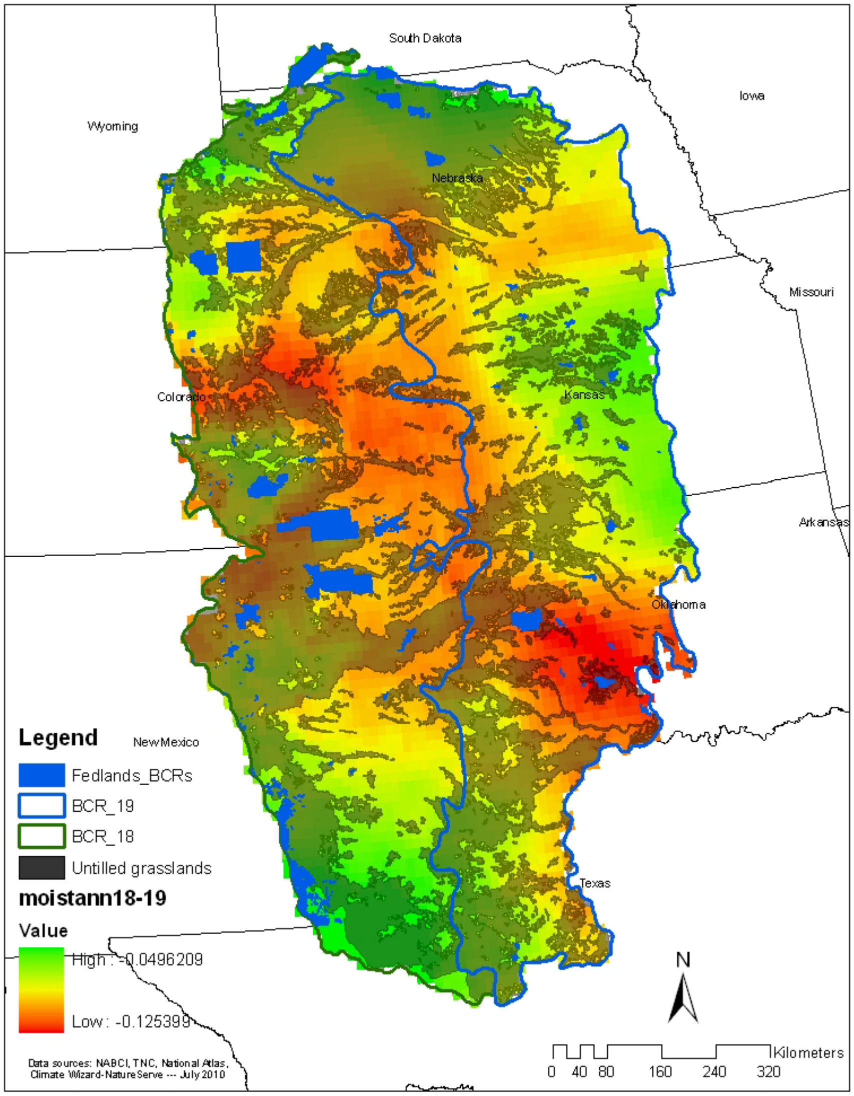
# Climate change planning for the Great Plains: Wildlife vulnerability assessment & recommendations for land and grazing management




Moisture Availability Projected for 2050 (AET:PET), Untilled Grasslands, and Federal Lands in the Great Plains LCC

**A summary report by:**

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**Overview:** A stated purpose of the Great Plains Landscape Conservation Cooperative (GP LCC) is to conduct applied science and make that information accessible to on-the-ground the managers to help the community of decision-makers in the GP LCC understand how to approach landscape-scale management in light of stressors such as climate change. To address this need, we executed a short-term project for the GP LCC to assess the vulnerability of grassland-dependent wildlife to climate change impacts in the GP LCC geography with the following as deliverables**:**

**1)** Vulnerability assessments for key grassland wildlife;
**2)** Workshop of experts for a climate change adaptation planning exercise; and
**3)** Summary report and draft outreach materials.

While we assessed the vulnerability of a number of different wildlife and plant species to climate change, none of those species exhibited high vulnerability to changes projected for the region and there was limited differentiation in vulnerability between the individual species. Given this shared level of vulnerability to climate change, we chose to focus our adaptation planning on grassland birds as they represent a large group with a diversity of habitat needs. These birds are obligate grassland wildlife species which have great potential to act as indicators for habitat quality since different species have distinct habitat structure needs. Participants in the adaptation planning workshop agreed that if the GP LCC is to meet the goals of sustaining grassland bird populations (and other Great Plains wildlife) across the region in light of climate change, the following will be required:

- An increase in the amount of grassland under conservation and grazing management to provide sufficiently large patches of diverse structural and compositional characteristics required by wildlife.
- Identification of several areas of contiguous grassland, with federal land included, to act as model landscapes for the creation and maintenance of structural and compositional heterogeneity at a scale relevant to wildlife, to “learn from doing”, generate best-management guidelines and monitor the success of management and policy actions.
- The use of a variety of policy and management tools at a landscape scale to address the stressors facing grasslands both now and in light of climate change.
- Engaging agricultural policy at the national, state, and county levels to develop programs that promote both ecological and economic values.

- Engaging private landowners to identify synergies between economics and managing for ecological diversity.
- Coordination across agencies and organizations to facilitate management, research and monitoring (as well as to unify datasets).
- Further emphasis on the need for adaptive approaches to making and implementing conservation and management decisions.

In the following sections of the report, we highlight the results of the vulnerability assessment, discuss the workshop and its products, and summarize the entire project.

## 1. Climate Change Vulnerability Assessment for Grassland Species in the Great Plains LCC (Summary by E. Rowland and K. Ellison)

We used the NatureServe Climate Change Vulnerability Index (CCVI) tool to conduct an assessment for a set of grassland species, focusing primarily on the species of concern listed in the wildlife action plans of the states within the GP LCC. The tool yields a relative ranking of the vulnerability of the species analyzed to future projections of climate change for the geographic area assessed (i.e., the GP LCC). We stress that the NatureServe CCVI tool is designed for use in conjunction with NatureServe conservation status ranks. Most grassland species are already in serious decline and we assessed how climate change may further stress grassland wildlife. More details on methods for the vulnerability assessment are included in Appendix 1.

### Results

None of the 30 grassland species analyzed were ranked as “highly vulnerable” to climate change. Only three species (Black-footed Ferret, Lesser-prairie Chicken and Regal Fritillary) generated “moderately vulnerable” index values. Most species were categorized as “presumed stable” or “increase likely”, based on their predominantly neutral sensitivity to most factors (Table 1). However, the responses to the sensitivity factors that increase vulnerability highlight the sources of vulnerability, providing information toward the development of potential adaptation strategies (see Appendix 1 for more detailed results from the vulnerability assessment).

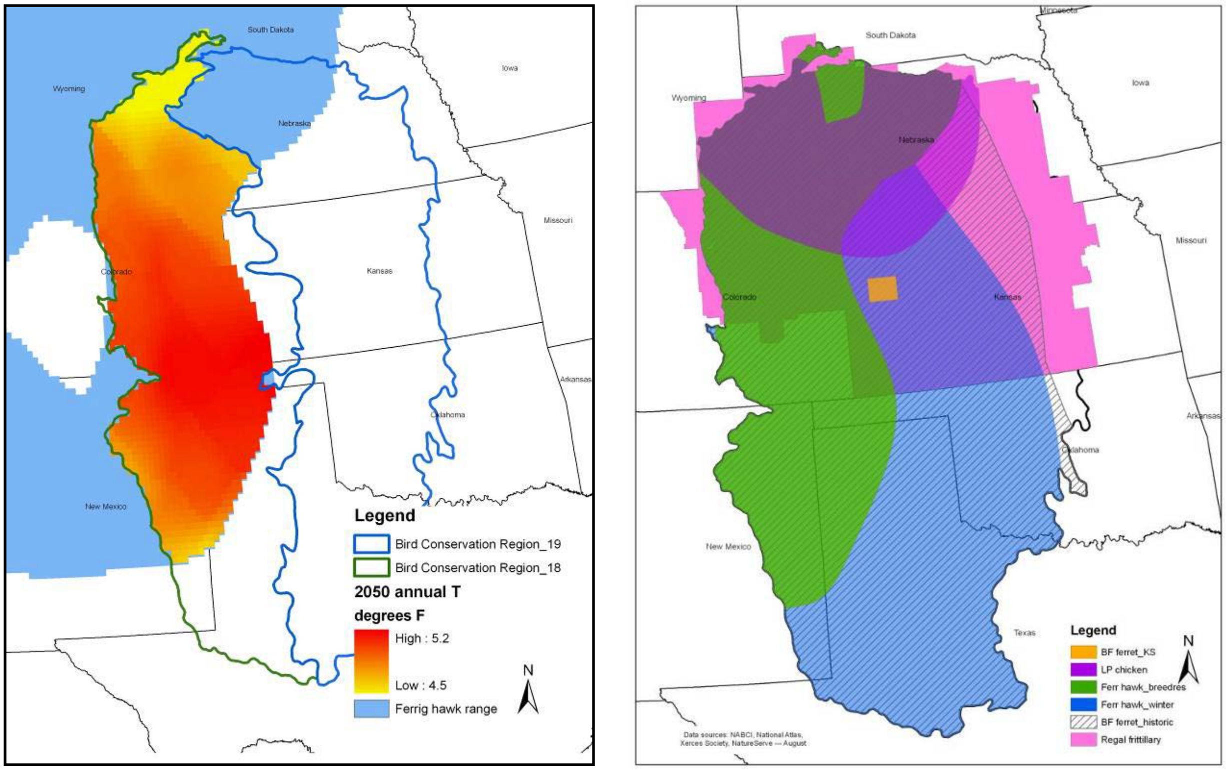
**Table 1.** Results (abbreviated) of climate change vulnerability assessment for species found to be moderately vulnerable in BCR 18 and/or 19. Highest conservation status rank = 1 (imperiled populations), lowest = 5 (stable populations).

