Evaluating the Potential of the Conservation Reserve Program to Offset Projected Impacts of Climate Change on the Lesser Prairie-Chicken

(*Tympanuchus pallidicinctus*)

A Conservation Effects Assessment Project

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INTRODUCTION

In 2003, a multi-agency effort initiated the Conservation Effects Assessment Project (CEAP) to quantify environmental benefits of U.S. Department of Agriculture (USDA) conservation programs such as the Conservation Reserve Program (CRP), Wetlands Reserve Program (WRP), and Environmental Quality Incentives Program (EQIP). This project is part of the Wildlife Component of CEAP which was created to quantify effects of conservation programs and practices on fish and wildlife in agricultural landscapes.

The Playa Lakes Joint Venture (PLJV), in collaboration with The Nature Conservancy (TNC), designed this CEAP project to assess the ability of the CRP to offset potential negative impacts of climate change on the Lesser Prairie-Chicken (LEPC; *Tympanuchus pallidicinctus*), a bird species of high conservation concern. This project uses state-of-the-art climate change and dynamic vegetation models to project climate-induced changes in vegetation communities in the PLJV region over the next 60 years, estimate potential impacts on the LEPC, and examine the ability of future CRP enrollment scenarios to offset such impacts. This assessment follows two previous CEAP assessments by the PLJV which examined the effects of CRP on priority birds in the short- and central mixed-grass prairie (BCRs 18 & 19, respectively).

Playa Lakes Joint Venture

The PLJV is a non-profit partnership of federal and state wildlife agencies, conservation groups, private industry, and landowners dedicated to conserving bird habitat in the Southern Great Plains. We provide science-based guidance and decision-support tools for all-bird conservation throughout the region, as well as outreach, coordination and financial support to our partners and local groups to conduct on-the-ground habitat work. The PLJV works in the Southern Great Plains which includes eastern Colorado and New Mexico, western Nebraska, Kansas, and Oklahoma, and the Texas Panhandle (Figure 1; about 160 million acres). The region largely encompasses the shortgrass and central mixed-grass prairie Bird Conservation Regions (BCR18 and 19, respectively; Figure 1). The PLJV also works cooperatively with Rainwater Basin Joint Venture (RWBJV) which spans the northern portion of BCR19.

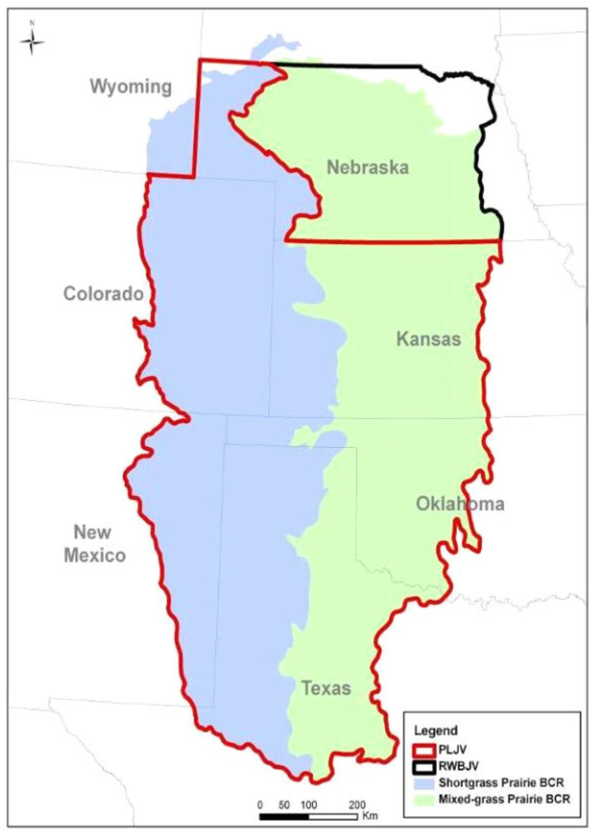

Figure 1. The shortgrass prairie and central mixed-grass prairie Bird Conservation Regions (BCRs 18 and 19) and the boundaries of the Playa Lakes Joint Venture and Rainwater Basin Joint Venture.

The PLJV is uniquely qualified and equipped to conduct regional bird analyses such as evaluating the effects of habitat change or conversion on bird population goals, developing spatially explicit models that locate suitable/critical bird habitat, and spatially targeting on-the-ground conservation efforts to maximize benefits to birds. The PLJV has compiled resources, developed tools, and established working partnerships that serve to further all-bird conservation in and around the JV. Chief examples are:

- Species for Management Action (SMA) database – This tool compiles and stores conservation status information from multiple sources (including federal, regional, and state-based sources such as U.S. Fish and Wildlife Service (USFWS) and Partners in Flight (PIF)) for all species breeding, wintering, or migrating in BCRs 18 and 19. This tool allows user to identify/classify species according to conservation information.
- A Review of Distribution, Habitat Use, and Population Density Data for the Hierarchical All Bird (HABS) Database (Dobbs 2007) – This document is an exhaustive literature review (updated frequently) that serves as a one-stop resource guide for demographic and ecological information on bird species occurring in BCRs18 and 19. This document provides data for the Hierarchical All Bird System (HABS) database, including bird density and use-day data specific to geographic location, season of the year, habitat, and its condition.
- Hierarchical All Bird System (HABS) database – HABS is a tool developed to calculate a landscape's capacity to achieve population objectives for priority species, both currently (i.e., based on current habitat availability), and in the future (i.e., based on alternative scenarios of future habitat availability based on conservation and management work). HABS allows its user to determine how much conservation work needs to be done for individual species as well as predict the potential impacts of habitat change or conversion on bird population goals.

The Nature Conservancy

The Nature Conservancy, founded in 1951 is the leading conservation organization working around the world to protect ecologically important lands and waters for nature and people. The Conservancy has protected more than 119 million acres of land and 5,000 miles of rivers worldwide and operates more than 100 marine conservation projects globally. More than 1 million members working in all 50 states and more than 30 countries to protect habitats from grasslands to coral reefs makes the Conservancy an integral partner in conservation planning and partnerships. The Conservancy is working to address threats to conservation involving climate change, fire, fresh water, forests, invasive species, and marine ecosystems. The Conservancy employs more than 700 scientists to help implement Conservation-By-Design, a science-based approach to pursue non-confrontational, pragmatic solutions to conservation challenges.

Developing mechanisms to integrate conservation delivery with the best available science has been the focus of the Conservancy's planning process. The Conservancy supports both a Migratory Bird Program and a Global Climate Change Initiative which has been identified as one of the organization's North American Priorities. This project pulls together priorities within the Conservancy's organizational structure and its expertise to address the interactions of complex systems of biology and climatology and the impacts to migratory birds. Climate change has the potential to impact all species of migratory birds at one or several points in the life cycle. It is important that we study these birds so that we can understand where they are most sensitive to risks in changing habitats and migration timing. When we understand the risks to species, we can incorporate these risks in to the conservation-by-design process and emphasize the resources needed to enhance the resilience of affected species.

The Conservancy has state programs with responsibility and expert resources to help preserve habitats that are vital to the LEPC. Planning for species under changing climate conditions will allow Conservancy programs to target scarce resources to maximize potential benefits to species under compounding uncertainties.

Lesser Prairie-Chicken (*Tympanuchus pallidicinctus*)
The LEPC, a resident grouse species endemic to the Southern Great Plains, is a species of high conservation concern. It is currently considered a Watch List Species according to Partners in Flight, a species of Highest Continental Concern according to the American Bird Conservancy, a State Threatened species in Colorado, and is currently a candidate for listing under the federal Endangered Species Act. It is also petitioned in Kansas to be listed as a state threatened species.

Lesser Prairie-Chickens were once found abundantly throughout the short- and central mixed-grass prairie regions in Colorado, Kansas, New Mexico, Oklahoma and Texas. Since European-American settlement, their population range has shrunk to 10% of its original extent (Figure 2; currently about 16 million acres) and population numbers have also declined by >90%. The decline is due to habitat degradation, fragmentation and loss due to agriculture and energy development.

Lesser Prairie-Chickens currently are patchily distributed in southern portions of BCRs 18 and 19 in Colorado, Kansas, Oklahoma, New Mexico, and Texas (Figure 2). They are most abundant in the southwestern portion of Kansas (Price et al. 1995). Habitat use varies across their range, but generally consists of dwarf shrub-mixed grass vegetation types associated with sandy soils, which may be

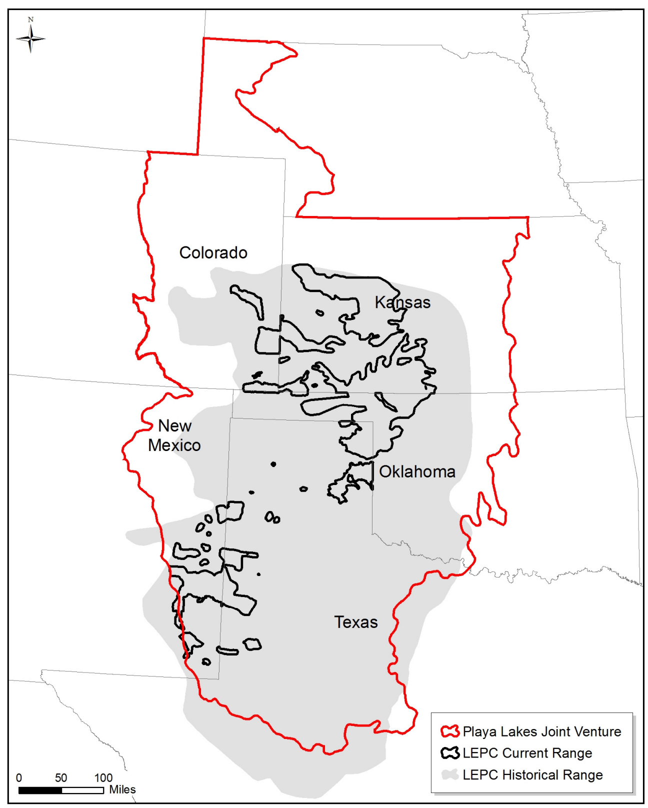

Figure 2. Historical and current range of Lesser Prairie-Chicken and the Playa Lakes Joint Venture boundary.

interspersed with shortgrass or mixed- grass prairie (Taylor and Guthery 1980; see Hagan 2005). Habitat is comprised primarily of sandsage prairie in Kansas (Andrews and Righter 1992, Giesen 1994, Busby and Zimmerman 2001) and Colorado, and primarily shinnery oak prairie in Oklahoma, Texas (Riley et al. 1992, Jackson and DeArment 1963; see Hagan 2005) and New Mexico.

This species also uses CRP in some areas (Davis et al. 2008) as well as cropland (Crawford and Bolen 1976). Field studies conducted in the Colorado and Kansas portions of the LEPC range have documented LEPCs leking, nesting, and roosting in grassland provided by the CRP (Fields 2004, Davis et al. 2008). In Colorado, leks were found in CRP fields with stunted 'sod-like' grass cover, providing the sparse and low-stature vegetation associated with leks (Davis et al. 2008). In Kansas, LEPC nests were found predominately in CRP with mid to tall native warm season grasses (Field 2004). Biologists think that native CRP located within 2-miles of native grassland has the most potential to serve as suitable nesting habitat (Davis et al. 2008). Conversely, in the Texas, New Mexico, and Oklahoma portions of the LEPC range, it appears that CRP may not be providing suitable LEPC habitat. In these states, CRP fields are predominately characterized by weeping lovegrass (*Eragrostis curvula*) and non-native bluestem species (*Bothriochloa* spp).

Wildlife and climate change

Systems within the Southern Great Plains have evolved to cope with a dynamic climate of drought and wet periods, as have the grassland birds of the region including the LEPC. Key factors influencing abundance, distribution, and vital rates of grassland bird species are changes in food resources (insects, seeds), patch size, and vegetative structure (height of herbaceous layer, presence, height and structure of shrubs or trees) (Rotenberry and Wiens 1980, Kantrud and Kologiski 1982, Peterjohn 2003, Chapman et al. 2004). These factors in turn are influenced by weather and disturbance events such as wildfire. Population trends and distribution of individual species have been linked to moisture and temperature conditions (Kantrud and Kologiski 1982, Niemuth et al. 2008).

Incorporating predicted climate change into bird and habitat conservation planning is vital for long-term success. In 2008, the PLJV commissioned a climate change specialist at the World Wildlife Fund to synthesize information on both past and predicted climate shifts in the PLJV region (Matthews 2008). According to the report, the PLJV region has been experiencing regional anthropogenic-driven climate shifts over at least the last 30 years, with drier summers, wetter springs in the north, drier springs in the south, and more frequent extreme weather events throughout, including both floods and extended drought (Matthews 2008). These trends are predicted to continue into the future with the largest decreases in precipitation in the south and southwest portions of the PLJV region and greatest increases in precipitation in the northeast portion (IPCC 2007 *in* Matthews 2008).

