GREAT PLAINS REGIONAL TECHNICAL INPUT REPORT

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Great Plains Regional Technical Input Report

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Printed on recycled, acid-free paper

Manufactured in the United States of America

10 9 8 7 6 5 4 3 2 1

Citation: Ojima, D.S., J. Steiner, S. McNeeley, K. Cozetto, A.N. Childress., A. Cole, J. Brown, G. Collins, L. Ferris, B. Gough, J. Gross, J. Hestbeck, D. Kluck, R. McMullen, J. Rattling Leaf, M. Shafer, M. Shulski, J. Yarbrough, M. Drummond, J. Morgan, T. Howell, S. Markstrom, H. Lazrus, K. Averyt, S. Skagens, K. Kunkel, L. Stevens, S. Stevens, M. Kruk, D. Thomas, E. Janssen, K. Hubbard, N. Umphlett, K. Robbins, L. Romolo, A. Akyuz, T. Pathak, T. Beragntino, E. Wood, K. Miller, B. Gascoigne, S. Tellinghouse, V. Tidwell, C. Aldridge, M. Rose, L. Wellings, T. Brown, J. Ramirez. 2015. *Great Plains Regional Technical Input Report*. Washington, DC: Island Press.

Keywords: climate change, Great Plains, National Climate Assessment, water resources, natural resources, agricultural system, conservation, land management, energy resources, human health, disease, adaption, mitigation, tribal landscapes, strategies

About This Series

This report is published as one of a series of technical inputs to the Third National Climate Assessment (NCA) report. The NCA is being conducted under the auspices of the Global Change Research Act of 1990, which requires a report to the President and Congress every four years on the status of climate change science and impacts. The NCA informs the nation about already observed changes, the current status of the climate, and anticipated trends for the future. The NCA report process integrates scientific information from multiple sources and sectors to highlight key findings and significant gaps in our knowledge. Findings from the NCA provide input to federal science priorities and are used by U.S. citizens, communities and businesses as they create more sustainable and environmentally sound plans for the nation's future.

In fall of 2011, the NCA requested technical input from a broad range of experts in academia, private industry, state and local governments, non-governmental organizations, professional societies, and impacted communities, with the intent of producing a better informed and more useful report. In particular, the eight NCA regions, as well as the Coastal and the Ocean biogeographical regions, were asked to contribute technical input reports highlighting past climate trends, projected climate change, and impacts to specific sectors in their regions. Each region established its own process for developing this technical input. The lead authors for related chapters in the Third NCA report, which will include a much shorter synthesis of climate change for each region, are using these technical input reports as important source material. By publishing this series of regional technical input reports, Island Press hopes to make this rich collection of information more widely available.

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Acknowledgments

The convening lead authors for this report were Dennis S. Ojima, Colorado State University, and Jean Steiner, USDA-ARS. We thank the following partners for their invaluable contributions, insights, and feedback:

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Support provided by

Support for the Great Plains assessment technical team was provided by Colorado State University, Department of Interior North Central Climate Science Center and the United States Geological Survey, United States Department of Agriculture-Agricultural Research Service. Additional support came from the National Park Service, USDA Natural Resources Conservation Service, US Forest Service, US Environmental Protection Agency Region 8, National Ocean Atmospheric Administration, Western Water Assessment Regional Integrated Sciences and Assessment Center (RISA), Southern Climate Impacts Planning Program RISA, Colorado State University, University of Colorado-Boulder, University of Nebraska-Lincoln, National Center for Atmospheric Research, and the Intertribal Council On Utility Policy.