| Common Name | Geographic Area | Range Relative to LCC | Global Rank | State Rank | Index Value |
|---|---|---|---|---|---|
| Black-footed ferret | GPLCC_BCR19 | Center of range | 1 | 1 | Presumed Stable |
| Black-footed ferret | GPLCC_BCR18 | Center of range | 1 | 1 | Mod. Vulnerable |
| Lesser Prairie Chicken | GPLCC_BCR18 | Entire range | 3 | 2 | Mod. Vulnerable |
| Lesser Prairie Chicken | GPLCC_BCR19 | Entire range | 3 | 1 | Mod. Vulnerable |
| Regal fritillary | GPLCC_BCR18 | Southern edge of range | 3 | 3 | Mod. Vulnerable |
| Regal fritillary | GPLCC_BCR19 | Southern edge of range | 3 | 3 | Presumed Stable |

NatureServe conservation status rank and vulnerability information, coupled with the relationship of species range to the assessment area, offer additional insights to the vulnerability results. For example, species of concern whose southern edge of distribution is found in the GP LCC may experience range contractions or shifts northward, while others with their northern edge in the GP LCC have the potential to expand their distributions within the GP LCC. East-west range shifts along existing precipitation gradients may also occur in response to changing moisture regimes.

Our analyses produced spatial assessments of how climate conditions may change within each species' distribution in the GP LCC (e.g., see Fig. 1). We plan to make these maps available to interested GP LCC partners. Our results can also be compared with those calculated using the same tool for target areas of more limited geographic scope by the Rainwater Basin Joint Venture and The Nature Conservancy.

**Figure 1.** Samples of spatial products from the vulnerability assessment: projected temperatures in the BCR-18 portion of the Ferruginous Hawk's range and the overlap in ranges of four grassland species.




## 2. Great Plains LCC Climate Change Adaptation Planning Workshop.

We assembled 25 science and management experts on grassland species and systems from government agencies and conservation science non-government organizations (see Appendix 2 for participant list) for a three-day workshop September 8-10, 2010 (see Appendix 3 for workshop agenda). The workshop followed several steps in a particular approach for translating general recommendations on climate change adaptation strategies into practical, specific actions for a given landscape called the Adaptation for Conservation Targets (ACT) Framework (developed by the Climate Change and Wildlife Working Group, which was convened by the Wildlife Conservation Society, the Center for Large Landscape Conservation, and the National Center for Ecological Analysis and Synthesis) (Cross et al. *in prep.*). WCS is working with a number of partner agencies and organizations across the United States to apply and continually refine the ACT Framework. The Framework is designed for collaborative application in a given landscape or seascape by a multidisciplinary group of natural resource managers, conservation practitioners, scientists, and local stakeholders. The planning phase of the ACT Framework draws on collective knowledge to translate climate change projections into a portfolio of adaptation actions.

The workshop succeeded in:

- Providing an overview of climate change impacts to grasslands within the GP LCC;
- Presenting the results of our wildlife climate change vulnerability assessment;
- Leading a climate change planning exercise to identify management actions to address the effects of climate change on grassland habitats and associated wildlife;
- Convening a field trip to the Pawnee National Grasslands to exhibit the results of long-term experiments on the effects of different cattle management, fire and drought on short grass-steppe system.

The overview of climate change impacts, presented by Dr. Jack Morgan, USDA, highlighted the response of grassland plants to: warming temperatures and changing precipitation levels, increasing $CO_2$ levels, an increasing frequency of extreme events (e.g., extreme rainfall events, drought and heat waves), increasing inter-annual variability in precipitation, and lengthening growing seasons.

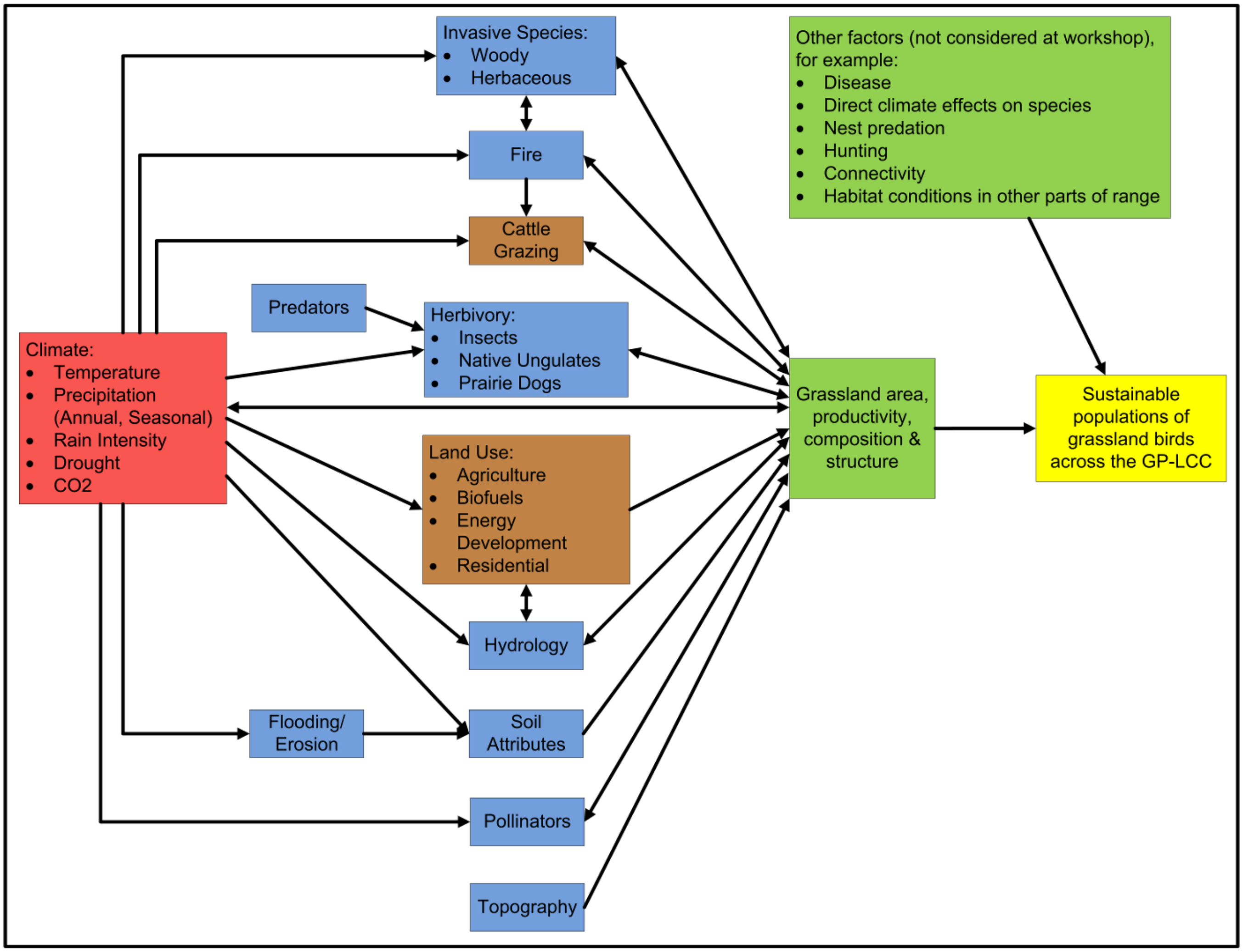
***Identifying Management Goals***

To start the climate change adaptation planning process, workshop participants identified a broad management goal for grassland habitats relevant for grassland wildlife: "To sustain populations of grassland birds across the GP LCC by maintaining and enhancing the availability of areas sufficient in extent and quality (as measured by patch-level heterogeneity in structural and compositional characteristics)." Participants recognized that the provision of sufficient high quality habitat is not the only factor necessary to support sustainable grassland bird populations, but agreed to limit discussions at the workshop to climate change impacts on and recommendations for managing grassland habitat for birds. Further discussion of additional factors relevant for sustaining bird populations could be addressed in subsequent meetings of GP LCC partners.

***Drafting a Conceptual Diagram of Key Drivers Affecting GP LCC Grasslands***

Workshop participants then revised a draft conceptual diagram highlighting several key drivers of grassland systems in the GP LCC (Fig. 2).