However, there is limited research indicating how individual bird species may respond to these predicted climate shifts. Only one study has examined potential responses of Great Plains species to climate change (Peterson 2003), predicting that species will respond differently but generally will expand north. We suggest that near-term (60 years) changes in climate or disturbance events will likely reduce the ability of habitats to provide resources necessary to sustain bird populations, or result in outright loss of certain habitats. For example, shifts from diverse herbaceous landscapes to invasive or C3-dominated landscapes will likely reduce brood survival; such an outcome has been projected for Greater Sage-Grouse (*Centrocercus urophasianus*) (Montana Sage-grouse Working Group 2004). Moreover, insectivores may face phenological mismatch between their breeding phenology and that of their prey because of insect vulnerability to changes in thermal regimes (Parmesan 2006).

These issues are important because direct loss of habitat, interim loss of habitat or habitat quality, or extreme climatic events may lead to the extirpation of birds and, possibly, other taxa. Species currently exhibiting population declines or receding occupied ranges, such as the LEPC, may be most vulnerable. However, not all species will be negatively affected by such changes. As shifts in habitat conditions occur, the new habitat will favor some species over the previous residents. Quantifying the direct effects of climate change on habitat and species therefore must include models predicting changes in the underlying factors of vegetation type and structure.

Bioclimatic vegetation modeling

Climate change modeling can predict changes in vegetation that may impact wildlife, such as the LEPC, by predicting changes in levels of above-ground carbon (C), the primary component of plant material. Higher measures of above-ground carbon (or vegetation carbon) imply higher amounts of above-ground biomass (i.e., denser/taller vegetation and litter build-up). For example, Derner et al. (2006) measured mean above-ground carbon levels for three prairie communities by analyzing above-ground live and standing dead biomass (leaf and stem tissue) in both grazed and ungrazed areas (Table 1). As seen in Table 1, carbon content of above-ground vegetation increased as biomass increased from shortgrass to tallgrass communities and mean carbon content accounted for approximately 40% of the total biomass in each grassland community (Table 1).

The MC1 dynamic vegetation model (Bachelet et al. 2001a) projects the amount of above-ground carbon in a plant community given a certain set of processes (e.g., disturbance, such as fire; variation in precipitation; temperature extremes). By changing the magnitude of a process (e.g., more frequent fire events; more extreme precipitation events), differences in above-ground carbon values can be projected. These changes in above-ground carbon values are related to changes in plant community structure (e.g., community dominated by grasses or shrubs) and productivity (e.g., height of grass). Changes in plant community or productivity can have beneficial or detrimental impacts for bird species that have historically used the area for breeding, brood rearing, migrating and wintering habitat.

Table 1. Mean biomass and carbon content for live and standing dead vegetation collected in 1994, 1998, and 1999 in three grassland communities and two grazing level (Derner et al. 2006). The shortgrass prairie study sites were located in northeast Colorado, the mixed-grass site was located in central Kansas near Hays, and the tallgrass site was located in eastern Kansas near Manhattan.

Grassland Community	Grazing Level	Mean Above-ground Biomass (g/m^2)[1]	Mean Carbon Content in Above-ground Biomass ($g\ C/m^2$)[2]
Shortgrass	Grazed	90	35
	Ungrazed	118	49
Mixed-grass	Grazed	121	50
	Ungrazed	208	89
Tallgrass	Grazed	113	264
	Ungrazed	190	441

[1] Biomass was measured for herbaceous species collected in July 1994.
[2] Carbon content of the biomass was determined by multiplying biomass by C concentrations levels that were determined through evaluation of plant samples collected in July 1998 in shortgrass and tallgrass sites and in September 1999 in mixed-grass sites.

Justification

There is mounting concern among a variety of stakeholders regarding the continued decline of the LEPC, including the potential implications of listing the LEPC as a federal threatened or endangered species. In addition to traditional threats to its long-term survival, climate change appears to be yet another source of habitat degradation via potential changes in vegetation structure and composition. Stakeholders are looking for ways to conserve the LEPC in its agricultural-dominated landscape.

Two previous CEAP assessments, conducted by the PLJV, indicated that the CRP is functioning as a LEPC conservation tool in two ways: (1) by providing suitable grassland habitat, when CRP fields are planted to ecologically appropriate native species, and (2) by forming large blocks of suitable habitat out of otherwise fragmented patches of habitat. According to the spatial habitat analysis, land enrolled in the CRP has increased the carrying capacity of the landscape for the LEPC by as much as 30% in the shortgrass portion of its current range (BCR18; McLachlan and Carter 2009) and by nearly 10% in the central mixed-grass region of its range (BCR19; McLachlan and Rustay 2007), illustrating the high value of the CRP as an effective conservation tool for the LEPC.

However, these previous analyses were based on assessing the current landscape without regard for potential vegetation changes due to climate change. In the Southern Great Plains, climate change scenarios predict that average temperatures will increase while precipitation will decrease in the southern portions of the range and increase in the northern portions. Changes in temperature and precipitation regimes are predicted to affect vegetation composition. Changes in vegetation could have significant effects on grassland birds, including the LEPC, which may have to immigrate to new areas with suitable habitat in order to survive.

Goals and objectives

The goal of this CEAP project was to assess the potential for the CRP to offset some of the projected impacts of climate-induced vegetation change with regard to LEPC conservation. We had three objectives for this project. Our first objective was to predict changes in vegetation in BCRs 18 and 19 (including the LEPC current range) over the next 60 years based on near term projections from climate modeling. Our second objective was to estimate and compare the LEPC carrying capacity of the current landscape and predicted future landscape, based on those projected changes. The final objective was to gauge the potential of CRP to offset these predicted changes, considering a range of future CRP enrollment scenarios.

Acronyms

This report uses acronyms listed and defined in table 2.

Table 2. List of acronyms used in this report and their definitions.

Acronym	Definition
AOGCM	Atmosphere-Ocean General Circulation Model
AR4	4^{th} Assessment Report from the IPCC
BCR	Bird Conservation Region
BCR18	Shortgrass Prairie Bird Conservation Region
BCR19	Central Mixed-grass Prairie Bird Conservation Region
FSA	Farm Service Agency
IPCC	Intergovernmental Panel on Climate Change
LEPC	Lesser Prairie-Chicken
MC1	Dynamic Vegetation Model
NRCS	Natural Resources Conservation Service
PLJV	Playa Lakes Joint Venture
USDA	United States Department of Agriculture
WCRP	World Climate Research Programme

METHODS

Study area

We conducted climate change and dynamic vegetation modeling throughout the PLJV region including the current LEPC range and spanning most of BCRs 18 and 19 (Figure 1). The PLJV region includes portions of six states including Nebraska, Colorado, Kansas, Oklahoma, New Mexico, and Texas.

For analyses specific to the LEPC (such as estimating carrying capacities) the study area was defined by a 10-mile buffer of the current LEPC range. The current range is located in the southern regions of the shortgrass and central mixed-grass prairie BCRs (BCR18 and BCR19), spanning approximately 37.9 million acres across portions of Colorado, Kansas, Oklahoma, New Mexico, and Texas (Figure 2). We included a 10-mile buffer of the LEPC range in the study for two reasons. First, the spatial modeling used to identify suitable LEPC habitat (i.e., Large Blocks as explained below) requires a minimum window of analysis to adequately measure habitat configuration, approximately a 10-mile radius from any given point on the landscape. Second, the LEPC current range boundary was delineated free-hand by members of the Lesser Prairie-Chicken Interstate Working Group and there is assumed error in the boundary, possibly excluding occupied habitat.

BCR18 is located in the western portion of the Southern Great Plains of North America, encompassing portions of seven states including Nebraska, Wyoming, Colorado, Kansas, Oklahoma, New Mexico, and Texas (Figure 1). BCR18 spans over 95 million acres of gently sloping terrain comprised of a variety of habitats, both naturally occurring (e.g., prairie, wetlands, streams) and man-made (e.g., cropland, urban areas, reservoirs). The shortgrass prairie is dominated by blue grama (*Bouteloua gracilis*) and buffalo grass (*Buchloe dactyloides*) interspersed with small amounts of tallgrass species in the east (e.g., little bluestem (*Schizachyrium scoparium),* Indian grass (*Sorghastrum nutans*)). Common shrub species occurring in BCR18 are sand sagebrush (*Artemisia filifolia*) and sand shinnery oak (Q*uercus havardii rydb*.). Woodland habitat ranges from scattered cottonwood trees (*Populus* spp.), small clustered plantings of Siberian elm (*Ulmus pumila*) and Russian olive (*Elaeagnus angustifolia*), to large expanses of honey mesquite (*Prosopis glandulosa)* and eastern red-cedar (*Juniperus virginiana*). Historically dominated by grassland and shrubland habitat, BCR18 now has as much cropland (comprising about 43% of its total landcover) as it does native grassland and shrubland combined. Major crop types are wheat, sorghum, corn (primarily in the north), soybeans, sunflowers, and alfalfa. Over 6 million acres of cropland in BCR18 (about 15%) are currently enrolled in the CRP.

BCR19 is located in the eastern portion of the Southern Great Plains of North America, encompassing portions of four states including Kansas, Nebraska, Oklahoma, and Texas (Figure 1). BCR19 spans over 97 million acres of gently sloping terrain comprised of a variety of habitats, both naturally occurring (e.g., prairie, wetlands, streams) and man-made (e.g., cropland, urban areas, reservoirs). Mixed-grass prairie vegetation is an integration of the shortgrass species to the west (e.g., blue grama (*Bouteloua gracilis*), buffalo grass (*Buchloe dactyloides*)) and the tallgrass species to the east (e.g., little bluestem (*Schizachyrium scoparium,* Indian grass (*Sorghastrum nutans*)). Common shrub species occurring in BRC19 are sand sagebrush (*Artemisia filifolia*) and sand shinnery oak (*Quercus havardii rydb.*) Woodland habitat ranges from scattered cottonwood trees (*Populus* spp.), to small clustered plantings of Siberian elm (*Ulmus pumila*), Russian olive (*Elaeagnus angustifolia*), and eastern red-cedar (*Juniperus virginiana*), to large expanses of honey mesquite (*Prosopis glandulosa)*, juniper (*Juniperus* spp.), and eastern red-cedar. Historically dominated by mixed-grass prairie, BCR19 is now dominated by cropland (comprising nearly 54% of its total landcover). Major crops are corn (primarily in the north), soybeans, wheat, sorghum, sunflowers, and alfalfa. Approximately 2.8 million acres of the cropland in BCR19 (about 8%) is currently enrolled in CRP.

Data analysis

Data analysis consisted of four major steps: 1) use climate and dynamic vegetation modeling to project historical and future habitat types and above-ground vegetation carbon levels, 2) estimate the LEPC carrying capacities of the current landscape based on spatial landcover data, 3) determine potential changes in LEPC carrying capacity due to predicted climate-induced vegetation changes, and 4) assess the potential of CRP to offset LEPC carrying capacity declines based on a range of possible future CRP enrollment scenarios. Each of these main steps is described below.

Step 1: Model historical and future habitat types and vegetative carbon levels

We modeled historic and future vegetation conditions in the PLJV region and the current LEPC range based on estimated above-ground carbon levels. The historical baseline year was considered 2000 (based on a range of data from 1989-2009) and the future was considered the year 2060 (based on data from 2050 – 2070). Historical and future above-ground carbon levels were estimated via climate change modeling based on the Atmosphere-Ocean General Circulation Models (AOGCM) and dynamic vegetation modeling using the MC1 model (Bachelet et al. 2001a), as described below.

> <u>Climate change model</u>: We obtained Atmosphere-Ocean General Circulation Models (AOGCM) projections of historical and future climate from the World Climate Research Programme (WCRP). The output from these models are results of experiments conducted by international climate modeling groups who participated in the third phase of the Climate Model Intercomparison Project (Meehl et al. 2007) and used in the 4th Assessment Report (AR4) on climate change by the Intergovernmental Panel on Climate Change (IPCC). We evaluated the AOGCMs by comparing how well each model is able to represent the natural climate variability for the late 20th century (1950–2000) across the study area. The historical runs from each AOGCM were evaluated and it was determined that the Hadley Model simulated the major influences to the Southern Great Plains better than the available alternatives (Pers. Comm. Ron Neilson - Oregon State University/ USDA Forest Service). Projections of future precipitation trends from AOGCMs are variable and model-dependent. To address the problem, we evaluated (Räisänen and Palmer 2001, Räisänen and Ruokolainen 2006) habitat change using a range of outputs, the ten years previous and post evaluation date (2050 – 2070), then applied a majority filter.

