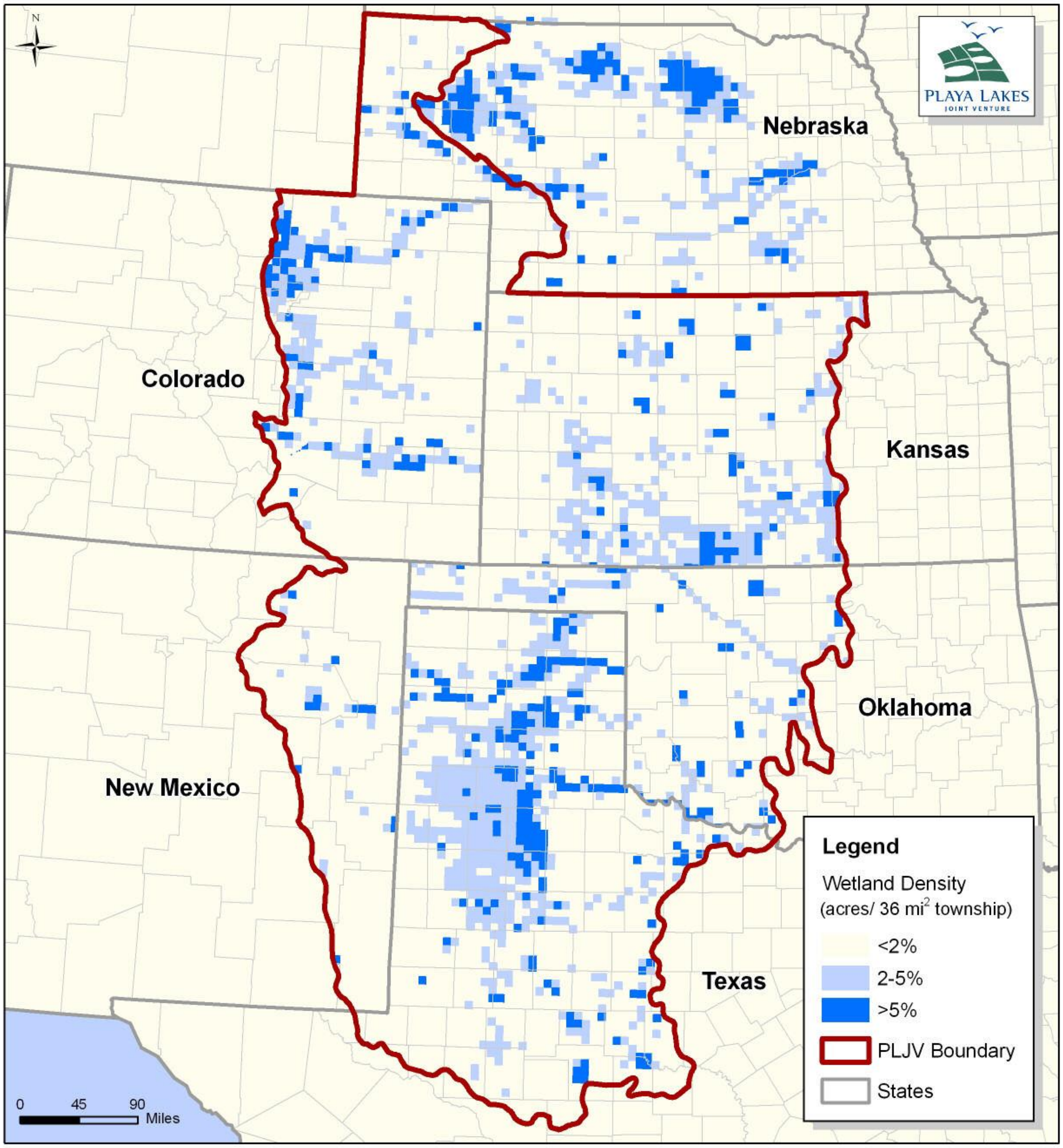
Map D.2



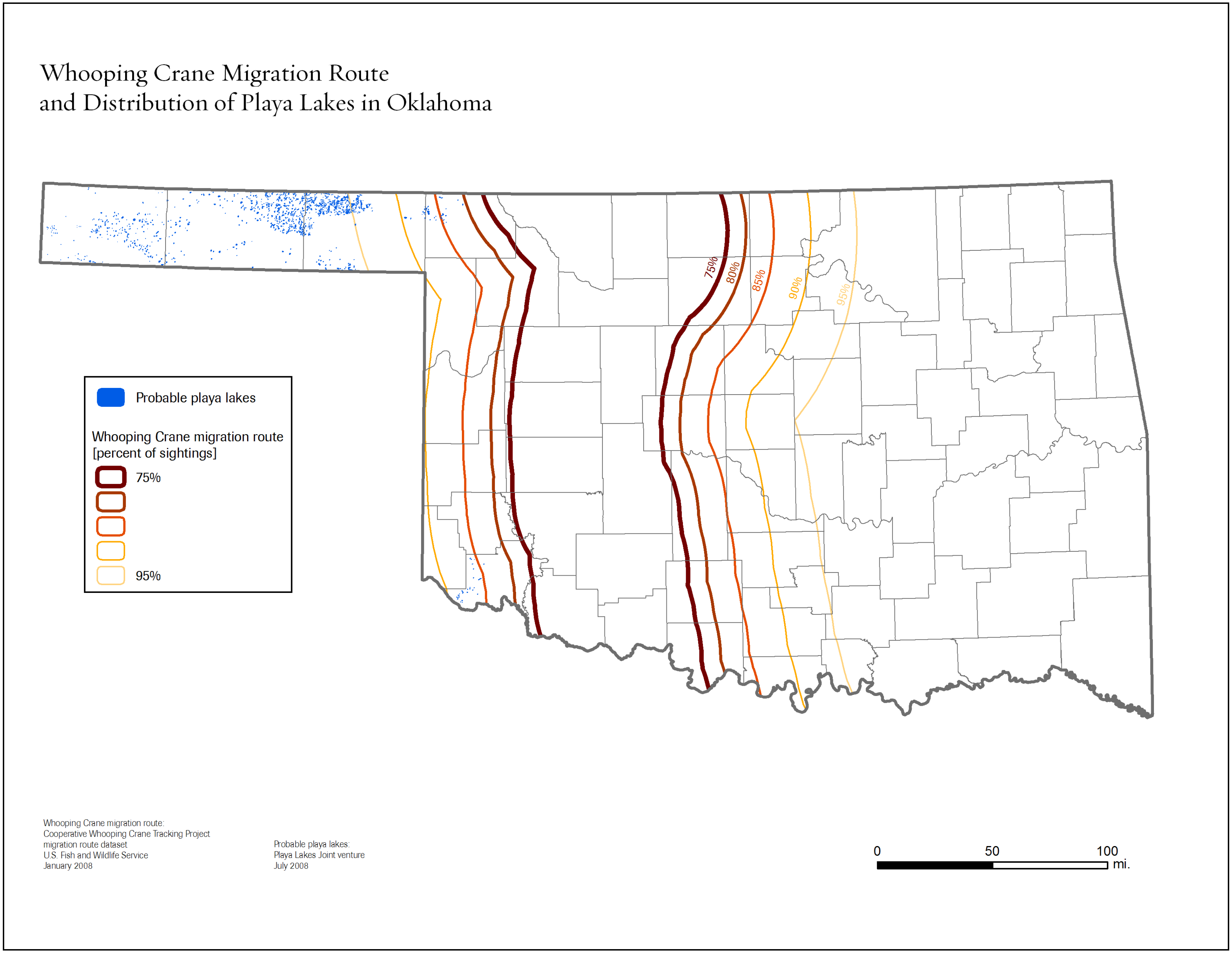
This map illustrates areas in which wind energy development may have negative impacts on Lesser Prairie-Chickens (LEPC). *The current range boundary encompasses most known LEPC leks and bird occurrences. **Areas in dark green indicate large contiguous patches of suitable habitat (within 10-miles of the current range) that may serve as core habitat. ***Areas in light green indicate suitable habitat in which conservation efforts will be most effective in expanding core habitat. Wind energy development in these areas will make recovery of LEPC even more challenging.