Acronyms

ASCE	American Society of Civil Engineers
CCC	Canadian Climate Center
CCS	carbon capture and sequestration
CO ₂	carbon dioxide
COOP	Cooperative Observer Network
CRP	Conservation Reserve Program
CSC	DOI Regional Climate Science Centers
EAP	Emergency Action Plan
EPA	Environmental Protection Agency
EWe	ethanol
FEMA	Federal Emergency Management Agency
GHG	Greenhouse gas
HAD	Hadley Center
N ₂ O	Nitrous oxide
NARCCAP	North American Regional Climate Change Assessment Report
NCDC	National Climate Data Center
NFIP	National Flood Insurance Program
NGO	nongovernmental organizations
NOAA	National Oceanic and Atmospheric Administration
NRCS	National Resources Conservation Service
NWS	National Weather Service
OTSA	Oklahoma Tribal Statistical Area
PET	potential evapotranspiration
RISA	Regional Integrated Science and Assessment

RPS	Renewable Portfolio Standard
TCW	total consumptive water
UHI	urban heat island
USDA	U.S. Department of Agriculture
WGA	Western Governors' Association
WSWC	Western States Water Council

Executive Summary

Great Plains Systems and Climate Change assesses how the Great Plains social-ecological system has been shaped by changing climate conditions and how future projections of climate change will result in a need for further adaptation and preparedness. This effort is part of the 2014 United States Global Change Research Program National Climate Assessment as required by the United States Congress.

The Great Plains region plays a very important role in providing food and energy to the economy of the United States from the great corn and wheat fields and rangelands in the agricultural sector, the Bakken Shale formation in North Dakota, the abundant coal and coal bed methane in the Wyoming and Montana Powder River Basin, bioenergy and wind farms in Texas in the energy sector. This makes the economy and livelihoods in the region extremely sensitive to climate, which means big implications of climate change impacts on the Great Plains region as well as mitigation strategies to reduce greenhouse gases critically important for the entire country. The region is also the home to 65 registered Native American tribes who stand to be vulnerable to climate change while also potentially contributing to innovation in sustainable practices and an alternative energy future. This all makes the Great Plains a complex and interesting place to look at the impacts of climate variability and change.

The Great Plains region is characterized by both high spatial and high temporal climate variability, however, throughout the region **climate change is already happening in the Great Plains** with an overall warming trend over the last 20 years both annually and in the summer. Climate change is being experienced in a variety of ways such as increased night-time temperature, increased intensity of extreme precipitation events, extended growing season, extended severe droughts, and elevated atmospheric CO₂ concentrations. Climate change is projected to continue into the future with more extreme heat events, droughts, and floods. Expected impacts include decreased water availability and increased competition for uses, changed water quality, expansion of weeds, pests, and diseases, changes to plant-animal communities and species composition, altered fire and storm patterns, and tree mortality, among others. Combined with changes in land use and land management, socio-economic and demographic changes, and uncertainty of our energy future, climate change will have substantial impacts on the ability to sustain natural resources, livelihoods, and well being in the Great Plains.

Over the last decade the region has seen significant extremes in climate and weather events from flooding in the Missouri River Basin, to exceptional drought in the Southern Plains, to fires and tornadoes resulting in billions of dollars in economic damage, morbidity, and mortality. Some of this unusual weather is the result of normal climate variability, but many climate experts understand these extremes as indicators of emerging climate changes, if not already a signal that we are seeing effects of a warming planet.

Key Findings

Multiple climatic and non-climatic stressors, of which climate change is one among many, put multiple sectors, livelihoods and communities at risk. The most vulnerable in the region are agriculture, water, ecosystems and rural and tribal communities.

The Great Plains climate is warming, and as of 2011, eight of the last ten summers have been above average temperature. Climate observations in the Great Plains show the warmest years on record were a tie between 1934 and 2006. The Northern Great Plains has experienced the most significant warming where North Dakota, for example, has experienced an annual average temperature increase of 0.26°F per decade during the last 130 years, the fastest increase in the nation. Growing season has extended with first freeze in the fall coming later and last freeze in the spring coming earlier; the average growing season is longer by about 6 days from 1991-2010 compared to 1961-1990. Annual precipitation was greater than normal during the 1990s, less than normal during the early 2000s when most of the western U.S. experienced severe drought, and greater than normal in the last few years. However, while some areas experienced major flooding such as in the Northern Great Plains, other areas were simultaneously experiencing extreme drought conditions such as in the Southern Great Plains. This shows that climate change will not manifest in a uniform way across the Great Plains and that preparations must be made within geographic sub-regions to deal with a range of extreme weather and climate conditions.