For direct climate comparisons, we used the minimum, mean and maximum temperature and precipitation values from the downscaled General Circulation Model (GCM) (downloaded from The Nature Conservancy's Climate Analysis Tool, climatewizard.org). The downscaling was performed by the US Forest Service, Forestry Sciences Laboratory, Corvallis, Oregon whose contributing members include Ron Neilson, Jim Lenihan, Ray Drapek, Dominique Bachelet, and Chris Daley. The data were processed in a manner to retain the relatively fine grid patterns consistent with those observable in historical datasets. Difference anomalies were used for temperature data and ratio anomalies were used for precipitation. Anomalies were calculated relative to the monthly average value for the years 1961 to 1990 (for example: January values were compared with the average historical January value). Anomalies were calculated using modeled data for both historical and for future climate values. In this way the anomalies showed how the climate changed for the model relative to its own climatology.

The anomalies were then interpolated to a 1/2 degree spatial resolution. The interpolated anomalies were then either multiplied with or added to the mean ground-measured historical climate. The mean historical climate is a 12 month average climate for the years 1961-1990 (average January value + average February value +…/12), this range includes an entire short term climate cycle of drought and flood. Anomalies were applied to the appropriate month, such that a January anomaly was applied to the mean historical January, etc. We proposed to use an ensemble of emission scenarios under high (A2), mid-range (A1B), and lower (B1) CO_2 emission pathways (Nakićenović and Swart 2000) from the IPCC Special Report. Current reports indicate the earth's emissions trajectory is more consistent with the A2 scenario. All comparisons and modeled data were therefore derived using the higher A2 scenario rather than assuming an international treaty will be reached to mitigate carbon to the lower A1B or B1 emissions pathway scenarios.

<u>Dynamic vegetation model (MC1)</u>: MC1 is a dynamic vegetation model that simulates vegetation types (e.g., temperature grassland, shrubland, broadleaf forest) and ecosystem processes. MC1 is routinely implemented (Bachelet et al. 2000, Daly et al. 2000, Bachelet et al. 2001b) on spatial data grids of varying resolution (i.e., grid cell sizes ranging from 900 m^2 to 2500 km^2); the cell size used for this analysis was $76 km^2$ (18,870 acres per pixels). The model reads climate data at a monthly time step and calls interacting modules that simulate biogeography, biogeochemistry, and fire disturbance. The biomass component of the model allows derivation of an index of homogeneity of cover and an index of vertical structure. Its fire model includes allometric relations used to estimate the amount of fine versus coarse fuels that can be used to describe vegetation's vertical structure. The model also simulates the growth of shrubs (small trees) that compete with grasses for water and nutrients but can be killed by fire.

Running the MC1 model under historic and future climate scenarios can provide a comparison of habitat types and conditions via estimated changes in above-ground vegetation carbon levels (Räisänen and Palmer 2001, Räisänen and Ruokolainen 2006). For this study, Neilson et al. (unpublished) supplied the MC1 model output for both historical and future climate conditions, using the A2 emission scenario. They documented changes in: 1) carbon pools associated with vegetation, allowing quantification of the impacts of woody invasion of grasslands, 2) wildfire occurrence and impacts that will estimate carbon losses and gains and the changes in the recovery potential of habitat characteristics if/when the fire regime changes, and 3) vegetation types that can affect habitat suitability for wildlife and other ecosystem services such as carbon sequestration and water availability. For this analysis, we focused on the estimated changes in habitat type and above-ground carbon levels to approximate changes in the amount and quality of habitat available to the LEPC over the next 60 years.

Estimated change in habitat type (as determined by crossing critical ecological thresholds) was calculated by counting the number of years in which an event occurred out of 21 years. The most frequently occurring habitat value was used for the future habitat. For purposes of comparison through time, we selected 21-year periods (1989-2009 and 2050–2070) from the model run. We then determined the number of periods of each outcome within each period when the future runs differ from the historic habitat values.

Estimated above-ground vegetation carbon levels were calculated as the mean carbon value over each time period (1989-2009 and 2050–2070). To validate the model output, we compared the MC1 vegetation carbon estimates for the year 2000 to field measures of carbon content in above-ground biomass collected in shortgrass and mixed-grass prairie sites in the mid and late 1990's (See Table 1; Derner et al. 2006).

Step 2: Estimate current LEPC carrying capacities

The second step was to estimate the current LEPC carrying capacity (i.e., the ability of the habitats within the study area to support LEPCs expressed in number of birds). To estimate the current carrying capacity we used the PLJV spatial landcover layer in concert with the PLJV HABS database (a brief description of HABS is provided in the Introduction and a detailed description is provided in Appendix A). The spatial landcover data provided distribution data for major vegetation communities (e.g., mixed-grass prairie) in the study area. Spatial modeling was applied to the landcover to identify Large Blocks of habitat suitable for the LEPC. The HABS database was used to: 1) track the amount and distribution of habitats in the landcover (including Large Blocks), 2) store LEPC densities associated with each of those habitats, and 3) estimate LEPC carrying capacities for each BCR-state area within the LEPC range. Carrying capacity estimates were calculated separately for each state portion of each BCR because bird-to-habitat densities as well as bird population goals are most appropriately related at this spatial scale. For example, the Kansas portion of BCR 18 and the Kansas portion of BCR19 are analyzed individually. Below we describe the landcover layer, the spatial modeling used to identify Large Blocks of habitat, and how LEPC carrying capacity estimates are calculated in HABS.

Landcover (vegetation communities): The spatial landcover data used in our analysis is a seamless landcover layer, developed by the PLJV, which spans nearly all of BCRs 18 and 19 (Figure 3). The seamless landcover is classified into a system of habitat Associations and Conditions that are used to determine the amount and types of habitat available to birds. Associations are major vegetation communities generally considered to be mappable at a landscape scale (e.g., shortgrass prairie). Conditions are recognized as having distinctive characteristics important to birds but are not always mappable with current GIS data (e.g., few shrubs/high grass).

The PLJV landcover incorporates the FSA's Common Land Unit (CLU) layer which delineates CRP and crop fields (current as of October 2009). Because of the numerous Conservation Practices (CPs), we partitioned CRP into one Association with six Conditions according to CP: grass, trees in upland, trees in riparian, wetland, playas/non-floodplain wetland, and other CRP practice. Although there are CPs distinguishing between native grass plantings (CP2) and a CP designating non-native grass plantings (CP1), these were not used in the Condition classes because there is uncertainty regarding the definition of a native planting. Through interviewing CRP professionals and researchers, we determined that native plantings (CP2) did not necessarily indicate species native to the area but rather to North America. For example, shortgrass or tallgrass species planted in the shortgrass prairie may be considered a CP2 but they are not truly native to the area. In addition, there is also a practice designating existing/established grass (CP10) which does not indicate native or non-native planting, creating more uncertainty. So we applied assumed proportions of native to non-native plantings specific to each state in the PLJV based on opinions of CRP professionals and researchers. In Kansas, we assumed all CRP grass plantings were native. In Colorado, New Mexico, Oklahoma, and Texas we assumed 10% were native and 90% non-native. We also updated the landcover layer with the crop field boundaries delineated in the CLU layer as it was the most current data available. Detailed information on the landcover layer including its development and list of Associations and Conditions are documented in "Habitat Assessment Procedures Technical Companion Document to the PLJV Implementation Planning Guide" (Playa Lakes Joint Venture 2007). Details regarding the development, uses, and limitations of the PLJV landcover layer are available in *Habitat assessment procedures: Technical companion document to the PLJV Implementation Planning Guide* (Playa Lakes Joint Venture 2007).

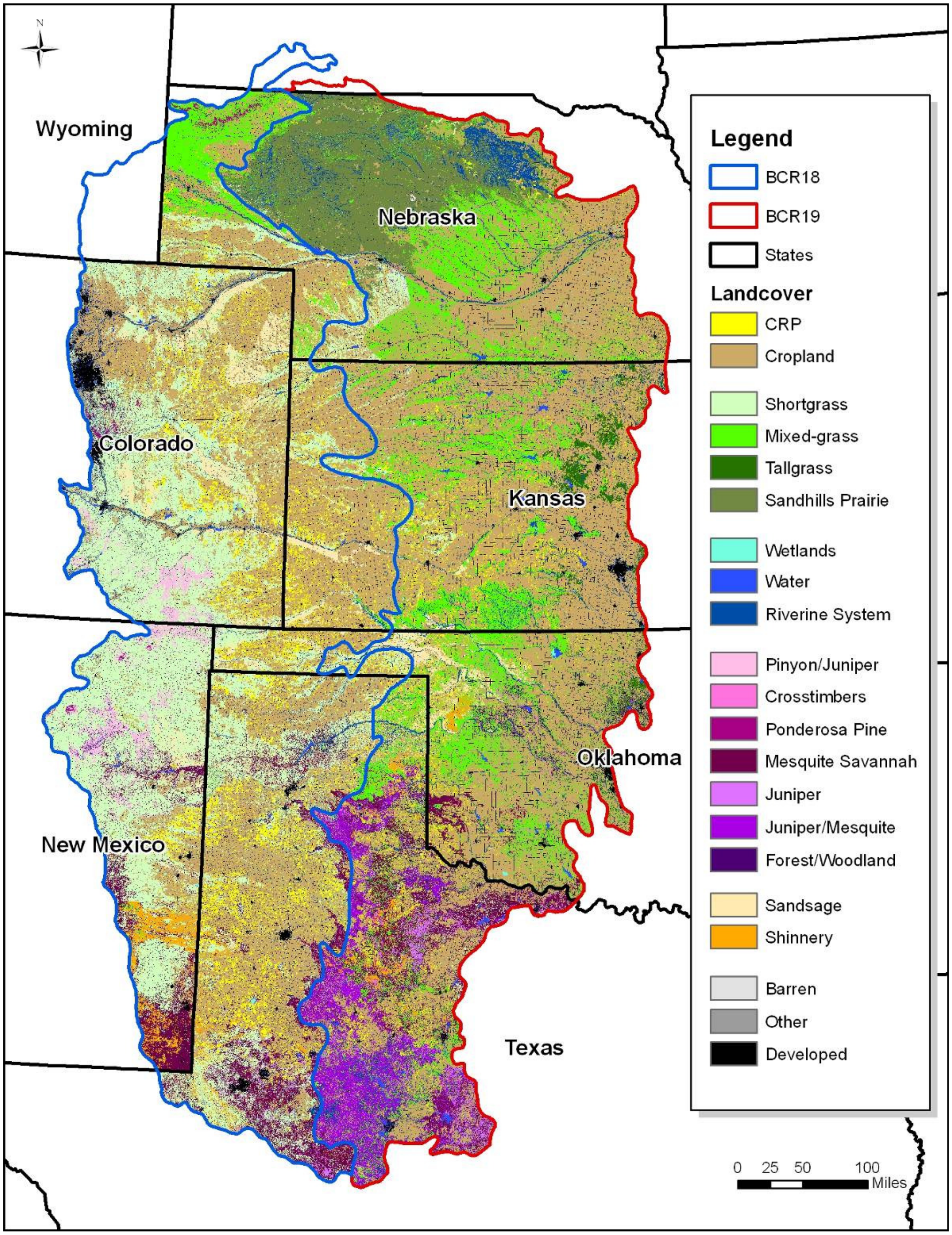

Figure 3. Seamless landcover for the shortgrass and central mixed-grass prairie Bird Conservation Regions (BCRs 18 & 19, respectively).

Habitat distribution and configuration (Large Blocks): The first step to estimating current LEPC carrying capacities was to track the amount and spatial configuration of all habitats, including CRP, occurring in each BCR-state portion of the study area (e.g., BCR18-KS). Using the landcover layer (described above) in a GIS, we determined the amount of each habitat Association and Condition in each state-BCR area and then entered into the HABS database.

Next, we used spatial habitat modeling (specific to the LEPC's habitat requirements) to determine how many of those habitat acres occurred in Large Block configuration (Figure 4). Large Blocks are areas that meet minimum habitat configuration requirements of the LEPC. LEPCs require large patches of suitable habitat (about 5,000 acres of grassland and shrubland) with minimal amounts of woodland, roads, and developed areas. The Large Block modeling was run within and up to 10-miles from the LEPC current range to account for its limited distribution in BCRs 18 and 19. By dividing the amount of suitable habitat in Large Block formation by the total amount of suitable habitat in the study area, we determined a Large Block factor which is entered into HABS. For instance, if there were 20,000 acres of suitable habitat in the study area but only 5,000 acres were in Large Block configuration, we applied a Large Block Factor of 0.25 when estimating carrying capacity in HABS. The Large Block factor accounts for both the limited range of the LEPC (it occur only in portions of BCR18 and BCR19) and the spatial habitat requirements of the species.