Although we highlight existing suitable habitat, it is important for users of this map to understand that recovery of LEPC will require creation of new habitat in currently unoccupied areas in order to connect fragments of suitable habitat. These 'connecting' areas may be effective sites for mitigation projects for wind and other energy development projects.

Map D.3



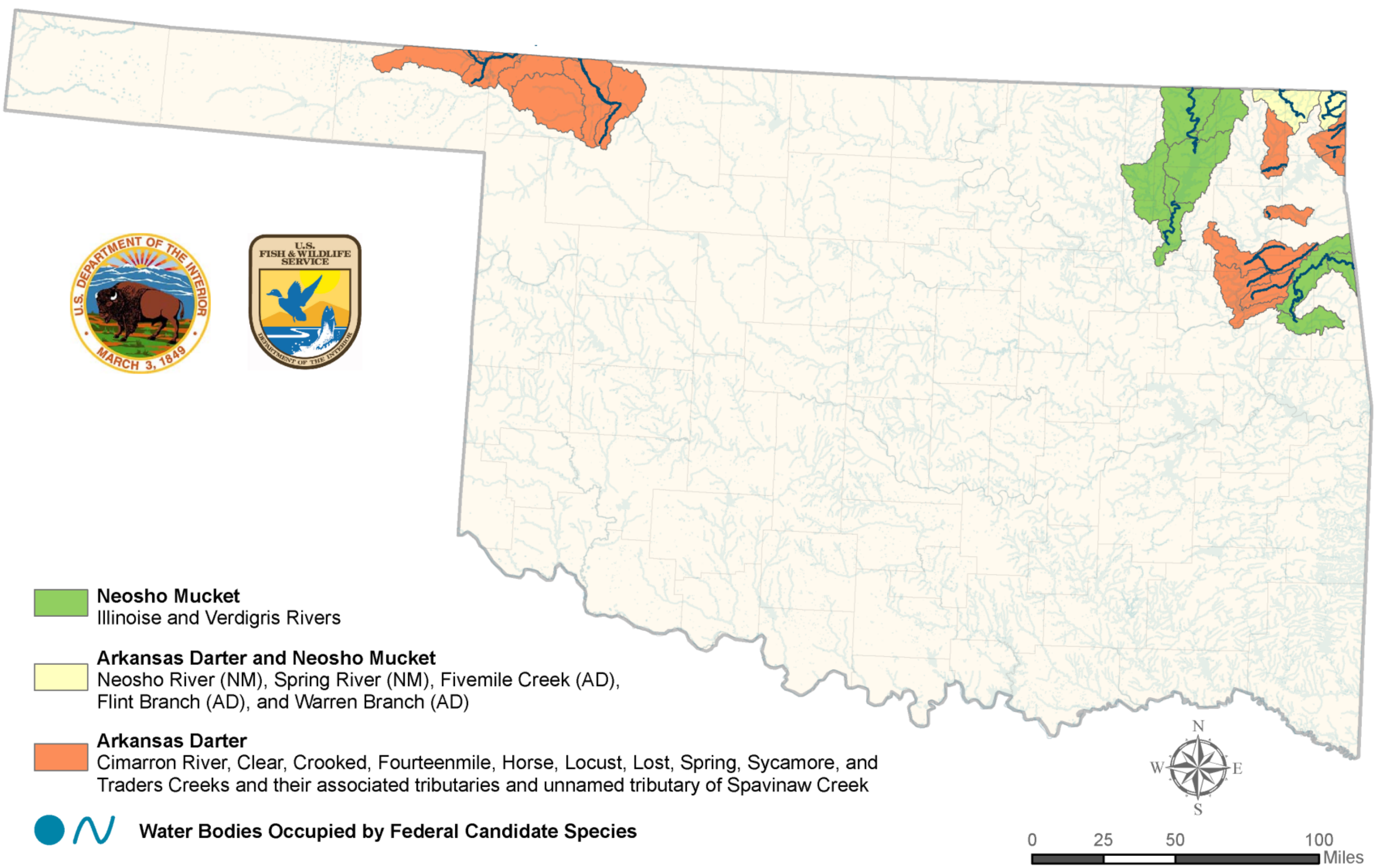
This map illustrates areas in which wind energy development may have negative impacts on birds. Blue squares indicate townships ($36mi^2$ land units from the Public Land Survey System) that have high densities of wetlands. Townships with 2% density have approximately 460ac of wetlands and those with 5% density have approximately 1,150ac of wetlands. Water is a limited resource in the PLJV so wetlands receive heavy bird use, especially during migration periods. Structures from wind energy development in these high density areas may introduce collision risks for birds flying in and out of wetlands.