Extreme hot temperatures will increase and climate projections show that temperature increases will be the largest in the summertime, which has huge implications for more heat waves, energy and water demands, and water scarcity. Mean summer temperature increases are projected to be 3.3°F in 2035, 5.4°F in 2055, and 9°F in 2085. The number of days above 100°F are projected to increase by 15 days by mid-Century with heat wave events nearly doubling in length.

Climate change impacts to the hydrological cycles will be felt throughout the region and across all sectors. Changes in precipitation patterns, the timing of seasonality of rain and snow and the alterations of large scale circulation patterns have major impacts on water availability in the region. Decreased snowfall in lower mountain elevations combined with earlier snow melt and earlier spring runoff will have big impacts on the timing and amount of streamflow affecting irrigators and other diverters and users of surface water resources. This can also affect lead to diminished late season streamflow, which impacts fish and riparian ecosystem health as well as the ability for late summer/early fall irrigation of crops. Increased conflict between competing users of water is likely to increase within and between states.

- **The Northern Great Plains region is expected to increase in extreme precipitation events, leading to more damaging flooding in some areas.** Heavy precipitation events could increase as high as 30% in some areas, such as South Dakota where flood disasters have been considerable over the last decade.
- **Drought is expected to increase, especially in the already drier western portions of the Great Plains.** The 2011 drought in the Southern Plains is consistent with climate projections, however, it is also strongly associated with natural variability and specifically the La Niña phase of El Niño Southern Oscillation.

Both climate variability and climate change increase drought risk for the region, and while some efforts are already underway as discussed in Chapters 8 and 9 of this report, much more effort is needed for assessment of drought vulnerability and for preparing for the impacts of extended severe droughts that are expected in the future.

- **Groundwater that is already stressed in the Great Plains, such as in the High Plains (Ogallala) Aquifer region will be exacerbated by climate change.** A combination of increased groundwater pumping, diminished water quality, drought, salinization, increased temperatures and evapotranspiration, and a variety of interacting surface and sub-surface dynamics all threaten the sustainability of groundwater in the region, all of which will likely be exacerbated by the effects of climate change.

Crops will be impacted differently across the Great Plains where some areas will benefit from a longer growing season and more rainfall where others parts will experience decreased productivity because of drought and extreme temperatures. Extended growing season could provide more options for crop diversification.

Bioenergy production is an area of potential economic development in the United States, especially in rural areas, as well as a potential source to contribute to domestic energy independence and reduction of fossil fuel use and greenhouse gas emissions, however, the limits in the Great Plains must be carefully considered. One limitation on the expansion of corn ethanol production in the Great Plains is the use of ground water in already vulnerable and water-stressed areas. Careful consideration must be given to producing corn ethanol in areas that are not already at high risk for water stress. Several states in the Great Plains region are being threatened by water shortages across local, state, and regional scale, yet, there is an economic incentive, and pressure to grow corn for energy in the High Plains is strong where irrigation costs are comparatively small to the amount of increased production it results in. Competition between water for biofuels and other demands will be highest in the nation in the High Plains region. These regional tradeoffs that must be considered between fossil fuel energy, renewable energy to meet Renewable Portfolio Standards (RPSs), and the water necessary to meet these economic and environmental goals. It is critical to take regional and local context into account for policy and planning across all scales of governance; and it requires careful planning at the watershed level within and between states at a regional level. Some experts have suggested “next generation” biofeed stock such as perennial grasses and woody biomass will help meet the needs for bioenergy, however, the extent to which this potential exists or is limited by local and regional conditions in the Great Plains has yet to be determined.