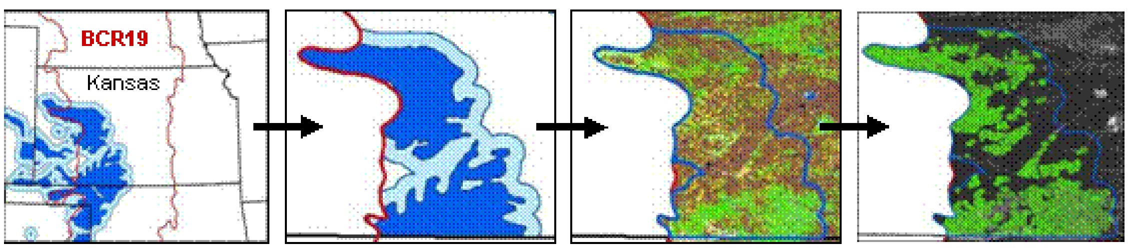

Figure 4. Illustration of the process used to identify large-blocks of suitable Lesser Prairie-Chicken habitat, BCR19 portion of Kansas: a) Lesser Prairie-Chicken range (dark blue) and 10-mile buffer (light blue) and BCR19 boundary (red), b) buffered range within BCR19 portion of Kansas only, c) landcover layer with 10-mile buffer on which large-block model is applied, and d) large-block acres as identified by model.

Associate LEPC densities with habitats: The HABS database contains density data for dozens of bird species that occur throughout BCRs 18 and 19, including the LEPC. Density data for the LEPC come from a variety of sources including published papers and technical reports from federal and state wildlife agencies. LEPC densities vary not only with habitat Association and Condition but also with state-BCR area. For example, field research in Kansas (Kansas Department of Wildlife and Parks) indicates that the LEPC occurs at a density of about 0.0125 birds/acre in mixed-grass prairie habitat. In Texas, field research (Lionberger 2006) indicates that the LEPC occurs at a density of about 0.0108 birds/acre in mixed-grass prairie. Most notably, the density rates for LEPC in CRP vary greatly between native and non-native grass plantings. According to professional opinions of local LEPC biologists, LEPCs occur in non-native CRP at 25% of the density at which they occur in native CRP.

Estimate LEPC carrying capacity for BCR-state areas: In HABS, the carrying capacity for a species is calculated for each habitat Association and Condition within a state-BCR area. For example, a carrying capacity is determined for shortgrass prairie with low grass and few shrubs in the Colorado portion of BCR 18. The calculation is determined by multiplying the number of habitat acres by the habitat-specific bird density and then by any appropriate factors (Large Block, Range, Suitability; see Appendix A for descriptions) as follow:

*Carrying Capacity = Habitat Acres * Bird Density * Large Block Factor * Range Factor * Suitability Factor*

In this analysis, the carrying capacities for the LEPC were calculated by multiplying habitat acres by LEPC densities and Large Block factors. LEPC densities vary by habitat Association and Condition as well as by state-BCR area. Large Block factors, also specific to each state-BCR area, account for the limited range of the LEPC because the spatial model used to delineate Large Blocks was only run within and 10-miles from the current range of the LEPC; therefore; a Range factor was not applied. A Suitability factor was not necessary (see Appendix A for an explanation of Suitability factor).

Next, the habitat-based carrying capacities were summed within each state-BCR area to provide a regional estimate of LEPC carrying capacity. By estimating carrying capacity at the state-BCR level they can then be compared to BCR-based population goals for individual bird species (see Appendix A for an explanation on determining species' population goals). This puts the carrying capacity in context of a conservation goal allowing a biologist to gauge how much conservation effort is needed and where.

Step 3: Determine potential future declines in LEPC carrying capacities
Declines in LEPC carrying capacity due to climate-induced vegetation changes could not be calculated using the HABS database as was intended at the onset of this project. The reason is due to an inability to relate changes in LEPC densities with projected changes in vegetation productivity. Published LEPC densities are related to broad vegetation communities, such as mixed-grass prairie or sandsage shrubland. Conversely, our projected climate-induced vegetation changes largely indicate changes *within* vegetation communities, such as mixed-grass prairie transitioning from high to low productivity (i.e., changes in vegetation structure from decreased productivity) – not transitioning from mixed-grass prairie to shortgrass prairie.

Based on the results of our climate change and dynamic vegetation modeling, we predict a decline in LEPC carrying capacity will occur over the next 60 years; however, we cannot quantify the decline. To adjust our analysis for this limitation, we instead calculated the amount of LEPC carrying capacity that could be provided by targeting

CRP acres, in varying amounts, specifically for LEPC conservation (see Step 4). These future carrying capacities were considered offsets of potential decline caused by climate change.

Step 4: Assess ability of CRP to offset potential declines
The final step was to assess the ability of CRP to offset the potential declines in LEPC carrying capacity. To do this we examined a range of future CRP enrollment scenarios assuming that some portion of future CRP enrollments would be 'targeted' for LEPC conservation – meaning the CRP fields would occur in Large Block configuration (near large patches of native habitat) and plantings would be appropriate for the LEPC (a mix of native grasses, forbs, and possibly shrubs). This analysis assumes that the CRP would still exist in 2060.

To gauge how much CRP could feasibly be targeted for the LEPC, we used the current CRP enrollment rates (the portion of cropland currently enrolled in the CRP), assuming that current CRP enrollment rates would reflect future enrollment rates. For each BCR-state area, we calculated the CRP enrollment rate within the LEPC range portion of that BCR-state area. Hereafter, we refer to these CRP acres as 'local CRP'.

We determined that targeting 75% of local CRP acres would safely represent the uppermost limit of how much CRP can feasibly be placed in Large Block configuration considering both the limits of placing CRP near native habitat (there are only so many opportunities in the landscape) and the problem with concentrating CRP to the exclusion of active cropland. The true limit is likely closer to 50%, based on results CRP enrollment data from Kansas (see Results).

We then used the HABS database (which contains BCR-state specific LEPC density data for CRP planted to native species) to calculate how much LEPC carrying capacity could be provided by targeting 10%, 20%, 30%, 40%, 50%, and 75% of local CRP acres. These future carrying capacities were considered offsets of potential declines caused by climate change. We did not calculate the carrying capacity for targeting <10% of local CRP acres because all BCR-state areas had at least 1% of their CRP incidentally targeted for LEPC, with most having >5% incidentally targeted; thus, the analysis would show little to no change in carrying capacity. Additionally, if a BCR-state area (e.g., BCR19-KS) currently exceeds the percent of targeted CRP (10%, 20%....75%), it was not reduced but maintained. For example, Kansas currently has >50% of its local CRP, in both BCRs, incidentally targeted for LEPC. This is a result of planting native species in CRP, unlike the other states, and incidentally enrolling acres near large tracts of native habitat. When we examined the effects of targeting 10% of local CRP acres for LEPC, we did not reduce Kansas's targeted CRP but maintained it at current levels.

RESULTS

Projected temperature and precipitation changes

Annual average temperatures are predicted to increase in the PLJV region and within the current LEPC range (Table 3). Temperatures in the PLJV region will increase approximately 2.6 – 3.1 degrees Celsius above the historical (year 2000) average temperatures (Table 3). The maximum temperature increase will occur in the largest portion of the LEPC range in Colorado, Kansas, Oklahoma and the northeast Panhandle of Texas (Figure 5). This area of the LEPC range also includes the largest number of chickens.

Precipitation is predicted to decrease in the PLJV region and within the current LEPC range (Table 3). Precipitation in the PLJV region will decrease by approximately 32 mm/yr (Table 3) compared to historical (year 2000) precipitation amounts. The maximum precipitation decrease also will occur in the largest portion of the LEPC range in Colorado, Kansas, Oklahoma, and the northeast Panhandle of Texas (Figure 6).

Table 3. Projected 2060 temperature and precipitation values and departure from historical (year 2000) temperature and precipitation in the PLJV region and in the current Lesser Prairie-Chicken range. The temperature values are the monthly averages averaged over a year (i.e. annual monthly average low/average/high temperature).

		PLJV Region		LEPC Range	
		2060 Average	Departure from historical	2060 Average	Departure from historical
Temperature (°C)	Low	7.6	2.6	7.7	2.8
	Average	15.8	2.9	16.0	3.2
	High	23.8	3.1	24.2	3.5
Precipitation (mm/yr)		492.4	-32.2	468.3	-49.8

Projected Change in Average Annual Temperature from 2000 to 2060 in the PLJV

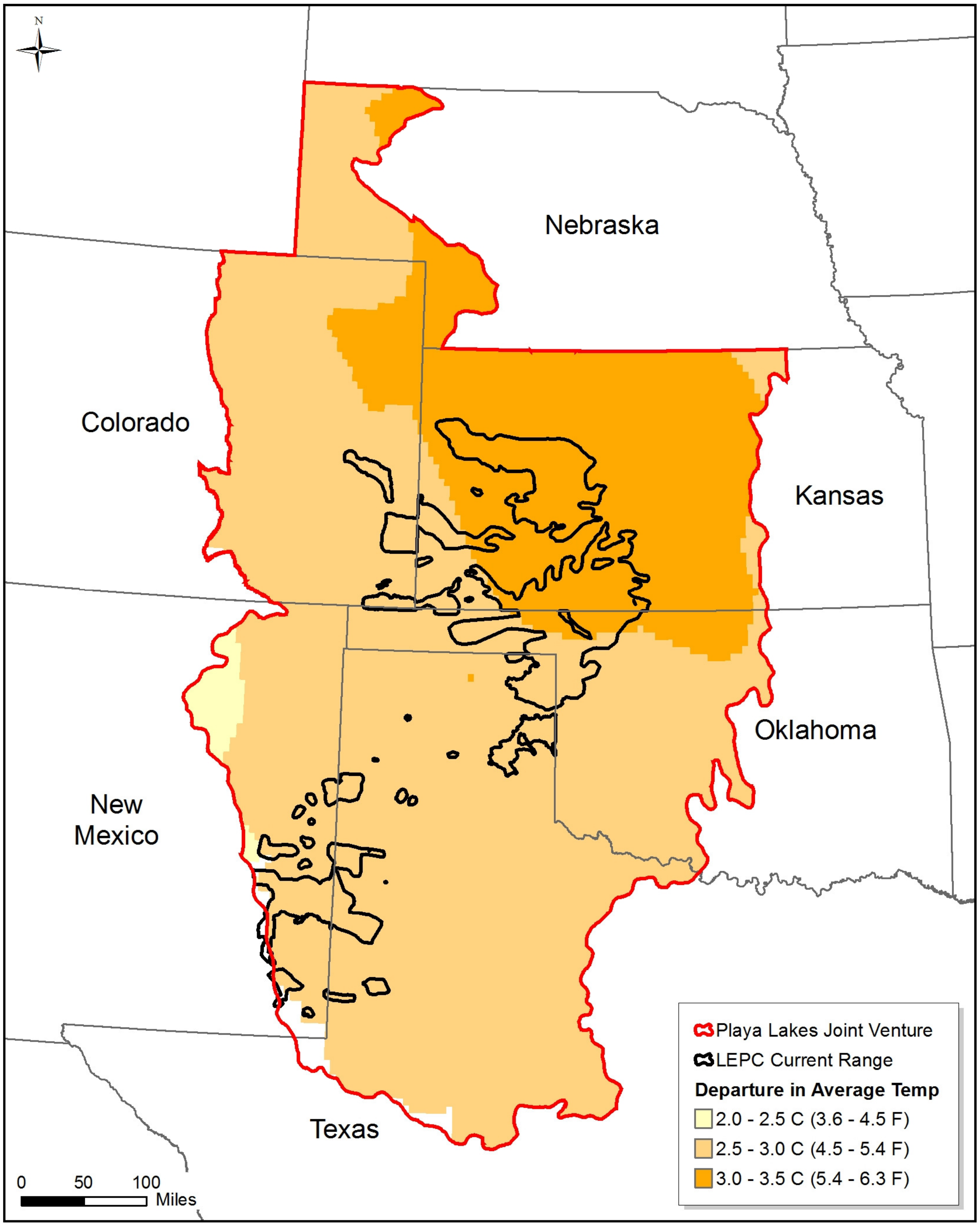

Figure 5. Projected change in average annual temperature (degrees Celsius and Fahrenheit) from 2000 to 2060 in the Playa Lakes Joint Venture region and current Lesser Prairie-Chicken range.