Whooping Crane Migration Route
and Distribution of Playa Lakes in Oklahoma
75%
80%
85%
90%
95%
Probable playa lakes
Whooping Crane migration route
[percent of sightings]
75%
95%
Whooping Crane migration route:
Cooperative Whooping Crane Tracking Project
migration route dataset
U.S. Fish and Wildlife Service
January 2008
Probable playa lakes:
Playa Lakes Joint venture
July 2008
0
50
100
mi.

Map D.6

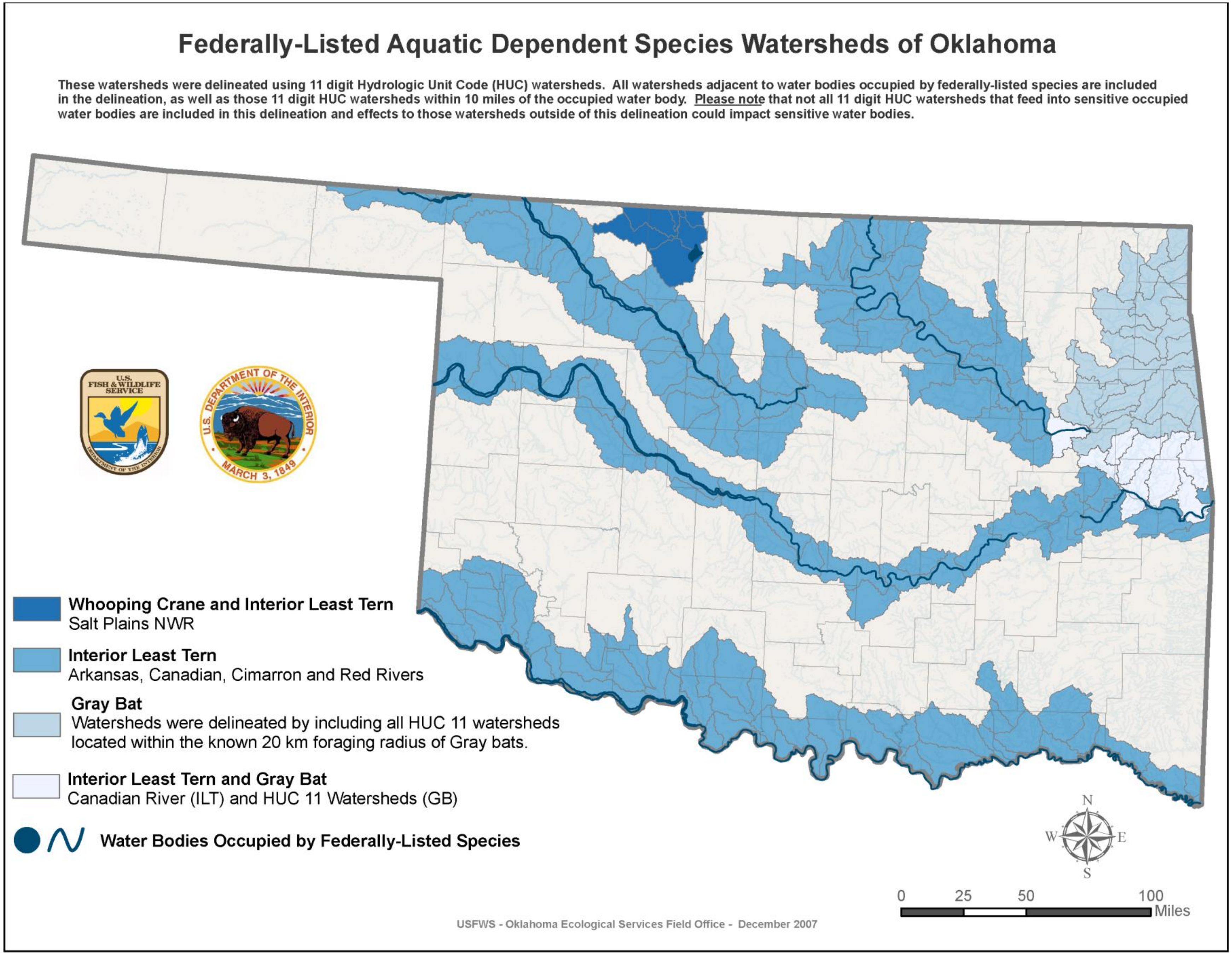
Federal Candidate Aquatic Species Watersheds of Oklahoma