**Figure 2.** Draft conceptual diagram highlighting several key drivers of grassland systems in the GP LCC. The diagram is simplified and not intended to represent the full complexity of interacting factors within grassland ecosystems (i.e., not all interactions among factors are depicted). It is intended to guide group discussions about the direct and indirect effects of climate change and opportunities for actions needed to achieve conservation goals.



*Discussion of Key Climate Change Impacts on GP LCC Grasslands*

Participant discussions about potential impacts to short-grass and mixed-grass prairies in the GP LCC were focused on a specific, plausible climate change scenario for 2040 (the "Main" future climate scenario, developed in consultation with Drs. Linda Mearns and Melissa Bukovsky at the National Center for Atmospheric Research and a review of relevant scientific literature): a $4^{o}$F increase in annual temperature, no change in annual precipitation or seasonality of rainfall but more intense rain events at a lower frequency, and increased severity of drought, longer growing season and earlier timing of spring, and an increase in atmospheric $CO_2$ levels (from ~380 ppm to ~500ppm). Using the conceptual diagram to consider pathways of change, participants generated a list of the potential impacts of the "Main" future climate scenario on the grasslands of the region (see Appendix 4 for additional details on participant discussions on climate change impacts of the "Main" future scenario).

In summary, the group felt that grasslands in the GP LCC will likely experience significant changes in response to the "Main" future climate scenario considered:

- A loss of grasslands microhabitats that cannot tolerate drier conditions.
- Some areas may gain grasslands (e.g., those places too dry for agriculture or currently too wet for grasslands) and some may lose grassland habitat (e.g., those places that become too dry or become converted to other land uses).
- Decreased productivity and changes in the type, quality, and distribution of grassland habitats (e.g., some may migrate through time outside of protected areas).
- A loss of large, intact habitat patches due to fragmentation.
- Large changes in agriculture (such as increases in production of corn or other biofuels), although the net or long-term impact on grasslands is not clear (e.g., while agriculture may expand into some current grassland areas, in some places increased drought may cause agriculture and ranching to become unsustainable and grasslands may have opportunities to re-establish). A big concern is: what will happen to lands after they are abandoned in terms of ownership, fragmentation, and land use?

In addition to discussing the effects of the "Main" future climate scenario at some length, workshop participants also briefly considered how alternate assumptions about future climate conditions might lead to fundamentally different impacts to the system. For example, under an alternate scenario of a ~15% increase in winter precipitation and a ~15% decrease in summer precipitation, participants pointed out that C3 cool season grasses and shrubs, and winter wheat crops, may benefit from increased moisture availability in the wintertime, but that many of the negative impacts on grassland productivity and distribution discussed under the "Main" scenario may still occur due to significant drying during the summer growing season.

***Recommendations for Management and Conservation Actions in Light of Climate Change***

Participants identified several strategic actions as being necessary to address the potential impacts resulting from the climate scenarios discussed, again with a focus on grassland birds as they can act as indicators of habitat quality (structure, spatial extent, insect abundance, etc.). The actions fell under broad categories of management, policy, and outreach (see Appendix 5 for a list of actions that might be considered for implementation – note that actions listed in Appendix 5 have not yet been evaluated for cost or political feasibility, practicality, or other factors). The group focused on a core combination of stressors: 1) too much structural homogeneity of habitat, 2) loss of habitat due to conversion and fragmentation, and 3) poor distributional and spatial representation of habitat types across the GP LCC region.

Participants agreed that if the GP LCC is to meet the desired goal of providing sufficiently large patches of diverse structural and compositional habitat characteristics to sustain diverse bird populations across the region in light of climate change, it will require:

- An increase in the amount of grassland under conservation management.
- Identification of several areas of contiguous grassland, with federal land included, to act as model landscapes for the creation and maintenance of structural and compositional heterogeneity at a scale relevant to wildlife, to "learn from doing", generate best-management guidelines and monitor the success of management and policy actions.
- The use of a variety of policy and management tools at a landscape scale to address the stressors facing grasslands both now and in light of climate change.
- Engaging agricultural policy at the national, state, and county levels to develop programs that promote both ecological and economic values.
- Engaging private landowners to identify synergies between economics and managing for ecological diversity.
- Coordination across agencies and organizations to facilitate management, research and monitoring (as well as to unify datasets).

- Further emphasis on the need for adaptive approaches to making and implementing conservation and management decisions.

***Next Steps***

The group considered some potential next steps for climate change adaptation planning and implementation to move forward in the GP LCC region:

- Focus on preserving and restoring large contiguous grasslands that will support more robust and resilient wildlife communities.
- Assessment of existing grassland cover and the establishment of sites (or networking of existing sites) to clearly demonstrate how management with grazing and/or burning, at appropriate scales, can benefit wildlife and grazers.
- Lay out action items that step down from overall recommendations identified during this initial workshop and that are specific to sub-regions within the GP LCC.
- Prioritize research and monitoring needs (see below) and develop plans for implementing priority research and monitoring (i.e., identify necessary partners, secure funding, etc.).
- Coordinate with neighboring LCCs and entities.

***Research and monitoring***

As stated in the GP LCC Action Plan, "[A] monitoring strategy will need to outline the appropriate monitoring to better understand priority species, refine key uncertainties critical to the biological foundation, and ensure the monitoring data collected will be applicable to develop conservation design tools that will help guide conservation delivery to address limiting factors for priority species." Workshop participants therefore identified a number of important applied science needs (i.e., research and monitoring) related to discussions on the consequences of climate change for management of grassland habitats and conservation of grassland birds (Table 2). Research and monitoring needs listed in Table 2 have not yet been ranked by importance, and represent topics that were insufficiently known or understood by those experts who participate in the workshop. Workshop participants suggested that subsequent discussions by either the group assembled or the GP LCC Technical Committee should review these needs, rank them by their priority for informing management (e.g., sort by those research and monitoring questions that would be "nice to know" versus those that are necessary for making management decisions), synthesize existing research and monitoring that is already completed or on-going on these topics, and develop a plan for addressing the highest priority research and monitoring needs.

**Table 2.** Research and monitoring needs identified by workshop participants.

| RESEARCH NEEDS: | |
|---|---|
| Grazing | • Conduct research on grazing and climate change impacts (like what was observed at the Pawnee National Grassland LTER site) across more locations within the GP LCC to expand the coverage to other areas. Perhaps standardized experiments across climatic and other gradients [note: east-west gradients may be better covered by current research than north-south gradients]. Perhaps increase the research going on in mixed-grass prairie.<br>• Understand relative grazing impacts of bison vs. cattle, and the ability to introduce bison on the landscape and/or manage cattle more like bison to create heterogeneous grassland structure across an area. |
| Birds & habitat | • Strengthen our understanding of the links between crashing bird populations and specific management tools and options (i.e., are changes to cattle grazing really what is needed? If so, what changes are needed?).<br>• Research to better understand the link between the persistence of grassland bird populations and the availability of habitat structural heterogeneity (e.g., What size patches of different structural types are needed? What spatial arrangement of those patches is needed at both fine scales and across the GP LCC?). |
| Phenology | • How will climate change affect the phenology of birds, plants, insect, pollinators, and the relative temporal matching between those interacting species?<br>• How will management activities be altered in response to phenological shifts in species and interactions? |
| Assessments | • Assess the vulnerability of ecosystems across the GP LCC and overlay with the species-level vulnerability information. Add a spatial component to assessments of the vulnerability of both species and ecosystems.<br>• Assess current land cover to understand how much of different habitat types (e.g., vegetation structures) are out there on both public and private lands, and what habitat types are less well represented [Note: this analysis will need to be revisited through time to get at the spatio-temporal changes].<br>• Model vegetation shifts and changes to disturbance regimes in light of climate change, to anticipate where grassland types may shift across the region.<br>• Improve our understanding of current and projected future human demographics and population changes.<br>• Establish criteria on which we can prioritize areas for different management/conservation/policy actions – apply those criteria to the GP LCC landscape [Note: this is likely to leverage many existing tools]. |