Projected Change in Average Annual Precipitation from 2000 to 2060 in the PLJV

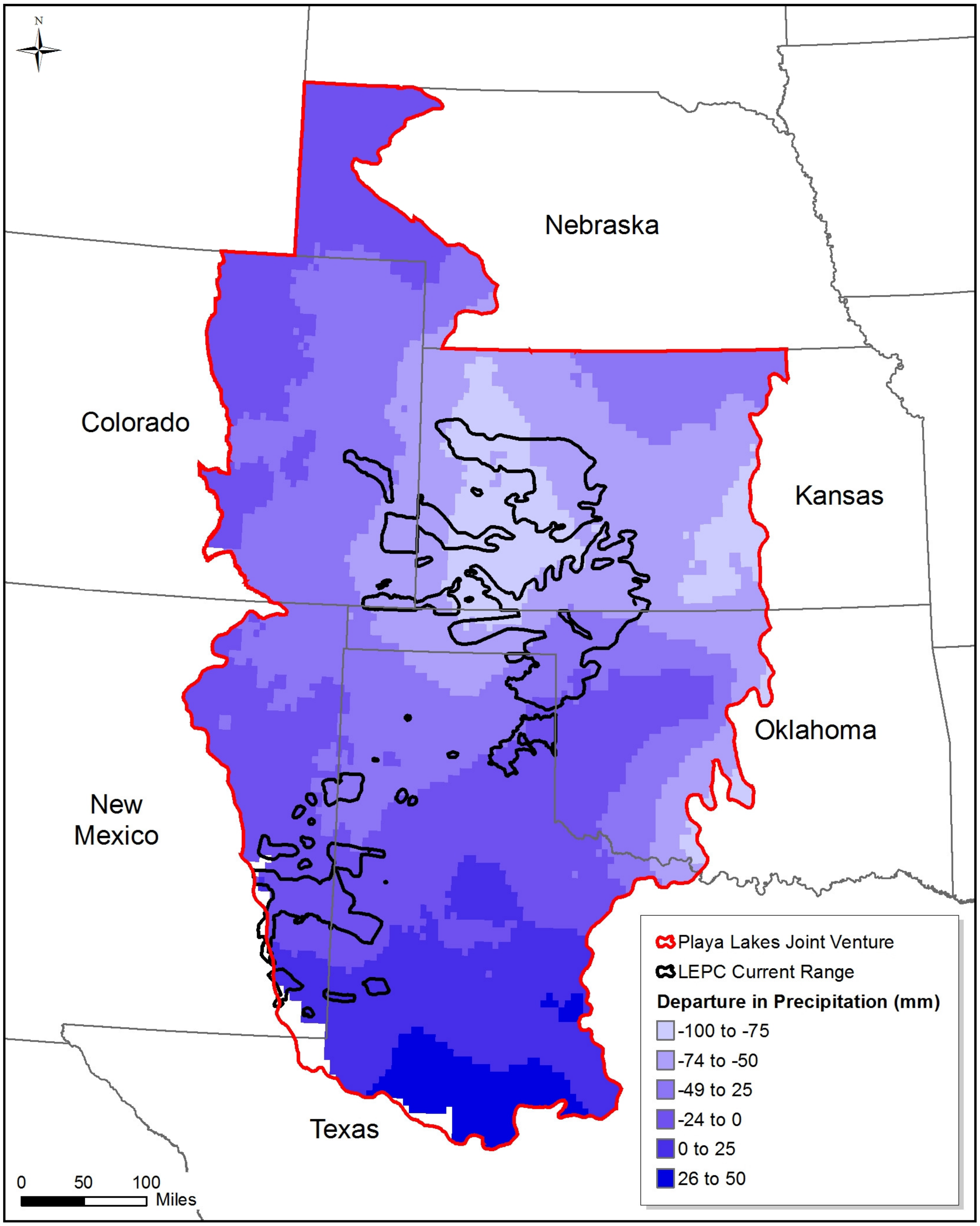

Figure 6. Projected change in annual precipitation (mm) from 2000 to 2060 in the Playa Lakes Joint Venture region and current Lesser Prairie-Chicken range.

Projected vegetation change under future climate conditions
The MC1 model was used to simulate both vegetation type (herbaceous versus woody plants) and above-ground vegetation carbon stocks; however, comparison of the vegetation type output from the model to known vegetation types in the study area revealed that the MC1model grossly under-represented shrubland habitats in grassland ecosystems. Because of this limitation the bioclimatic vegetation model was not capable of projecting changes between grassland and shrubland types except in a very small area in the western portion of the PLJV region and outside the current LEPC range. Future calibration of MC1, given sufficient training data, may provide more reliable output variables that can be translated into grass-shrub habitat suitability criteria relevant to birds and potentially other terrestrial wildlife. This is an obvious limitation regarding our analysis of LEPC habitat given the close relationship between the species and shrubland communities such as sandsage and shinnery-oak. *Therefore, in order to assess predicted changes in habitat available to the LEPC, we restrict our conclusions to the interpretation of the above-ground vegetation carbon outputs as a proxy to herbaceous grassland biomass (forgoing any predictions on habitat type).*

The historic (year 2000) above-ground carbon estimates from the MC1 model were substantially lower than the 1990 field measures of carbon content in shortgrass and mixed-grass communities as published in Derner et.al 2006 (Table 4). This discrepancy in carbon values is due to the fire schedule used in the fire model of MC1 (see Assumptions and Limitations for more details). Fire frequency was not suppressed in the model, allowing for a fire frequency which is much greater than actual fire frequency observed in the PLJV (a region where fire is heavily suppressed), thus, causing decreased above-ground carbon. That said, the relationship between the MC1 carbon outputs and field carbon measures is constant – projected carbon levels are about half those of measured field carbon levels (Table 4). Therefore, we maintain that the trajectory and gradient of the MC1 carbon output are reliable indicators of changes in plant biomass, although the magnitude is not reflective of the amount of biomass.

The MC1 vegetation model projected that above-ground vegetation carbon will decline throughout much of the PLJV region and the LEPC range over the next 60 years (Table 5, Figure 7). The mean carbon level for the PLV region decreased 13% (-2.7g/m^2). Within the current range of the LEPC, carbon loss was greater, with a reduction of 18% (-4.8 g C/m^2). Overall, 84% of the PLJV region and 99% of the LEPC range are projected to have reduced above-ground carbon by 2060 (Table 5).

The maps in Figure 8 illustrate the spatial distribution of historic and future estimated above-ground carbon levels, showing predicted geographic shifts over the next 60 years. The MC1 model predicted an eastward shift in vegetation carbon levels such that carbon levels historically occurring in the shortgrass prairie BCR shift east into the mixed-grass prairie BCR in 60 years. Likewise, new lower carbon levels are projected for much of eastern Colorado, including the western reach of the current LEPC range.

Table 4. Estimated mean above-ground vegetation carbon levels (g C/m^2) from the MC1 dynamic vegetation model (by time period and grassland community) compared to above-ground vegetation carbon levels measured from field clippings from the 1990's. Field data are average carbon values for live and standing dead above-ground biomass collected in two grassland communities and grazing types by Derner et al. 2006. The shortgrass prairie study sites were located in northeast Colorado and the mixed-grass sites were located in central Kansas near Hays. Carbon values from the MC1 model for the 2000 time period are approximately half of the carbon values from field data.

Grassland Community	**Year**	**Carbon Estimates from MC1 (g C/m^2)**			**Mean Carbon Content from Grazed and Ungrazed Sites (g C/m^2)[1]**
		Mean	**SD**	**Mean +/- 1 SD** (rounded)	
Shortgrass (BCR18)	2000	21.5	3.3	18 - 25	35 – 49
	2060	17.8	3.4	14 - 21	n/a
Mixed-grass (BCR19)	2000	29.2	5.6	24 -35	50 - 89
	2060	26.5	4.6	22 - 31	n/a

[1] Biomass was measured for herbaceous species collected in July 1994. Carbon content of the biomass was determined by multiplying biomass by C concentrations levels that were determined through evaluation of plant samples collect in July 1998 in shortgrass and in September 1999 in mixed-grass sites.

Table 5. Projected change in above-ground carbon (as g C/m^2 and percent loss/gain) from 2000 to 2060 in the PLJV region and in the current Lesser Prairie-Chicken range. Statistics are based on pixel counts and values; pixel size is approximately 76km^2 (18,780 acres).

Area	**n (pixels)**	**Change in Above-ground Carbon (g C/m^2)**				**Portion of Area Losing Carbon**
		Min.	**Mean**	**Max.**	**sd**	
PLJV region (~160 million acres)	8450	+3.1 (+14%)	-2.7 (-13%)	-14.7 (-38%)	2.7 (11%)	84%
LEPC Range (~16 million acres)	848	+1.0 (+7%)	-4.8 (-18%)	-9.7 (-34%)	2.3 (9%)	99%

Projected Change in Above-Ground Vegetation Carbon from 2000 to 2060 in the PLJV

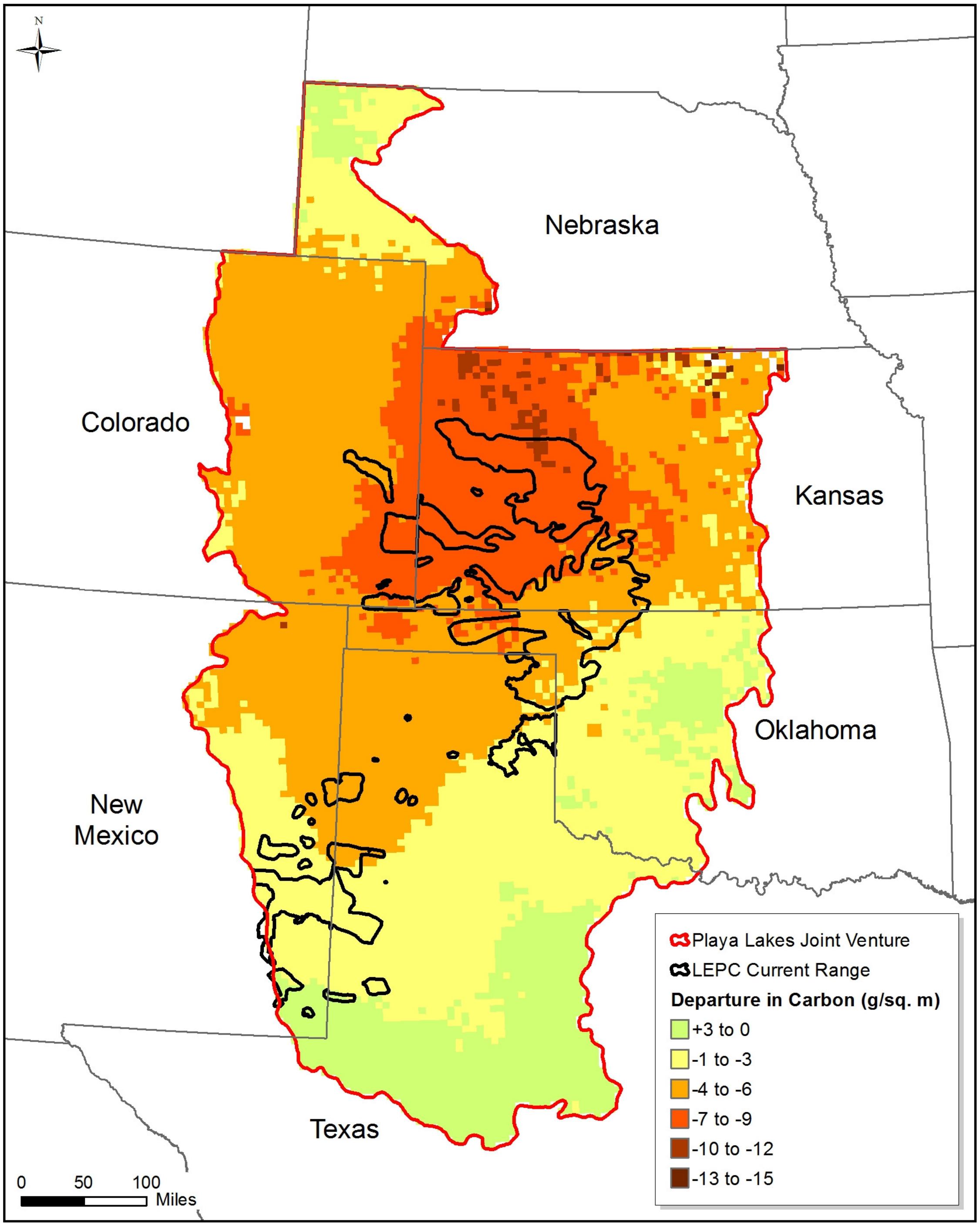

Figure 7. Projected change in vegetative carbon (g C/m^2) from 2000 to 2060 in the Playa Lakes Joint Venture region and current Lesser Prairie-Chicken range.