These watersheds were delineated using 11 digit Hydrologic Unit Code (HUC) watersheds. All watersheds adjacent to water bodies occupied by federal candidate species are included in the delineation, as well as those 11 digit HUC watersheds within 10 miles of the occupied water body. Please note that not all 11 digit HUC watersheds that feed into sensitive occupied water bodies are included in this delineation and effects to those watersheds outside of this delineation could impact sensitive water bodies.



USFWS - Oklahoma Ecological Services Field Office - January 2008

Map D.7

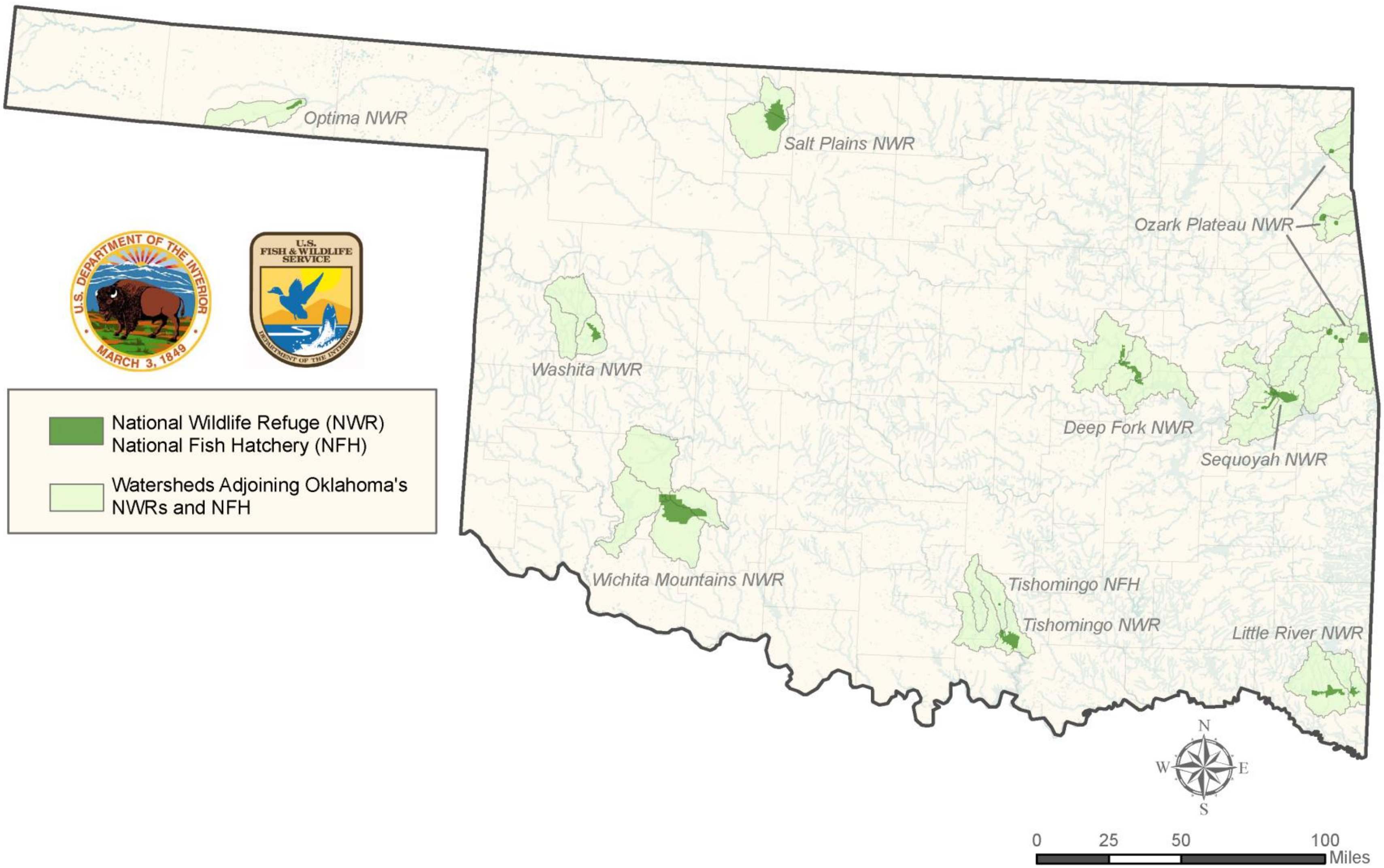


Federally-Listed Aquatic Dependent Species Watersheds of Oklahoma
These watersheds were delineated using 11 digit Hydrologic Unit Code (HUC) watersheds. All watersheds adjacent to water bodies occupied by federally-listed species are included in the delineation, as well as those 11 digit HUC watersheds within 10 miles of the occupied water body. Please note that not all 11 digit HUC watersheds that feed into sensitive occupied water bodies are included in this delineation and effects to those watersheds outside of this delineation could impact sensitive water bodies.