The many Native American tribes throughout the Great Plains are located in relatively marginal areas lacking access to fertile soils, appropriate housing, electricity and energy sources, food and water sources. All of this makes many tribal members highly vulnerable to the impacts of climate change. However, many tribal governments have started the process of developing and sustaining viable economies on their lands and providing a set of strategies to cope with climate change.

The population of the Great Plains has been moving into urban areas, which will also see many impacts from climate change. Increased temperatures will lead to

more heat wave events and increased morbidity and mortality of the highly vulnerable populations in cities. Heat waves with long stretches over 100°F will increase leading to problems with transportation infrastructure as well as loads on electricity systems, highly dependent on water for cooling. When heat events combine with droughts this can be disastrous for cities when heat and water scarcity threaten power outages, water use curtailment, and heavy damages to crops and livestock as Texas has experienced in 2011. Climate change will also bring intense storms taxing already stressed stormwater and sewage infrastructure and water quality.

The nexus between water and energy is increasingly important to understand as climate change complicates this already complex relationship. Water is needed for energy extraction, production, and power; energy is needed to move and treat water. Mitigation and adaptation strategies must take into consideration the water-energy nexus as choices about our energy future require tradeoffs for the use of land and water; and adaptation choices must be made in the context of large uncertainties about the availability of both. Because of the importance of energy and water in the Great Plains, the water-energy nexus is critical to understand.

Ecosystems are already stressed by climate variability and change such as droughts, floods, and winter storms that have altered plant community phenology, hydrological dynamics of streamflow and wetland dynamics. Warming water temperatures are already pushing aquatic species to their limits, and combined with multiple stressors such as impoundments, diversions, sedimentation, decreased water quality, and the changing of the timing and amount of hydrological events critical to breeding or migration times will be exacerbated by climate change. Some species will be pushed past their threshold limits as a result.

Climate change will shift the geographic distribution of diseases in the Great Plains, which will affect human, ecosystem, and livestock health.

Multiple coping response and adaptation strategies are already being implemented by state and federal agencies, urban areas, tribes, and natural resource managers in decision makers in the Great Plains. However, there must be continued support across all levels of government as well as the private sector and industry to adequately mitigate and adapt to climate change.

Research needs

Effectively addressing climate change and its effects on ecosystems, resources, and society will require coordination in the research and observation capabilities of multiple organizations, institutions, and government programs. This report outlines a rich and varied set of activities to address climate change, however, it is apparent that there are few well-coordinated efforts between agencies or institutions. There is an additional challenge of knowledge dissemination and monitoring of impacts, vulnerabilities, and adaptations or coping strategies for responding to or preparing for climate change. This lack of coordination and communication results in a great inefficiency and ability to assess climate change impacts to focus research activities more strategically in the region. However, some good examples are emerging such as the initiatives of the Western Governors Association (WGA), the Western Federal Agency Support Team (discussed

in Chapter 9). Wherever possible participatory research, iterative risk-based analysis between researchers and stakeholders, natural resource managers, policy makers are needed for collaborative decision making to deal with the impacts of climate change.

Research efforts have brought attention to the role ecosystems have in providing key economic goods and the ecosystem services that sustain, regulate, and support life on Earth (Costanza et al. 1997, Daily 1997, Daily and Ellison 2002). But the societal and ecological contributions of the ‘underpinning’ services provided by ecosystems often remain ‘invisible’ and unvalued (or undervalued). The array of such services is broad, from those services that regulate critical human-environment processes (e.g., climate, disease, flooding, detoxification) to services that support economic activity (e.g., soil formation, primary productivity, nutrient cycling, pest control, pollination).

Incorporating ecosystem services into the decision making process allow managers to better understand effects of land use and management. Development of a more robust adaptive management approach that recognizes the existence of transitioning landscapes (e.g., shrub invasion of grasslands) and the importance of change as a basic component of the system dynamic (Berkes and Folke 1998; Gunderson and Holling 2002; Walker and Meyers 2004; Tschakert et al. 2007) needs further attention.