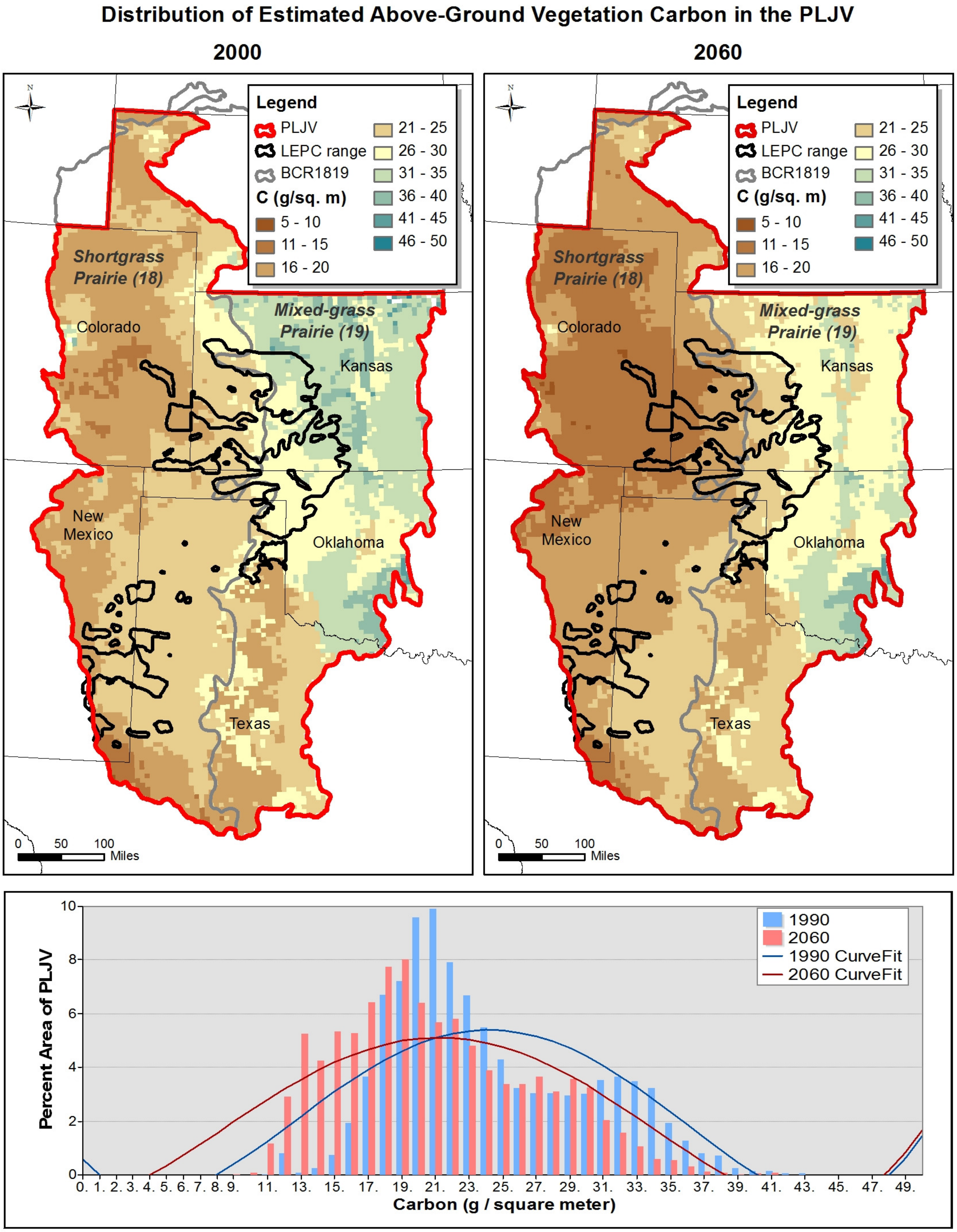

Figure 8. Maps show the spatial distribution of estimated above-ground vegetation carbon in 2000 versus 2060, based on the MC1 dynamic vegetation model. The chart shows the percent area of the PLJV by estimated carbon levels for both years (fit is a 5th order polynomial trend line).

CRP in the LEPC range

The 10-mile buffer of the current LEPC range spans approximately 37.9 million acres across five states with the largest portions of the study area occurring in Kansas and Oklahoma (Figure 2; Table 6). Over 36% (13.8 million acres) of this study area is comprised of cropland and an additional 10% (3.9 million acres) is comprised of CRP enrolled in a grass-type Conservation Practice (i.e., CP1, CP2, CP10, etc – practices potentially suitable for the LEPC).

CRP enrollment rates (i.e., the percent of cropland enrolled in CRP) varies by state and BCR within the study area, ranging from 16% in BCR19-KS to 33% in BCR18-TX (Table 6). Across the study area, about 22% (3.9 million acres) of cropland is enrolled in the CRP.

The amount of CRP in Large Block formation also varies by state and BCR, ranging from 1% in BCR19-TX to 54% in BCR19-KS (see Methods for explanation of Large Blocks). All states within the LEPC range have <15% of their CRP in Large Block formation with the exception of Kansas which has >50% in both of its BCRs. This disparity occurs because nearly all CRP grass in Kansas is planted to native species considered suitable habitat for the LEPC. Therefore, the parameters of the Large Block spatial model are set to include CRP as a suitable habitat *only* in Kansas, resulting in many more CRP acres in Large Block formation in Kansas. Across the entire study area, about 23% (925,527 acres) of CRP is currently in Large Block formation (Table 6).

Table 6. Amount and distribution of cropland and CRP in the study area (a 10-mile buffer of the Lesser Prairie-Chicken current range) by BCR and state. CRP includes only enrollments in grass-type Conservation Practices such as CP1, CP2, CP10, etc. See Methods for an explanation of Large Blocks.

Portion of LEPC Range	Cropland (acres)	Percent of Cropland in CRP	CRP (acres)	CRP in Large Blocks (acres)	Percent of CRP in Large Blocks
BCR18					
CO	1,129,177	30%	477,071	45,280	9%
KS	4,064,830	16%	756,511	392,861	52%
OK	479,266	30%	204,591	12,925	6%
NM	860,085	31%	379,356	28,033	7%
TX	2,317,524	33%	1,125,366	20,999	2%
BCR19					
KS	4,158,371	15%	726,516	393,029	54%
OK	574,878	26%	205,688	31,406	15%
TX	262,615	28%	102,329	995	1%
TOTAL	13,846,746	22%	3,977,428	925,527	23%

Current LEPC carrying capacities

The estimated current LEPC carrying capacity of the study area is about 49,592 birds (Table 7). In each of the states within the study area, most (>96%) of the carrying capacity for the species is provided by native habitats in Large Block formation except for the BCR18 and 19 portions of Kansas where CRP provides a substantial portion of the carrying capacities, 47% and 20%, respectively (Table 7). This disparity occurs because CRP grass plantings in Kansas (where native grasses were planted) provide suitable habitat, unlike all other states in the LEPC range.

For all state areas within the study area, the population goal is to triple the current carrying capacity except in BCR19-KS where the goal is to double the current carrying capacity. Therefore, all state portions of the study area can currently support about 33% of the population goal for the LEPC except for BCR19-KS which can currently support about 50% of the population goal (Table 7). Combined, the study area can currently support about 40% of the population goal with 8% of that goal attributed to CRP (the rest is provided by native habitats).

Table 7. Current Lesser Prairie-Chicken carrying capacities and population goals by BCR and state, including the portion of carrying capacity and population goal attributed to CRP.

Portion of LEPC Range	Current Carrying Capacity (# birds)	Carrying Capacity from CRP (# birds)	Percent of Carrying Capacity from CRP	Carrying Capacity Goal (# birds)	Percent of Goal from all Habitats	Percent of Goal from CRP
BCR18						
CO	4,834	42	1%	14,503	33%	<1%
KS	10,442	4,911	47%	31,329	33%	16%
OK	611	13	2%	1,833	33%	<1%
NM	1,624	29	2%	4,872	33%	<1%
TX	429	19	4%	1,287	33%	1%
BCR19						
KS	24,091	4,912	20%	48,182	50%	10%
OK	7,173	74	1%	21,521	33%	<1%
TX	388	4	1%	1,164	33%	<1%
TOTAL	49,592	10,004	20%	124,693	40%	8%

Potential declines in LEPC carrying capacities

We were unable to quantify projected changes in LEPC carrying capacity caused by climate change (see Methods for explanation). However, our results indicate a decrease in vegetation productivity across the LEPC range; therefore we predict a future decline in the landscape's capacity to support the LEPC. Below we provide a range of possible declines in LEPC carrying capacity based on the current estimated capacity to give the reader an understanding of potential magnitude of decline.

With a current carrying capacity of 49,592 birds (Table 8), for every 1% decline in capacity (applied equally across the study area), the landscape loses the ability to support 496 LEPCs. A 5% decline in carrying capacity means the landscape can support 2,480 fewer LEPCs. With a 10% decline in carrying capacity the landscape can support 4,959 fewer LEPCs. And with a 15% decline in carrying capacity the landscape can support 7,439 fewer LEPCs.

Table 8. A range of potential declines in Lesser Prairie-Chicken (LEPC) carrying capacity that could result from impacts of climate change, translated into the number of birds that would no longer be supported by the landscape. For example, a 5% decline in carrying capacity means the landscape can support 2,480 fewer LEPCs.

Portion of LEPC Range	Current Carrying Capacity (# birds)	Potential Declines in Current LEPC Carrying Capacity (# birds)				
		1%	2%	5%	10%	15%
BCR18						
CO	4,834	-48	-97	-242	-483	-725
KS	10,442	-104	-209	-522	-1,044	-1,566
OK	611	-6	-12	-31	-61	-92
NM	1,624	-16	-32	-81	-162	-244
TX	429	-4	-9	-21	-43	-64
BCR19						
KS	24,091	-241	-482	-1,205	-2,409	-3,614
OK	7,173	-72	-143	-359	-717	-1,076
TX	388	-4	-8	-19	-39	-58
TOTAL	49,592	-496	-992	-2,480	-4,959	-7,439

Ability of CRP of offset declines in LEPC carrying capacities

If future CRP acres were targeted for the LEPC (in Large Block formation and planted to native grassland species), targeting as little as 10% of the current local CRP acres could offset a 1-2% decline in LEPC carrying capacity (about 811 birds; Table 7). This scenario means that all BCR-state portions of the LEPC range, except for Kansas, would have 10% of their current CRP acres targeted for the LEPC. Since Kansas currently has over 50% of its CRP already targeted (in Large Block formation and planted to native species), all targeted CRP acres in Kansas would be maintained, not reduced to 10%. In BCR19-OK, where 15% of the CRP acres are currently in Large Block formation, only a small fraction is planted to native species; therefore, we reduced the amount of targeted CRP to 10% and assumed all these acres would be planted to native species. Taking into account the 785,890 CRP acres currently targeted in Kansas, 249,440 acres of additional targeted acres would be needed across the rest of the LEPC range to achieve this offset – a total of 1,035,300 total targeted CRP acres (26% of all current CRP acres; Table 9). There are currently 3,977,428 acres of CRP in the study area and 13,846,746 acres of cropland (Table 6).

For every 10% increase in targeted CRP acres, a 1-2% decline in LEPC carrying capacity (about 992 birds) could be offset. For instance, targeting 20% of local CRP acres could offset a 3-4% decline in LEPC carrying capacity (about 1,803 birds). This scenario later would require about 498,880 acres of CRP to be targeted throughout all states in the LEPC range except Kansas (where 785,890 acres are currently targeted) – a total of 1,284,770 acres of targeted CRP.

Our estimates of potential offsets in decline of LEPC carrying capacity caused by targeted CRP acres only include the direct impact of CRP as ‘new’ habitat; it does not incorporate any increases in LEPC carrying capacity that occur as new CRP acres turn previously fragmented native habitat patches into Large Blocks. In such cases, the landscape’s LEPC carrying capacity would increase further because the once fragmented native habitat patches would now become suitable LEPC habitat. Therefore, potential offsets in decline could be greater in some areas depending on the opportunity to create new Large Blocks via targeting CRP acres.

Table 9. Potential declines in Lesser Prairie-Chicken (LEPC) carrying capacity due to climate change, potential offset in decline provided by varying levels of targeted CRP acres, and number of targeted CRP acres required for offsets. Targeted CRP acres are assumed to occur in Large Block configuration (near large tracts of native habitat) and planted to species appropriate to provide suitable LEPC habitat (native grasses, forbs, shrubs).

Potential Decline in LEPC Carrying Capacity (%)	Min. Targeted CRP Acres Required to Offset Decline (% of Local CRP Acres)[a,b]	Potential Offset in Carrying Capacity (# birds)	Currently Targeted CRP (acres)[c]	Additional Targeted CRP Required for Offset (acres)	Total Targeted CRP Required for Offset (acres)
1-2%	**10%**	811	785,890	249,440	1,035,330
3-4%	**20%**	1,803	785,890	498,880	1,284,770
5-6%	**30%**	2,795	785,890	748,320	1,534,211
7-8%	**40%**	3,787	785,890	997,760	1,783,651
9-10%	**50%**	4,779	785,890	1,247,201	2,033,091
20%	**75%**	11,338	785,890	2,197,181	2,983,071

[a] 'Local' refers to the amount of CRP that currently exists in the LEPC range

[b] Future CRP acres assumed to be targeted (in Large Block formation and planted with native plant species)

[c] Current CRP acres in Large Block formation in Kansas are assumed to be currently targeted. Other states contain no targeted CRP acres because of dominance of non-native plantings.