U.S. FISH & WILDLIFE SERVICE
U.S. DEPARTMENT OF THE INTERIOR
MARCH 3, 1849
Whooping Crane and Interior Least Tern
Salt Plains NWR
Interior Least Tern
Arkansas, Canadian, Cimarron and Red Rivers
Gray Bat
Watersheds were delineated by including all HUC 11 watersheds located within the known 20 km foraging radius of Gray bats.
Interior Least Tern and Gray Bat
Canadian River (ILT) and HUC 11 Watersheds (GB)
Water Bodies Occupied by Federally-Listed Species
N
W
E
S
0
25
50
100
Miles
USFWS - Oklahoma Ecological Services Field Office - December 2007

Map D.8

Watersheds Adjoining Oklahoma's National Wildlife Refuges and National Fish Hatchery

These watersheds were delineated using 11 digit Hydrologic Unit Code (HUC) watersheds. All watersheds adjacent to National Wildlife Refuges or National Fish Hatcheries are included in the delineation, as well as those 11 digit HUC watersheds within 10 miles of a Refuge/Hatchery. Please note that not all 11 digit HUC watersheds that feed into delineated areas are included, and effects within those watersheds outside the boundries shown also could impact these installations.



USFWS - Oklahoma Ecological Services Field Office - September 2008