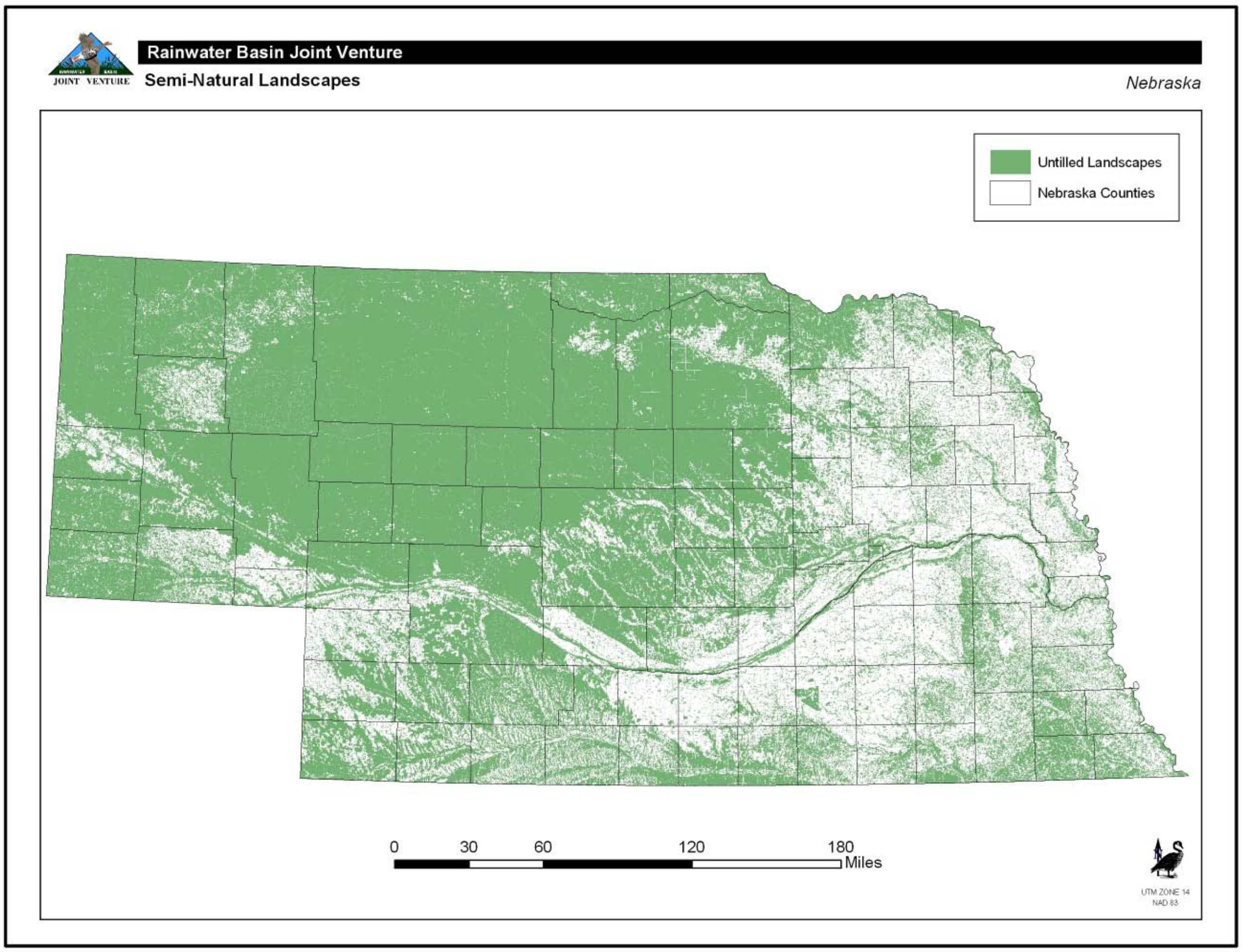
| | |
|---|---|
| Ecosystem impacts | • Better understanding of the role of groundwater in influencing the location and quality of grassland types.<br>• Determine the effects of climate change and land management activities on carbon storage and nutrient cycling in grasslands.<br>• Integrate across multiple disciplines/modeling approaches to get a sense of how the big picture may change for GP LCC grasslands (e.g., hydrology, socio-economics, vegetation, wildlife, land-atmosphere interactions). |
| Invasive species | • Determine the impacts of climate change on exacerbating the problems of invasive species. |
| MONITORING: | |
| Protocols & implementation | • Develop systematic monitoring protocols and plans, and secure consistent and prolonged funding to support coordinated monitoring across large areas.<br>• What we need to monitor will require discussion of partners across the GP LCC. Bird abundance and productivity are likely to be one variable to measure, but a systematic process for determining other monitoring priorities is needed.<br>• Inventory and monitor grassland microhabitats and their importance to bird species.<br>• Provide access to data and archiving. |
| Policy/ Management | • Monitor the effects of particular management or policy changes to determine project success.<br>• State transition models for different types of grasslands, and how climate change may influence those state transitions (and help inform the development of system-specific Best Management Practices). |

***<u>Summary</u>***

Through our project, we have assessed the vulnerability of key grassland wildlife to climate change. We found that few species appear vulnerable solely to climate change, in part due to the historically extreme conditions that characterized grassland systems in the GP LCC and the adaptive capacity of associated wildlife. Our vulnerability assessment was presented to a group of experts and can be reviewed relative to similar efforts in the region (e.g., those by the Nature Conservancy and Nebraska Game & Parks). More importantly, our assessments provided a starting point for climate change adaptation and more general conservation planning for the GP LCC, toward which we feel that our workshop was an early step. Workshop participants identified many needs in land conservation and management, policy development, research and monitoring, and outreach. We feel that one of the strongest needs to fulfill is that of creating demonstration sites where basic connections between management and wildlife can be clearly exhibited and then shared with habitat and grazing managers. Demonstrations would be of how grazing and fire, applied at different spatial and temporal scales, can impact wildlife habitat use, population productivity, and range quality. Such direct research and

outreach would greatly aid grassland conservation efforts both now and in light of future climate changes. Two suggested locations for such work are the Pawnee National Grasslands (>21,000 acres of shortgrass with an established LTER site) and extensive mixed-grassland complexes in Nebraska (Fig. 3).

**Figure 3.** Map of untilled grassland complexes in Nebraska.

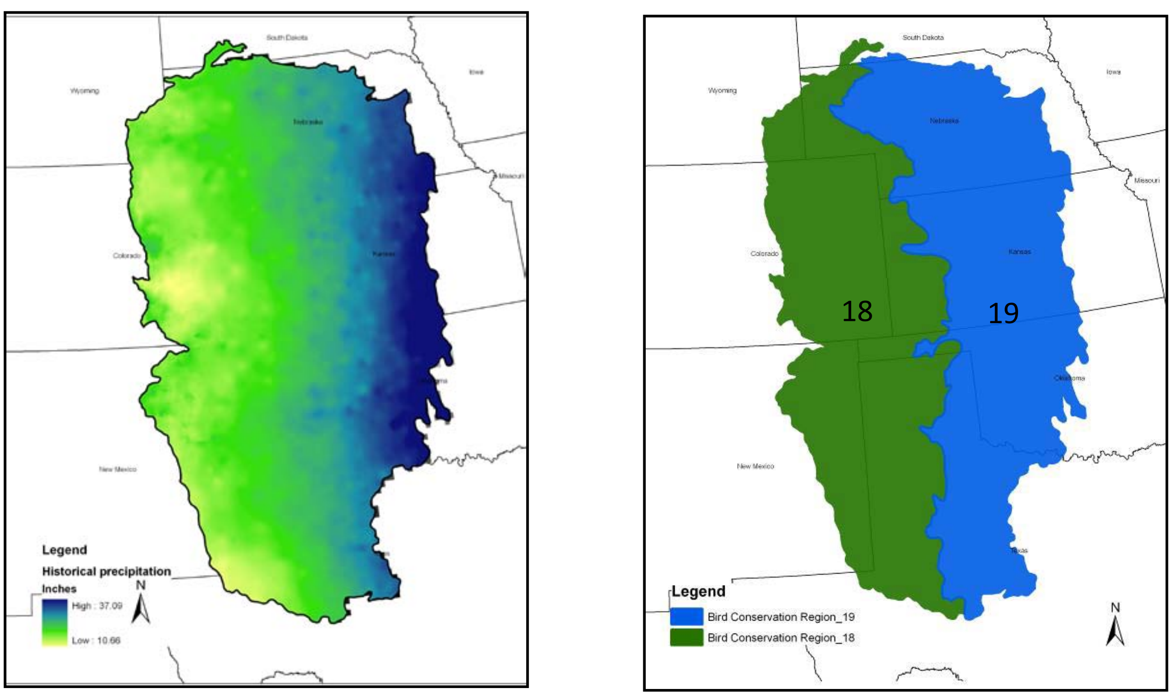


## Appendix 1. Vulnerability assessment methods and detailed results.

Methods:

An important precursor to identifying appropriate adaptation strategies for natural resources is to assess the potential impacts of climate change on conservation strategies and the outcomes of existing management in order to develop and modify management actions and allocate resources. Vulnerability assessments, which take on many forms, represent one approach that is often used. Given the time constraints, we chose to use an established tool, NatureServe's Climate Change Vulnerability Index v.2.1 (CCVI), to conduct the vulnerability assessment (Young et al. 2010). Climate change vulnerability for the CCVI tool is defined as a function of a species' exposure to changing climate and its sensitivity to the changes. The CCVI tool assesses vulnerability through four corresponding sections: exposure to projected temperatures and moisture balance changes, indirect exposure to climate change (e.g., land use changes resulting from human response to climate change), sensitivity, and documented or modeled response to climate change (Table 1). The tool guidelines recommend a state/small region as the maximum spatial extent for CCVI tool application to minimize the variation in climate variables in whatever portion of a given species range is located within the assessment areas. We chose the existing Bird Conservation Regions (18 and 19) to divide the GPLCC to capture the east-west moisture gradient of the region (Figure 1).

**Figure 1.** (a) Pattern of mean annual precipitation in the Great Plains LCC from 1951-2006. (b) Bird Conservation Regions 18 and 19 boundaries.