DISCUSSION

Projected vegetation changes in the PLJV region

This analysis projected a trend of decreasing moisture, increasing temperatures, and decreasing above-ground vegetation carbon throughout the PLJV and LEPC current range over the next 60 years (Figures 5-8). These projected reductions in above-ground vegetation carbon indicate reductions in plant biomass (Derner et al. 2006), and thus, changes in the grassland habitat available to the LEPC. The predicted geographic shifts in vegetation carbon (Figure 8) suggest that in 60 years grasslands occurring in the mixed-grass prairie BCR will have productivity/biomass levels reflective of those currently occurring in the shortgrass prairie BCR. We suggest that in 60 years grassland habitats in the LEPC current range will be less productive, possibly of shorter stature and less dense cover – ultimately, providing less suitable habitat for this species of high conservation concern.

Although we predicted changes in plant biomass, we were not able to predict changes in plant composition, expressed either as species or functional groups (C3 versus C4 plants). There is uncertainty about how future rises in CO_2 may interact with the historical relationships among rangeland plants, temperature, and precipitation making it difficult to predict how plant species, groups, or communities may shift in abundance or range (Matthews 2008, Morgan et al. 2008). We could only infer changes in biomass as changes in vegetation structure (i.e., height, density, litter). We were also not able to predict changes between grass and shrub species because of a limitation in the MC1 model which was unable to approximate current known distribution of shrubland habitat such as sandsage and shinnery-oak. However, we believe that calibration of the MC1 model could remedy this issue so we intend to run a re-calibrated model in the future.

We used the dynamic vegetation model to project vegetation changes over the next 60 years. This timeframe was selected as being appropriate for biological planning in the PLJV and a point far enough in the future to detect vegetation changes. While the model results did not provide evidence of wholesale shifts in vegetation communities, changes in vegetation biomass were projected. This information will be used by PLJV and its partners to make decisions about habitat conservation over the near term.

Projected impacts of climate change on the LEPC

Our results heed a cautionary and pressing message that the LEPC may be facing significant challenges to long-term survival due to climate-related vegetation changes over the next 60 years. Although we were not able to project a quantified impact of climate change on the LEPC (i.e., calculate change in carrying capacity), we infer from the results of our climate change and dynamic vegetation modeling that the LEPC will likely be negatively impacted by climate change. Our climate change modeling predicted increases in temperature and decreases in precipitation across most of the PLJV region, with some of the greatest changes occurring within the current LEPC range (Figures 5&6). Likewise, the dynamic vegetation modeling predicted declines in grassland biomass across the study area, with some of the greatest changes occurring within the LEPC range (Figure 7-9).

If grassland biomass declines in the LEPC range, then LEPC carrying capacity should also decrease. The LEPC requires grassland habitat with relatively high vertical structure and plant density, both herbaceous and woody, for nesting and wintering habitat. Field research has shown that nest site selection and nest success are associated with greater vertical structure and vegetation density as compared to surrounding rangeland (Davis et al. 2008). When grass height and density is limited, LEPCs rely more on shrub vegetation for cover, especially in winter (Davis et al. 2008).

Can CRP offset impacts of climate change on the LEPC?

Field research has shown that CRP can provide suitable habitat for the LEPC if planted to appropriate species, managed for suitable vegetation structure, and located near occupied native habitat (see Introduction). Two previous CEAP assessments by the PLJV (McLachlan and Rustay 2007, McLachlan and Carter 2009) quantified the current benefit of CRP to LEPC, showing that the degree of benefit varied by state and BCR, with CRP in Kansas providing the most benefit (CRP in Kansas is planted to native species unlike other states in the LEPC range; McLachlan and Rustay 2007, McLachlan and Carter 2009). The purpose of this study was to determine how much benefit CRP could provide the LEPC in view of predicted future climate-induced habitat changes. To do this, we assessed how effective targeting CRP could be at offsetting potential impacts of climate change on LEPC. Our results indicated that targeting as little as 30% of current CRP acres in LEPC range could offset a 5-6% decline in LEPC carrying capacity (about 2,800 birds). Targeting half of current CRP acres within LEPC range could offset a 10% climate change-induced decline in LEPC carrying capacity (nearly 5,000 birds; Table 9).

These CRP-targeting scenarios would not require additional acres to be allocated into the CRP nor would they require increases in county caps because they are based on targeting portions of what currently exists on the landscape (most counties within the LEPC current range have reached or are near the set cap of 25% of a county's cropland). This approach helped keep the potential CRP-targeting scenarios realistic, in terms of acres available for targeting and expectations for future CRP enrollment rates. Although we analyzed the potential offset of targeting 75% of current CRP acres in the LEPC range, we feel that targeting 50% is a more feasible goal for several reasons. First, there are a finite number of places to spatially target CRP such that it creates or expands a Large Block of habitat that includes native vegetation. Second, landowners with cropland near Large Blocks cannot be expected to enroll all their cropland in the program. Using Kansas' CRP enrollment rate and spatial distribution as a guide, we estimated that about 50% of cropland surrounding Large Blocks of native habitat can be expected to be enrolled in the CRP. This presumed threshold may be increased if incentives for enrollment were offered (such as increased rental rates or incentive payments). Lastly, we recognize that the CRP has multiple objectives, of which wildlife habitat conservation is only one. There must be sufficient CRP acres aimed at achieving soil and water quality objectives as well, which likely require field enrollment in areas not considered suitable for LEPC conservation.

Implications for other priority birds

Although this assessment is focused on conservation of the LEPC, the results have strong implications for other species of conservation concern that occur within LEPC range as well as the PLJV region. The LEPC is considered an umbrella species so projected effects on the LEPC suggest effects on other species sharing LEPC range and its habitats. For example, Grasshopper Sparrow (*Ammodramus savannarum*) is a conservation priority species that occurs within the LEPC range, breeds in mixed-grass prairie, and requires large tracts of grassland. The area requirement is much smaller for Grasshopper Sparrow (20-30 ac in Nebraska; Helzer 1996, Helzer and Jelinski 1999) relative to the LEPC and also to the average size of a CRP field in BCR18 and 19 (about 125 ac for grass and wildlife habitat plantings). Grasshopper Sparrows prefer grass of intermediate height, moderately deep litter, and sparse woody vegetation (Dechant et al. 2002). Decreases in grassland biomass (i.e., shorter/sparser vegetation) could result in lower quality grassland habitat for the Grasshopper Sparrow. However, like the LEPC, Grasshopper Sparrows use CRP as breeding habitat so targeting CRP for the LEPC could also benefit Grasshopper Sparrows and other species that share similar habitat requirements.

Currently, there are over 30 priority bird species that breed in BCR18 and 19 and they use a wide variety of grassland and shrubland habitats (see Appendix B). This variety in habitat requirements suggests that climate-induced vegetation changes over the next 60 years could have a range of impacts on priority birds species including variation in direction (i.e., positive or negative impacts) and magnitude (i.e., degree of impact). In general, we predict that negative impacts can be expected for those species that require taller and denser grassland vegetation structure because of the predicted decrease in grassland biomass. However, these impacts may not necessarily result in the form of decreased population size, but may result in geographic shifts in populations. Our dynamic vegetation modeling indicates an eastward expansion of lower stature grasslands – relative to current grassland condition. Bird species' ranges may shift geographically to coincide with these projected shifts in vegetation, meaning receding ranges for some species (possibly those that require higher grassland biomass) and expanding ranges for other species (possibly those that require lower grassland biomass).

RECOMMENDATIONS

Based on our findings in this CEAP assessment and two previous CEAP assessments (McLachlan and Rustay 2007, McLachlan and Carter 2009), we recommend that the CRP (as administered within the LEPC range) be adapted to include a LEPC conservation component (possibly a Conservation Priority Area (CPA)) under which a portion of each county's cap is targeted, both spatially and ecologically, to conserve the LEPC. Specifically, we suggest that 30% to 50% of each county's cap be allocated for LEPC conservation.

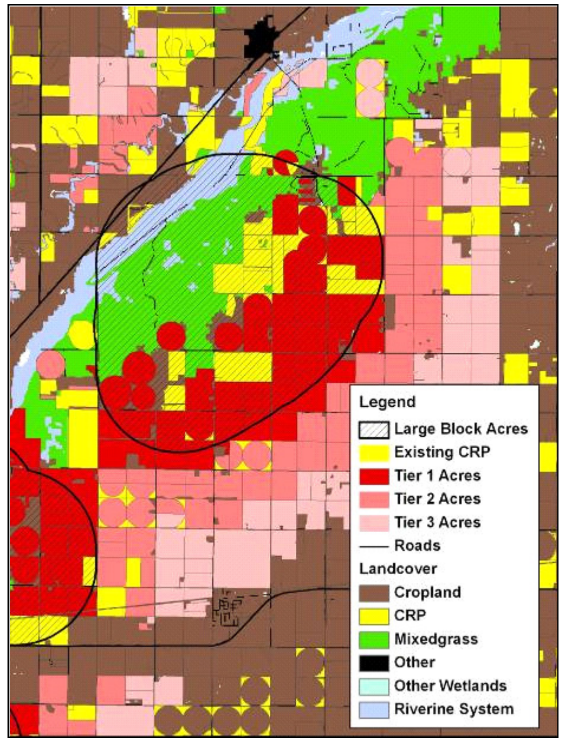

Figure 9. Map produced by a Decision Support Tool showing the rank (Tier 1 = highest priority (red), Tier 2 = medium priority (dark pink), Tier 3 = low priority (light pink)) of crop fields near existing large blocks of suitable Lesser Prairie-Chicken habitat.

Reaching this goal would likely occur over several years, as existing CRP contracts expire and new applications are submitted; however, the more quickly CRP acres are targeted, the more effective we can be in preventing or offsetting any losses in LEPC (caused by climate change or other ongoing threats such as habitat fragmentation caused by human development). We also recommend that financial incentives (such as a signing incentive payment (SIP) or Practice Incentive Payment (PIP)) be offered to increase landowner interest in enrollment. Additionally, we suggest that existing CRP acres be transitioned into grazing lands through the Environmental Quality Incentive Program (EQIP) or other programs to create more permanent habitat for the LEPC.

If CRP acres were targeted for LEPC conservation, it is imperative that they are spatially targeted for the species in order to expand or create requisite large blocks of habitat. We recommend development of a spatially explicit Decision Support Tool (DST) that would identify target areas for enrollment. The DST should evaluate CRP fields, crop fields, and the habitat requirements of the LEPC (including its spatial habitat requirements) against the landscape using a Geographic Information System (GIS).

The illustration in Figure 9 shows how a DST can rank crop fields into tiers of potential benefit to the LEPC considering adjacency to large blocks of native habitat, existing CRP fields, and major roads (no tolerance). When CRP and crop fields are ranked according to potential benefit to birds, it allows strategic enrollment and re-enrollment of fields, creating more and higher quality habitat. To maximize the number of high ranking fields enrolled in CRP, we suggest targeted solicitation of landowners for enrollment and increased financial incentives to landowners of high ranking fields. Landowners of high ranking fields may receive a SIP, PIP, or higher soil rental rates. The DST and resulting target area should be re-evaluated every few years as the landscape changes (i.e., target areas may need to be re-drawn).

ASSUMPTIONS AND LIMITATIONS

Climate and vegetation models

Results from the climate and dynamic vegetation models (MC1 model) are only as good as the data used. Although climate data has gone through extensive testing and vetting by the international scientific community, it represents a projection into the future based on current knowledge which has associated error because no one can definitively determine what the future will be.

The field-collected vegetation carbon data used to validate the MC1 carbon output (Derner et al. 2006) was collected at two sites in the PLJV region. The carbon values in these prairies may not be representative of prairies throughout the PLJV region. In addition, the carbon data used from Derner et al. (2006) were presented without error bars; therefore, our data ranges are conservative. For example, we used the mean value for shortgrass grazed as the low value and un-grazed for the high value. We understand that there is a distribution of values around each mean and suggest future research use this range of values to better capture the range of values to represent each community.

The MC1 model run was performed using a full fire schedule without suppression which caused the above-ground vegetation carbon levels to be lower than expected (approximately half) compared to field-collected carbon measures in the study area where fire is heavily suppressed. Fire suppression can greatly impact the above ground carbon levels in the MC1 model as shown below (Figure 10; unpublished Rogers 2011). That said, the relationship between the MC1 carbon outputs and field carbon measures is constant – projected carbon levels are about half those of measured field carbon levels (Table 4). Therefore, we maintain that the trajectory and gradient of the MC1 carbon output are reliable indicators of changes in plant biomass, although the magnitude is not reflective of the amount of biomass. In future runs of the MC1 model, we would alter the fire schedule to better reflect observed fire frequency in the PLJV region.