Forecasting technologies have advanced tremendously over the past decade; incorporating field observations, remote sensing, and modeling systems to provide seasonal forecasts of crop and ecosystem productivity. In addition, observations of ecosystem indicators associated with biotic assemblages (e.g., host-pest relationships), ecosystem functions (e.g., water use efficiency, nutrient cycling, and carbon storage and fluxes), and structural changes (e.g., woody to herbaceous ratio, bare soil exposure) can provide clues to emerging dangerous thresholds. Complex multi-dimensionality of ecological thresholds can be resolved through the use of integrative modeling and analytical approaches. Development of a threshold prognostic or ecological forecasting tool to evaluate probabilities of achieving a threshold event would be extremely helpful in managing natural resources and developing adaptive management strategies to maintain ecosystem services. A number of ecosystem services can also be monitored to assess the impacts of change to society and vice versa.

A systems approach which incorporates aspects of ecosystem services, livelihoods, and ecosystem integrity needs further development. A number of approaches on social-ecological vulnerabilities have been developed over the past decade or more (Adger et al., 2001, Moss et al., 2000; Turner et al. 2003 (Ford et al. 2010, Adger et al. 2007, Adger et al. 2004, Fussel and Klein 2006, Smit and Wandel 2006). Such approaches allow for better integration of environmental and societal metrics and variables to evaluate social-ecological vulnerability. These analyses would provide greater insight to the range of coping choices to make under various levels of adaptive capacity.

Adaptive capacity is constrained by factors that restrict people’s set of options to choose from when environmental and social conditions change (Berkes and Folke 1998, Gunderson and Holling 2002). Institutional hierarchies often constrain adaptive mechanisms operating at the community level, determining in part how adaptation to climate change manifests through policy processes (Adger and Kelly 1999). Institutional responses to climate change are often best suited for mitigation of emergency situations and isolated events, rather than for slower onset, cumulative or systemic climate-related

problems leading to disruption of social and ecosystem services. Institutional and regulatory entities are less well-suited to working with underlying social factors that determine vulnerability (Handmer et al. 1999). Where institutional rule-making occurs in a compartmentalized and fragmented framework, responses to climate change have been either nonexistent in the worst case, or case-based mitigation in the best case (McNeeley 2011).

Both scientists and managers suggested solutions or products that could reduce management barriers and improve climate change response. The reinforcement of partnerships was a common theme that was promoted through the workshop. Managers noted the need for a centralized mechanism to communicate current and ongoing research projects in the region. Products that promote education and awareness of local climate change issues, including additional webinars and workshops, were seen as critical to engage stakeholders and inspire action. Climate change can also present opportunities; for example, carbon sequestration can be a driver for implementing grassland restoration projects. Other participants suggested more specific measures, such as implementing changes in breeds or species of grazers to cope with changes in forage productivity or composition. New technologies can be integrated into management, such as the transmission of real-time remote-sensing data through wireless devices to better inform day-to-day management decisions, or use of social networking to bring together stakeholders.

There are lessons to be learned from efforts of the WGA that illustrate how state, federal, tribal, and academic communities can work in a coordinated fashion to develop and implement strategies to deal with critical regional needs related to climate change. Issues, including water resources, land use, forest fire, and conservation needs, have been proactively addressed over the years, as mentioned above. The WGA has helped to define issues and to provide a framework to address these across the West. Other regional efforts include river basin initiatives, such as the Missouri River Basin efforts and the various agency coordination efforts to deal with flood control, land use practices, and conservation efforts. These bodies have a goal to provide better communication and, where needed, coordination of actions to deal with specific issues. The energy sector also has regional action groups, as mentioned in previous sections of this report. However, assessments of climate change impacts and long-lasting climate change solutions need to be developed across sectors and include multiple stakeholders. We need to create a platform to support this more integrative effort in the research and the management activities implemented across the Great Plains.