The CCVI tool requires information on species' distributions, natural histories, and historical and projected climate. Most species distributions were downloaded from the NatureServe website, which offers GIS shapefiles covering the United States and Canada (http://www.natureserve.org/explorer/eodist.htm). In some cases distribution data were augmented by or compared with other sources, particularly for species that have been extirpated from their historical ranges by anthropogenic activities, such as the black-footed ferret. We used occurrence maps published by the Butterflies and Moths of North America (http://www.butterfliesandmoths.org/) for the two butterfly species, as data for invertebrates are not available on the NatureServe site. County-level GIS data for the county-based distributions of the butterflies and black-footed ferret were obtained from Census 2000 TIGER/Line shapefiles (http://arcdata.esri.com/data/tiger2000/tiger_download.cfm).

The CCVI tool is programmed in Microsoft Excel and combines scores from the exposure, indirect exposure, sensitivity, and (an optional) species response sections of the assessment into a numerical sum. The numerical output is then converted into one of six categorical vulnerability designations based on predetermined threshold values (extremely vulnerable, highly vulnerable, moderately vulnerable, not vulnerable/presumed stable or not vulnerable/increase likely). Because a species may be exposed to significant changes in climate but not inherently sensitive, or sensitive to changes in climate but not expected to experience significant exposure, the CCVI tool weights the numerical scores for the sensitivity factors by the magnitude of projected temperature and moisture change across the assessment area (Young et al. in press).

The NatureServe assessment is designed to analyze the climate exposure of individual species' distributions in a GIS environment; thus, the data inputs for exposure are quantitative. We downloaded temperature data projected for 2040-2069 (high emissions A2 scenario and ensemble average) from Climate Wizard (http://www.climatewizard.org/AboutUs.html), an on-line tool that provides climate data from 16 Global Climate Models statistically downscaled to 12-km resolution for the United States. The moisture deficit data and mean annual ranges of temperature and precipitation for 1895-2003 were downloaded from NatureServe (also generated by the Climate Wizard group). The Hamon moisture metric was used to convert the temperature and precipitation projections for 2020-2069 combined with daylight hours and saturated vapor pressure to a ratio of actual evapotranspiration to potential evapotranspiration (Hamon 1961). The historical climate data used in scoring the species' physiological sensitivity to temperature and precipitation were based on the 4-km resolution PRISM products (http://www.prism.oregonstate.edu/). Exposure factors and temperature and hydrologic sensitivity were assessed by clipping the spatial extent of climate parameters by the portion of the species' distribution within the respective BCR (Figure 2).

Responses (or scores) for the factors in the indirect climate exposure, sensitivity and modeled/observed distribution shifts sections are evaluated qualitatively. There are seven options for assessing the effect of any one of these factors on overall vulnerability that range from "Greatly increase vulnerability" to "Decrease vulnerability" and include "Neutral" and "Unknown" selections. The CCVI tool offers guidelines, quantitative if the factor allows, for the selection of effect response. If there is uncertainty in the influence of a given factor on a species' vulnerability to climate change, more than one response may be selected. Geospatial information available for factors in these sections, such as the anthropogenic barriers or species' modeled response to climate change, may also be analyzed in a GIS to generate scoring responses. Most of the information for scoring these sections, especially the sensitivity factors, came from the published literature.

**Figure 2.** Example of historical (1895-2003) and projected (2040-2060) climate exposure clipped to the BCR-19 portion of the range of the Ferruginous Hawk.

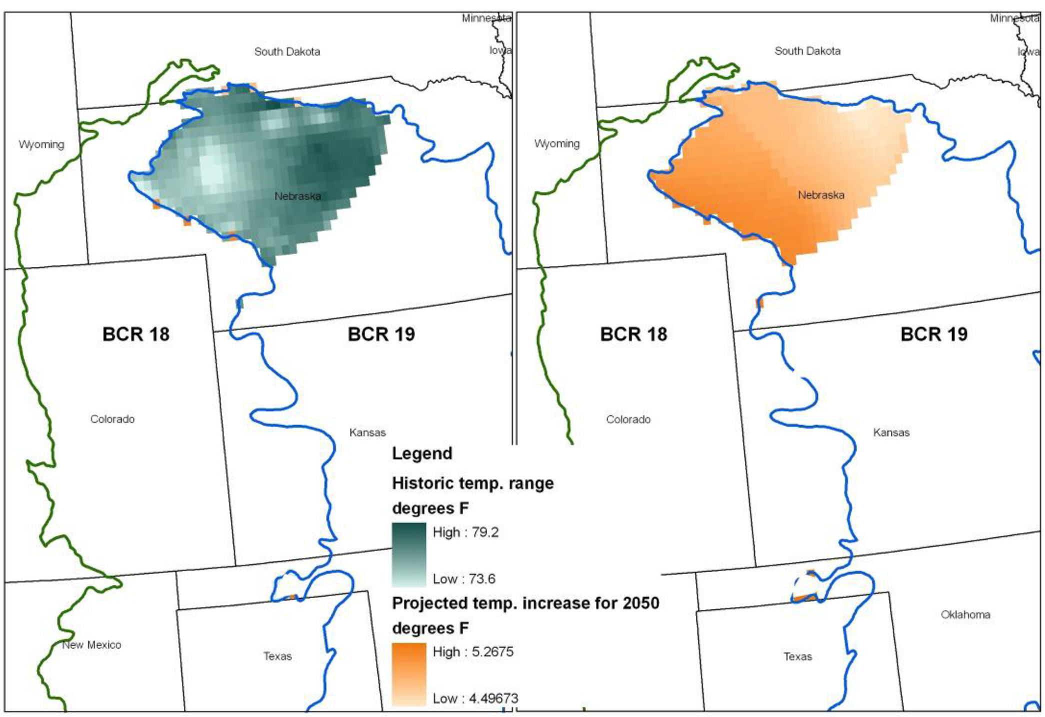


**Table 1. Summary of the exposure and sensitivity factor scores of the species assessed for the Great Plains LCC.**

| Vulnerability Assessment Factors | | Summary of Scoring/Potential Sources of Vulnerability |
|---|---|---|
| **Climate Exposure** | *Temperature* | Species experience temperature increases of 4-5.5°F by 2050. |
| | *AET:PET* | While increases in mean annual precipitation of up to 25% (over 1961-1990 base) are projected for 2050, available moisture generally declines throughout the GPLCC (deficit in highest CCVI categories). |
| **Indirect Exposure** | *Sea level* | NA |
| | *Natural barriers* | Considered generally not applicable for mammals and birds--neutral. |
| | *Anthro barriers* | Considered generally not applicable for mammals and birds--neutral. |
| | *Climate change mitigation* | The potential for the expansion of wind development and/or expansions and shifts in crop species for biofuels considered to somewhat increase-increase vulnerability. |
| **Sensitivity or Species-Specific Factors** | *Dispersal /Movement* | With the exception of plants (grasses), generally decrease climate change vulnerability. |
| | *Historical thermal niche* | Neutral effect on climate change vulnerability. |
| | *Physiological thermal niche* | Neutral effect on climate change vulnerability. |
| | *Historical hydrological niche* | **Somewhat increase to increase** the climate change sensitivity of most species assessed. |
| | *Physiological hydrological niche* | Neutral effect for most species; a few record somewhat increased or somewhat decreased vulnerability. |
| | *Disturbance* | Neutral effect on climate change sensitivity for most species (does not include grazing). |
| | *Ice/snow* | NA |
| | *Physical habitat* | For most species, neutral to somewhat decreased vulnerability. |
| | *Other species for habitat* | **Only increase vulnerability** for Black-footed Ferret, Burrowing Owl and Mountain Plover. |
| | *Diet* | **Only increase vulnerability** for Black-footed Ferret, Ferruginous Hawk and Regal Frittillary. |
| | *Pollinators* | NA |
| | *Other spp disp* | Neutral--no species dependent on other species for dispersal. |
| | *Other species interaction* | **Only somewhat increase vulnerability** for Burrowing Owl and N. Harrier. |
| | *Genetic variation* | Mostly somewhat decrease or have neutral effect on vulnerability. |
| | *Gen bottleneck* | Unknown/undocumented effect on most species. |
| | *Phenological response* | Unknown/undocumented effect on most species. |
| **Documented or Modeled Response** | *Doc response* | Documented northward shifts for some bird species (Breeding Bird Survey). |
| | *Modeled change* | Unknown for all species. |
| | *Modeled overlap* | Unknown for all species. |
| | *Protected Areas* | Unknown…but, while modeled range shifts are unavailable for all species, only 2-3% of the grassland is protected within the GPLCC and in the grassland regions to the north of it (within US). |

Results:

Based on the factors we were able to assess (using currently available information), none of the species were extremely or highly vulnerable to climate change. The assessment of only 3 species (Black-footed ferret, Lesser-prairie chicken and Regal fritillary) generated “moderately vulnerable” index values (light blue in results Table 2). Most species were categorized as “presumed stable” or “increase likely”, based on their predominantly “neutral” sensitivity to most factors. However, the responses to the sensitivity factors that increase vulnerability highlight the sources of vulnerability and offer insight for potential adaptation strategies (Table 1). Commonalities in dietary specificity were evident for Black-footed Ferret, Ferruginous Hawk, and the Regal Frittilary. Likewise, interspecific dependence, like that between the Burrowing Owl and prairie dogs, increased the vulnerability of the Burrowing Owl, ferret, Mountain Plover and the Northern Harrier.