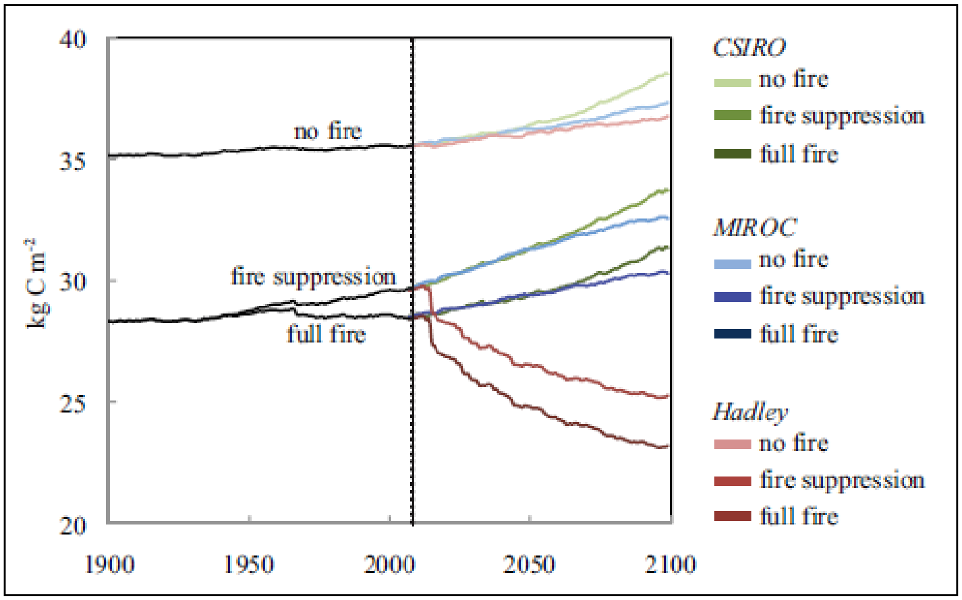

Figure 10. An example of how fire frequency can impact results of the MC1 carbon output (presented by Brendan Rogers at the 2011 MC1 User's Conference). The graphic shows the differences in ecosystem carbon levels (kg C/m^2) output by the MC1 model using three different fire scenarios (no fire, suppressed fire, and full fire) under three climate change models. This analysis used the Hadley model.

Population goals and carrying capacity estimates

Population goals and carrying capacities presented in this report are estimates and do not reflect a true census of any bird species, and thus, should be viewed with caution. These estimates reflect the potential capacity of the landscape to support bird populations based on the best available spatial landcover and current understanding of species-to-habitat densities. Furthermore, the species-to-habitat densities used in this analysis are based on bird count data rather than nesting success/density; therefore, carrying capacity represents species occurrence not recruitment. Data on species recruitment is generally very sparse relative to occurrence data and, thus, were not incorporated into our analysis. While the carrying capacities presented in this project must be viewed with caution, the *percent* of the current carrying capacity which CRP holds for each species listed can be viewed with greater confidence because density information has been tied to each specific habitat type found within the region.

Density data

At the onset of this assessment, we intended to predict a quantified estimate of impact of climate change on the LEPC. Unfortunately, an unforeseen information gap prevented this analysis. We were not able to relate changes in LEPC densities with our projected changes in vegetation biomass. Published LEPC densities are related to broad vegetation communities, such as mixed-grass prairie or sandsage shrubland. Conversely, our projected climate-induced vegetation changes largely indicated changes *within* vegetation communities, such as mixed-grass prairie transitioning from high to low productivity (i.e., changes in vegetation structure from decreased biomass) – not transitioning from mixed-grass prairie to shortgrass prairie. Until we can gather more precise data relating

LEPC density to vegetation *condition* data (as opposed to community level data), including shrubland conditions, we are unable to quantify predicted effects of climate change on the LEPC.

Density data were gathered through an exhaustive literature search; however, because this analysis considers several habitats simultaneously (and so required several habitat-specific density estimates for a single species) it was sometimes necessary to apply density estimates from multiple sources to a single species. This lack of consistency among density estimates, resulting from various methods authors used in calculating density, can cause discrepancy when comparing habitats. A strong effort was made to identify outliers in the density data to reduce such problems. Furthermore, density data are almost exclusively available for the breeding season so this analysis is limited to those species occurring in BCR18 during the breeding season and its results (i.e., carrying capacity) applied only to the breeding season.

Trend data

Population goals were derived, in part, from species trend data from the U.S. Geological Survey (USGS) Breeding Bird Survey (BBS). The BBS is a long-term (30+ years) national bird survey from which trend data are calculated for individual species (Sauer et al. 2006). See <http://www.mbr-pwrc.usgs.gov/bbs/trend/tf06.html> for an explanation of the methods used to calculate trends and limitations of BBS data. Using BBS trends to determine population goals may result in goals that are greater than the ability of the current landscape to deliver. This could happen for several reasons: 1) habitat acreages have changed over the last thirty years because of habitat change or conversion, 2) current GIS landcover data do not accurately reflect the true landscape, or 3) factors outside of the breeding range may be affecting trend. For those species where a trend-based population goal required more than doubling the estimated current carrying capacity, the population goal was capped at doubling.

Landcover data

Carrying capacities presented in this report are based on habitat acres as depicted in a regional landcover developed by PLJV. The landcover is a combination of multiple state-based and regional coverages reclassified to single classification system to create a continuous landcover across state boundaries. All spatial landcover layers have inherent error so the habitat acres used in estimating carrying capacity can only be considered estimates themselves. Currently, there is no accuracy assessment for the landcover layer; however, accuracy levels of the source data used in creating it are available in Playa Lakes Joint Venture (2007).

Not all habitat Conditions are spatially explicit (i.e., not mapped) so acres for these Conditions were derived from statistics (e.g., the National Agricultural Statistics Service provided statistics of crop type acres) or assumed based on expert opinion (e.g., 25% of the mixed grass prairie has ‘many shrubs’ and ‘high grass’). The *Range Factors* applied to acres of habitat Associations and Conditions are based on estimated species’ range boundaries which have some inherent error as ranges can be dynamic (i.e., change over time, with weather). The *Suitability Factor* is based on literature or expert opinion. The

Large Block Factors are based on calculations from spatial models that were developed with criteria based from scientific literature and expert opinion (e.g., Lesser Prairie-Chicken Interstate Working Group).

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APPENDIX A – Hierarchical All Bird Systems (HABS)

Calculating the carrying capacity of an area for a particular bird species requires at minimum two pieces of information, the number of habitat acres in the geographic area of interest and the density at which the species occurs (or does not occur) in each of those habitats. The Hierarchical All Bird System (HABS) database is a tool developed by PLJV to store such parameters as well as calculate a landscape's capacity to achieve population objectives for priority species. The carrying capacity can be based on current conditions (i.e., current habitat availability) and/or potential future conditions (i.e., alternative scenarios of future habitat availability resulting from conservation and management work). In HABS, data are stored in a hierarchical manor such that each bird density is specific to not only a species but also to a geographic area, a habitat within that area, a condition of that habitat, and a season of the year (Table A1). For example, Lesser Prairie-Chickens occur at a density of 0.0125 birds/ac in the BCR18 region of Kansas in CRP with native plant species during the breeding season. The hierarchical levels on which HABS functions are described in Table A1.

Densities

The PLJV Landbird Team and Waterbird Team assigned priority species to habitat Associations and Conditions which correspond to the PLJV landcover layer. They conducted an exhaustive literature review to determine at which densities species occurred in their assigned habitat Associations and Conditions (Dobbs 2007). Data sources included peer-reviewed journals, theses and dissertations, government publications, unpublished reports, species accounts in the Birds of North America (BNA) series, state bird books and breeding bird atlases, published and unpublished (courtesy of Cornell Lab of Ornithology) Breeding Bird Census (BBC) data (1982-1996), and world wide web-publications. Where density data were not available for a species, those densities that were most similar in location and habitat Condition were assigned and adjusted using Breeding Bird Survey (BBS) relative abundance maps when necessary (BBS is a U.S. Geological Survey (USGS) long-term (>30 years) monitoring program under which volunteers conduct annual, fixed, road-based point count surveys nation-wide). Densities are stored in HABS and related to the habitat acres to calculate carrying capacities. All densities used in this project are documented in "A Review of Distribution, Habitat Use, and Population Density Data in the Hierarchical All Bird System (HABS) Database" (Dobbs 2007).

Factors

To better reflect a species' full range of spatial-temporal distribution and habitat use within the PLJV region, HABS also stores data on the availability and suitability of habitat acres (Table A2). HABS incorporates three factors regarding spatial-temporal variation among species: *Range Factor, Suitability Factor, and Large Block Factor*. These are described in Table A2.

Table 10. Each of the five hierarchical levels of the Hierarchical All Bird System, a description, and an example (listed from highest to lowest level of order).

Hierarchical Level	**Description**	**Example**
Area	where a Bird Conservation Region (BCR) intersects a state	BCR18 portion of Kansas
Association	a mappable habitat	CRP
Condition	management condition or a more specific, potentially un-mappable, habitat	Native grasses
Season/Period	breeding, wintering, migratory	Breeding
Species	priority bird species	Lesser Prairie-Chicken

Table 11. List of spatial and temporal factors considered in the Hierarchical All Bird System database, including a description, and an example.

Factor Type	**Description**	**Example**
Range Factor	Proportion of total acres of an Association or Condition (see Table 3) that are within a species range.	In BCR18-NM, there are 9.4 million acres of shortgrass prairie but only 5.6 million acres are within Mountain Plover range. *Range Factor* = 0.60.
Suitability Factor	Proportion of total acres of an Association or Condition that are suitable for species use during the specified Season/Period (see Table 3).	In BCR18-TX, there are 2.9 million acres of wheat; however, because of early Spring harvest, this habitat Condition is no longer suitable to Grasshopper Sparrows during their breeding season. *Suitability Factor* = 0.
Large Block Factor	Proportion of acres of an Association or Condition that are in large block configuration. Criteria for large blocks are determined in a spatial model developed for each Species and Area (see Table 3).	In BCR18-CO there are 1.9 million acres of sand sage but only about 273,000 acres are in large block configuration. *Large Block Factor* = 0.15.

Population Goals
The PLJV Landbird Team developed population goals for all priority species in BCR18 and 19. They followed the recommendation of Partners in Flight (PIF) which aims to return bird population numbers back to the same levels as 30 years ago. They determined population goals using two factors, estimated current carrying capacity and BBS population trend (specific to each BCR). They calculated population goals as follows. If the species' population trend is > 0 (a growing population), the population goal equaled the estimated current carrying capacity (a goal of maintaining the population). If the species' trend is < 0 (a declining population), we applied the following formula to determine a population goal:

$$\frac{\textit{Current Estimated Carrying Capacity}}{(\textit{1-Absolute Value [Trend]})^{29}}.$$

To ensure robust data were used, BBS trend data were limited to those trends where the P-value was < 0.1 and the number of routes within the BCR on which the bird was detected was ≥ 14. If these criteria were not met, then a survey-wide (national) trend was used instead of the BCR-based trend. For some species, there was no appropriate trend, in which case population goals were developed through expert opinion. For example, Lesser Prairie-Chicken population goals were determined by members of the Lesser Prairie-Chicken Interstate Working Group. Trends used for each priority species are stored in HABS.

APPENDIX B – Priority Birds Species of the Shortgrass and Central Mixed-grass Prairie Bird Conservation Regions (BCRs18 and 19)

Table B1. List of priority bird species that breed in the shortgrass prairie Bird Conservation Region (BCR18), including common name, scientific name, and description. Species are limited to those which use CRP and/or cropland habitats.

Common Name	Scientific Name	Description
Cassin's Sparrow	*Aimophila cassinii*	migratory landbird
Grasshopper Sparrow	*Ammodramus savannarum*	migratory landbird
Lark Bunting	*Calamospiza melanocorys*	migratory landbird
Lesser Prairie-Chicken	*Tympanuchus pallidicinctus*	resident upland game-bird
Mountain Plover	*Charadrius montanus*	migratory shorebird
Ring-necked Pheasant	*Phasianus colchicus*	resident upland game-bird
Swainson's Hawk	*Buteo swainsoni*	migratory raptor

Table B2. List of priority bird species that breed in the central mixed-grass prairie Bird Conservation Region (BCR19), including common name, scientific name, and description. Species are limited to those which use CRP and/or cropland habitats.

Common Name	Scientific Name	Description
Cassin's Sparrow	*Aimophila cassinii*	migratory landbird
Dickcissel	*Spiza americana*	migratory landbird
Eastern Meadowlark	*Sturnella magna*	resident landbird
Grasshopper Sparrow	*Ammodramus savannarum*	migratory landbird
Greater Prairie-Chicken	*Tympanuchus cupido*	resident upland game-bird
Lark Bunting	*Calamospiza melanocorys*	migratory landbird
Lesser Prairie-Chicken	*Tympanuchus pallidicinctus*	resident upland game-bird
Northern Bobwhite	*Colinus virginianus*	resident upland game-bird
Ring-necked Pheasant	*Phasianus colchicus*	resident upland game-bird
Swainson's Hawk	*Buteo swainsoni*	migratory raptor
Upland Sandpiper	*Bartramia longicauda*	migratory shorebird
Western Kingbird	*Tyrannus verticalis*	migratory landbird