The CCVI tool is designed to be used in conjunction with NatureServe conservation status ranks. This information coupled with the relation of species range to the assessment area (CCVI tool header) offers some additional nuance to the vulnerability results. For example, species whose southern edge of their distribution is found in the Great Plains LCC may contract/shift northward (light green in table), while others with their northern edge in the Great Plains LCC have the potential to expand/increase (light purple in table). There is also some potential for east-west distribution shifts in response to changing moisture regimes (light orange in table).

Uncertainty

There is uncertainty associated with much of the data input to the vulnerability assessment tool (e.g., the climate change projections). The output from the tool does not quantify this or take it directly into account, and, thus, there are limitations to the application of results. However, the CCVI tool does generate a confidence level associated with the certainty in species information. Multiple responses may be selected for a particular factor in the spreadsheet. Monte Carlo simulations are run to determine how permutations of the multiple responses affect the vulnerability category assigned to the species, and reported as a confidence level. Confidence level in the output of the CCVI tool is also diminished when the numerical sum of the factor scoring results in a value near the threshold for categorical assignment (Young et al. 2010).

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**Table 2.** Results (abbreviated) of climate change vulnerability assessment, species listed by the following categories: blue = moderately vulnerable; green = southern range limit falls within the LCC and may move out; purple = east/west range limit falls within BCR 18 and/or 19; orange = range may expand in assessment area. Highest conservation status rank = 1 (imperiled populations), lowest = 5 (stable populations).

| Common Name | Geographic Area | Range Relative to LCC | Global Rank | State Rank | Index Value[1] |
|---|---|---|---|---|---|
| Black-footed ferret | GPLCC_BCR19 | Center of range | 1 | 1 | PS |
| Black-footed ferret | GPLCC_BCR18 | Center of range | 1 | 1 | MV |
| Lesser Prairie Chicken | GPLCC_BCR18 | Entire range | 3 | 2 | MV |
| Lesser Prairie Chicken | GPLCC_BCR18_Jun | Entire range | 3 | 2 | MV |
| Lesser Prairie Chicken | GPLCC_BCR19 | Entire range | 3 | 1 | MV |
| Regal fritillary | GPLCC_BCR18 | Southern edge of range | 3 | 3 | MV |
| Regal fritillary | GPLCC_BCR19 | Southern edge of range | 3 | 3 | PS |
| Ottoe Skipper | GPLCC_BCR18 | Southern edge of range | 4 | 2 | PS |
| Ottoe Skipper | GPLCC_BCR19 | Southern edge of range | 4 | 2 | PS |
| Chestnut-collared longspur | GPLCC_BCR18_breeding | Southern edge of range | 5 | 1 | PS |
| Wilson's phalarope | GPLCC_BCR18_breed | Southern edge of range | 5 | 4 | PS |
| Wilson's phalarope | GPLCC_BCR19_breed | Southern edge of range | 5 | 4 | PS |
| Sharp-tailed grouse | GPLCC_BCR18 | Southern edge of range | 4 | 3 | IL |
| Sharp-tailed grouse | GPLCC_BCR19 | Southern edge of range | 4 | 3 | IL |
| Ferruginous Hawk | GPLCC_BCR19 | Southern edge of range | 4 | 1 | IL |
| Ferruginous Hawk | GPLCC_BCR19 | Southern edge of range | 4 | 1 | IL |
| McCown's longspur | GPLCC_BCR18_breed | Southern edge of range | 4 | 2 | IL |
| Mallard | GPLCC_BCR18_resident | Southern edge of range | 5 | 5 | IL |
| Mallard | GPLCC_BCR19_resident | Southern edge of range | 5 | 5 | IL |
| Bobolink | GPLCC_BCR18_breed | Southern edge of range | 5 | 3 | IL |
| Bobolink | GPLCC_BCR19_breed | Southern edge of range | 5 | 4 | IL |
| Bobolink | GPLCC_BCR19_breed | Southern edge of range | 5 | 4 | IL |
| Sprague's pipit | GPLCC_BCR18_winter | Northern edge of range | 4 | 2 | PS |
| Sprague's pipit | GPLCC_BCR19_winter | Northern edge of range | 4 | 2 | PS |
| Cassin's Sparrow | GPLCC_BCR19 | Northern edge of range | 5 | 4 | IL |
| Cassin's Sparrow | GPLCC_BCR18 | Northern edge of range | 5 | 4 | IL |
| Chestnut-collared longspur | GPLCC_BCR18_winter | Northern edge of range | 5 | 3 | IL |
| Chestnut-collared longspur | GPLCC_BCR19_winter | Northern edge of range | 5 | 3 | IL |
| McCown's longspur | GPLCC_BCR18_winter | Northern edge of range | 4 | 3 | IL |
| McCown's longspur | GPLCC_BCR19_winter | Northern edge of range | 4 | 3 | IL |
| Lark Bunting | GPLCC_BCR18_winter | Northern edge of range | 5 | 4 | PS |
| Lark Bunting | GPLCC_BCR19_winter | Northern edge of range | 5 | 4 | IL |
| Greater-prairie chicken | GPLCC_BCR18 | Northern edge of range | 4 | 4 | IL |
| Greater-prairie chicken | GPLCC_BCR19 | Northern edge of range | 4 | 4 | PS |

| Common Name | Geographic Area | Range Relative to LCC | Global Rank | State Rank | Index Value[1] |
|---|---|---|---|---|---|
| Long-billed curlew | GPLCC_BCR18 | East/west edge of range | 5 | 3 | PS |
| Long-billed curlew | GPLCC_BCR19 | East/west edge of range | 5 | 3 | PS |
| Ferruginous Hawk | GPLCC_BCR18_breeding | East/west edge of range | 4 | 2 | PS |
| Ferruginous Hawk | GPLCC_BCR18_winter | East/west edge of range | 4 | 2 | PS |
| Smith's Longspur | GPLCC_BCR19 | East/west edge of range | 5 | 4 | IL |
| Grasshopper Sparrow | GPLCC_BCR19 | East/west edge of range | 5 | 4 | IL |
| Grasshopper Sparrow | GPLCC_BCR18 | East/west edge of range | 5 | 4 | IL |
| Mountain Plover | GPLCC_BCR18_breed | East/west edge of range | 3 | 2 | IL |
| Mountain Plover | GPLCC_BCR18_breed | East/west edge of range | 3 | 2 | IL |
| Eastern Meadowlark | GPLCC_BCR18_res | East/west edge of range | 5 | 5 | IL |
| Eastern Meadowlark | GPLCC_BCR19_res | East/west edge of range | 5 | 5 | IL |
| Swift fox | GPLCC_BCR19 | East/west edge of range | 3 | 2 | IL |
| Little bluestem | GPLCC_BCR18 | Center of range | 5 | 5 | PS |
| Side-oats grama | GPLCC_BCR18 | Center of range | 5 | 5 | PS |
| Blue grama | GPLCC_BCR18 | Center of range | 5 | 5 | PS |
| Western wheatgrass | GPLCC_BCR18 | Center of range | 5 | 5 | PS |
| Western wheatgrass | GPLCC_BCR18 | Center of range | 5 | 5 | PS |
| Western wheatgrass | GPLCC_BCR19 | Center of range | 5 | 5 | PS |
| Blue grama | GPLCC_BCR19 | Center of range | 5 | 5 | PS |
| Side-oats grama | GPLCC_BCR19 | Center of range | 5 | 5 | PS |
| Little bluestem | GPLCC_BCR19 | Center of range | 5 | 5 | PS |
| Lark Bunting | GPLCC_BCR18_breeding | Center of range | 5 | 4 | PS |
| Lark Bunting | GPLCC_BCR19_breeding | Center of range | 5 | 4 | PS |
| Black-tailed prairie dog | GPLCC_BCR18 | Center of range | 4 | 3 | PS |
| Black-tailed prairie dog | GPLCC_BCR19 | Center of range | 4 | 3 | PS |
| Mallard | GPLCC_BCR18_winter | Northern edge of range | 5 | 5 | IL |
| Mallard | GPLCC_BCR19_winter | Northern edge of range | 5 | 5 | IL |
| Burrowing owl | GPLCC_BCR18 | Center of range | 4 | 4 | PS |
| Burrowing owl | GPLCC_BCR19 | Center of range | 4 | 3 | PS |
| Northern Harrier | GPLCC_BCR18 | Center of range | 4 | 3 | PS |
| Northern Harrier | GPLCC_BCR19 | Center of range | 4 | 5 | PS |
| Swift fox | GPLCC_BCR18 | Center of range | 3 | 3 | IL |
| Horned lark | GPLCC_BCR18 | Center of range | 5 | 5 | PS |
| Horned lark | GPLCC_BCR19 | Center of range | 5 | 5 | IL |
| American bison | GPLCC_BCR18 | Center of range | 4 | X | IL |
| American bison | GPLCC_BCR19 | Center of range | 4 | X | IL |

**[1]Index Values**

| | |
|---|---|
| PS | *Presumed Stable* |
| MV | *Moderately vulnerable* |
| IL | *Increase likely in assessment area* |

**Appendix 2. Workshop participant list:**

| Name | E-Mail | Affiliation |
|---|---|---|
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**Appendix 3. 2010 Great Plains Landscape Conservation Cooperative Workshop.**

## Climate change planning for the Great Plains: Wildlife vulnerability assessment and grazing management

**Wednesday- 8 Sept. at the Denver Zoo**

1:00-1:30 pm – Introduction & overview (Dr. Steve Zack, WCS).

1:30-2:30 – Participant self-introductions and ice-breaker discussion [How has weather affected your work?].

2:30-3:30 – Climate change impacts on grassland ecology by Dr. Jack Morgan Plant Physiologist, USDA-Agricultural Research Service, Fort Collins, CO.

3:45-4:30 – GP LCC Wildlife Vulnerability Assessment (Drs. Erika Rowland & Kevin Ellison, WCS).

4:30-5:00 – Management planning in light of climate change – overview of Thursday and Friday breakout sessions (Dr. Molly Cross, WCS).

5:00-6:00 pm detailed description on the NatureServe tool was applied in our vulnerability assessment.

**Thursday- 9 Sept. at the Denver Zoo**

8:00 am– 12:00pm – Group activity: Great Plains climate change scenario planning exercise (facilitated by M. Cross and E. Rowland, WCS).

12-5 pm – Field Trip: Pawnee National Grasslands LTER, where we will visit a few research sites that demonstrate experimental effects of grazing, burning, and treatments simulating aspects of climate change (led by Dr. Justin Derner, USDA-ARS, Rangeland Scientist). We will also hear from 3 managers on their experiences with drought management.

**Friday- 10 Sept. at the Doubletree Hotel**

8:00am -12:00pm – Group activity: Developing management recommendations for the Great Plains (facilitated by M. Cross and E. Rowland, WCS).

12:00 -2:00pm – Identify priority recommendations for research and management. Next steps.

**Depart afternoon**

**Appendix 4. Climate Change Impacts on Great Plains Grasslands and Wildlife for the "Main" future climate scenarios (2030-2040).**

| Key Climate-Influenced Drivers/Effects | Observed & Predicted Climate Change Impact |
| --- | --- |
| Agriculture and energy development | • Climate change (especially droughts) in the GP-LCC and beyond may drive changes in agriculture and energy development pressures.<br>• With drought, may see a decline in sustainability of biofuels, agriculture and ranching, especially in drier regions of the GP-LCC. This may reduce those pressures on grasslands in some areas.<br>• In some areas, there may be a short-term increase in agricultural production (e.g., corn belt may expand westward), but then droughts and aquifer depletion may decrease longer-term productivity and sustainability of those agricultural systems. In the southern part of the GP-LCC, may see some areas that can re-establish grasslands as agriculture is abandoned (although woody vegetation may move in faster than grasses). In the northern part of the GP-LCC (which is wetter), may see continued loss of grassland due to conversion to agriculture.<br>• In places where agriculture declines, there is a potential for fragmentation of large parcels and habitat loss, or transition to more corporate-scale agriculture, biofuel or other land uses that are detrimental to grasslands.<br>• Unclear what will happen to agricultural and ranching lands that become unsustainable → may see shifts in ownership and/or land use. |
| Distribution of short-grass and mixed-grass types | • Potential for eastward expansion of short-grass and a contraction of mixed-grass. |
| Persistence of microhabitats, endangered habitats | • May see the greatest losses of more rare microhabitats, especially those that cannot tolerate much drier conditions. |
| Availability of bare and very short grass habitat-type | • Drought forces ranchers to "manage to the middle" because stocking rates and limited (i.e., you cannot graze enough head of cattle to create the bare ground grassland structure). |
| Plant species composition | • Drier conditions may favor woody species and those with deeper tap-roots. |
| Plant productivity and phenology | • Changes in plant productivity, phenology, and timing of peak nutrient content may impact when management actions occur.<br>• Potential for increased conflict between timing of management activities and critical nesting periods for birds. (BUT depends on relative phenological shifts for birds, vegetation, and managers). |
| Level of protection of grasslands | • Shifts in grassland distribution may move habitats outside of protected areas. |

| | |
|---|---|
| Invasive species | • Potential for expansion of current invasive species and arrival of new invasive species (e.g., woody native vegetation, disturbance-fed invasive species, and species that are planted and then expand). |
| Woody plant invasion | • Woody plant abundance may increase due to drier conditions and increased $CO_2$. |
| Fire | • Not clear what the net effect will be on natural fire in GP-LCC grasslands: On the one hand, drier conditions = less productivity = lower and less continuous fuel loads = less fire. On the other hand, drier conditions = more difficult to implement prescribed fire = build-up of fuel loads = more natural fire.<br>• Increased inter-annual precipitation variability may lead to some years where productivity is high, creating high fuel loads and increased fire risk. |
| Grazing | • Increased drought is likely to lead to increased grazing on Conservation Reserve Program lands, and a loss of the more "rested" grassland structure. |
| Haying | • Extreme rain events may inhibit haying because it gets too wet during critical times (this happened in some places in summer 2010). |
| Prairie dogs | • Drought depresses prairie dog populations -increasing area impacted by colonies at lower densities. |
| Soils and erosion | • Increased rain intensity may create flash flooding, erosion and down-cutting. |
| Remobilization of sand dunes | • Drought and increased warming trends could lead to a remobilization of the Sandhill Dunes (and other dune systems in the GP-LCC), leading to a loss of grasslands on the dunes themselves, and the deposition of sand onto other grassland areas. |
| Desertification | • Potential for expansion of Chihuahuan Desert into southern part of GP-LCC |
| Aquifer recharge and hydrology | • Remobilization of dunes could reduce aquifer recharge due to decreased infiltration and absorption by dune vegetation.<br>• Water extraction for urban use likely to increase with warmer and drier conditions.<br>• Decrease in the "sponge effect" of grasslands during droughts and extreme rain events.<br>• In more flat areas (e.g., playas, lakes, places where water is near the surface), recharge may increase with larger rain events because current rain events can be too small to result in recharge. (In areas with more topography, erosion problem may outweigh potential for increased recharge).<br>• Decrease in snow in winter due to warmer temperatures may decrease infiltration and recharge. |
| Bird nesting success | • Some evidence that extreme rain events correlates with reduced nesting success of a few bird species, although cause is unknown. |

**Appendix 5. Identification of Strategic Management and Conservation Actions to Address Climate Change Impacts on Great Plains LCC Grasslands and Wildlife.** [Note: actions listed have not been evaluated for cost or political feasibility, practicality, or other factors].

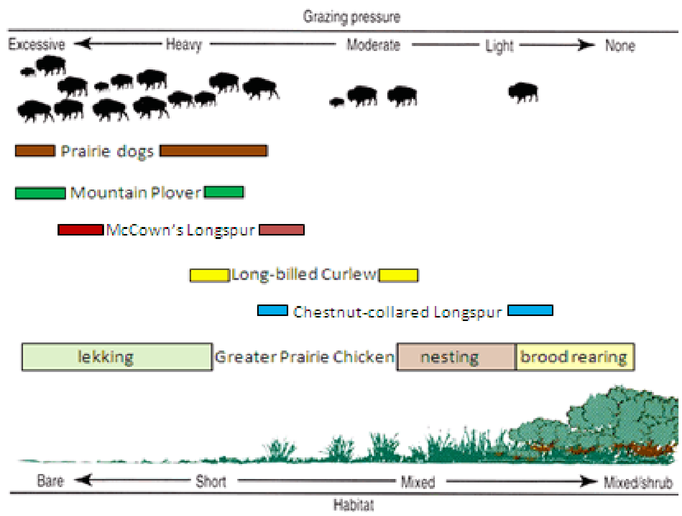
| Intervention Point | Main Scenario Strategic Actions |
|---|---|
| Grazing Management | • Refine grazing management to adjust to changes in plant productivity – monitor productivity and adjust grazing intensity accordingly.<br>• Work with family farmers on land management – manage bison or cattle to mimic historic grazing patterns.<br>• Public land grazing – demonstration projects to use during workshops to demonstrate how to graze towards a grassland with heterogeneous structure.<br>• Provide a grazing model that meets both economic and conservation needs.<br>• "Best practices" guidance for how to manage lands for diverse grassland structure (grazing, but probably other land management activities too). Major Land Resource Areas (MLRAs) – give you a jumping off point for ecoregional perspective and scale. Best practices need to clearly connect to successful economic models for ranchers (connect practices to the endpoint that landowners value – e.g., weight gain on cattle). How do you manage today to sustain through an extended drought? |
| Land protection and restoration | • Increased land protection needed – Great Plains grasslands are one of the least protected ecosystems in the world, and if systems are going to shift around, we need more protected lands.<br>• Identify a core number of areas within the GP-LCC across public and private lands – establish "demonstration areas" to lead by example in providing the type of heterogeneous habitat structure distribution at sufficient scale. Use the different land management tools available (grazing, fire, etc.) and capitalize on different incentive programs to show how it can be done (lead by doing). Involve landowners and landowner groups in the identification of these demonstration places, and development of the projects. [e.g., Rocky Mountain Bird Observatory has developed a grassland cooperative (i.e., grass bank), and there's an effort to bring together other grassland cooperatives from around the west]<br>• Target grassland restoration and conservation in areas that will create more or larger blocks of grassland habitat to increase connectivity and allow birds to move in their search for new or better habitat as drivers change.<br>• Focus on core habitats and corridors/connectivity of highest priority and importance (i.e., those that connect important core areas). To what extent has this mapping been done, or is further analysis needed?<br>• Do a spatial analysis to get a handle on how much of different habitat types are out there on both public and private lands, and what habitat types are less well-represented. Also clear mapping of land ownership. Use state, federal and organizational lands to fill in the gaps of the types of habitat that are lacking across private lands. May require expanding parcels of state, federal and organizational lands in order to fill those gaps at sufficiently large scale and across the GP-LCC region.<br>• Assess current land cover, and define what core habitat areas are and where they are located to inform state technical committees, Environmental Benefit Indices, and to guide standards and activities.<br>• Increase funding for the Grassland Reserve Program to place more easements on grasslands and keep more lands un-tilled.<br>• Work with and encourage conservation ranchers. |
| Policy and Incentives | • Policy changes at the Federal, State, and County levels as outlined below:<br>• Policies to help convert old CRP lands that are coming out of the program to grazing lands rather than crops – to include restrictions |

| | |
|---|---|
| | on seed mixtures to encourage planting of native seed mixes appropriate for the local area. May require incentives/cost-share options to help fund the use of alternate seed mixes.<br>• In areas that are irrigated agriculture – policies that will help convert from irrigated agriculture to dryland agriculture or grazing (more water-efficient practices).<br>• Develop and implement (and enforce) management plans for CRP lands, and allow for mid-contract management changes.<br>• Greater involvement of state and university extension services and NRCS state technical committees in these discussions.<br>• Provide cost-share and incentives to keep grasslands in place (i.e., Wyoming EQIP).<br>• Work with existing USDA and other programs to maintain and/or expand and incentivize beginning farmer and ranching programs (e.g., FSA loan programs, matching existing farmers with new farmers trying to get started).<br>• Policy changes to remove incentives to continue/start agriculture in areas that are unsustainable. Reduce commodity payments and increase conservation payments.<br>• Increase payments for family farmers – incentives for non-traditional businesses, tourism, ecosystem service payments, development of alternative industries and retirement incomes. |
| Invasive Species Management | • Increase the inventory and monitoring efforts of invasives and exotics, and increase vigilance and management of invasives.<br>• Try to be proactive rather than reactive (e.g., cleaning off vehicles and equipment). |
| Water conservation | • Water conservation activities to conserve water and increase aquifer recharge. |
| Fire Management | • Increased guidance and planning on how to use prescribed fires in a drier environment. Possibly altering/reviewing the timing of when prescribed fires are applied.<br>• Re-establishing natural fire processes (although it's not clear what the new "natural" fire regime will be under altered climate conditions). |
| Cross-jurisdictional and cross-scale coordination | • Need to link between the state level and county level since CRP decisions are influenced by both.<br>• Some information is being generated at the state level (e.g., mapping of core areas and connectivity and prioritization of habitats and areas) that can help then drive activities at finer scales.<br>• Get more landowners involved at the decision-making level (e.g., NRCS state technical committee meetings) so that when decisions come down from the state level, there's already been landowners involvement and acceptance is higher. |
| Integration of science and management | • Need to have strong science backing up recommendations for what activities are needed, and then measurable outcomes.<br>• Look at resources available in the The Nature Conservancy short-grass and mixed-grass ecoregional analyses to help set priorities (TNC is starting to look at these analyses through the lens of climate change). |
| Stakeholder outreach and education | • Need to increase involvement of landowners in these discussions, and provide them with information to balance out other sources of information they may be receiving.<br>• Technology transfer to influence land management towards the heterogeneity goal (e.g., Pawnee and Crow Valley Association).<br>• The more research we have that talks about the need for heterogeneity on the landscape, the more it will become understood and accepted. |

**Apppendix 6.** Sample outreach materials for private and reserve managers (next page). We envision separate documents for private livestock producers and reserve managers (FWS refuges, TNC sites, NPS holdings). The intent of these documents is to inform and engage managers in thinking beyond current practices and climate conditions. We offer a draft here.

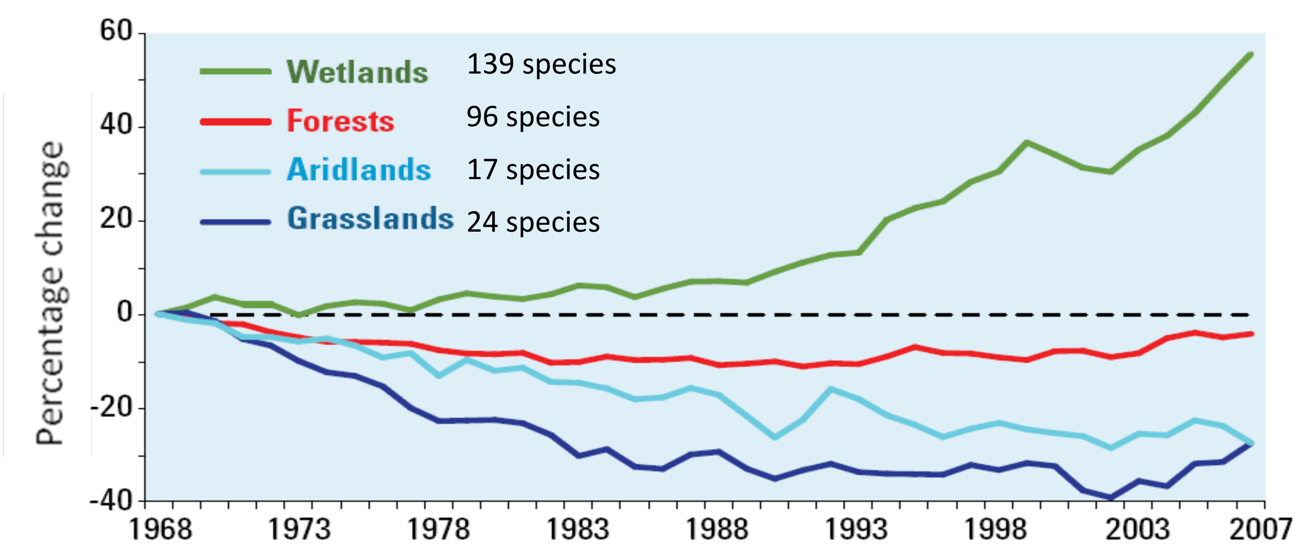
## Great Plains wildlife & grazing

Many species of grassland wildlife have specialized on different habitat types. These associations represent the historic impacts of large herds of free-ranging grazers (see figure at right) whose movements were affected by drought, predators, and fires. Specialization on habitats primarily created and maintained by grazing meant that these species had to track habitats shifting in space and time. However, these habitats were also present in a landscape-scale mosaic. Today, with fencing, many habitat patches are smaller and more similar structurally than in the past.



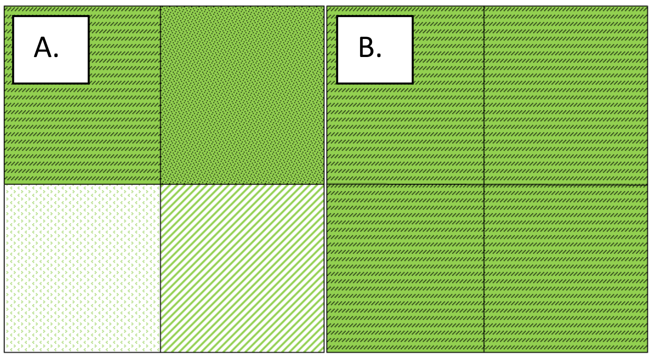

Habitat associations between grassland species and grazing (after Knopf 1996). Species like prairie chickens use different habitats seasonally.

Such changes in habitat availability and quality are of particular concern because grassland birds have been declining consistently since the 1960s (U.S. State of the Birds 2009). Habitat patch size is one thing that grazing managers can largely control. Patch size is important because most grassland birds nest on the ground and are exposed to many sources of nest failure. Most species have rates of 25-40% nest success and hence re-nest several times per season in attempts to produce young. More habitat is needed to locate multiple nest attempts in and evade predators.



## Managing for wildlife & livestock

Different pasture usage can improve the scale of habitat available for grassland birds. In the example below, small pastures can be managed separately (A) during a rotational grazing program or as a single block of habitat (B). The latter case would attract more individuals of a reduced diversity of species and would be more productive for the species using that habitat (nearly all grassland birds nest on the ground). Larger patches can produce more birds as there are more sites to nest and re-nest following predation.





Nearly all grassland birds nest on the ground and most face nest failure rates of 60-75%. Hence, most nest several times per season in attempts to produce young.

The Great Plains Landscape Conservation Cooperative (LCC) is a group of science, management, and conservation partners dedicated to conserving the landscape outlined (at right). This document is intended to encourage the development of new practices that can increase benefits for producers and wildlife. Projected changes in temperature, available moisture and the severity of droughts suggest that more planning for range management practices are needed to best serve concerns for both wildlife and ranching economics.

If you are interested in learning more about this partnership, we encourage you to contact us and we will provide you with a copy of our Action plan.

James Broska
Science Coordinator- GP LCC
US Fish and Wildlife Service Or
Michael Carter
GP LCC Coordinator