

Ecological Drought in the North Central United States

Droughts of the future will not be the droughts of the past

North Central Climate Science Center Workshop
December 7–8, 2015
Fort Collins, Colorado

The Department of the Interior Climate Science Centers (CSCs) and their managing organization, the National Climate Change and Wildlife Science Center at the U.S. Geological Survey, have chosen the emerging climate science field of Ecological Drought as a research focus area. However, there is currently no working framework for drought-induced ecological impacts, and drought planning capabilities are needed for biodiversity conservation and the ecosystem services that natural areas provide. This workshop is part of a series of meetings at each of the nation's eight CSCs aimed at collating our existing knowledge of the ecological impacts, resistance, and recovery from drought to help chart the way forward for related research activities and management options. The eight CSCs provide a fantastic opportunity to consider ecological drought across different regions, spatial scales, and biomes.

Droughts of the future will not be droughts of the past

A dramatic example of desertification in the United States occurred on the Great Plains. Ranchers overgrazed the land and farmers overworked the soil and the great drought of the 1930's turned the Plains into a raging Dust Bowl. Fortunately, thanks to conservation efforts and a series of wet years in the 1940's, the Great Plains recovered. Our past has shown us that water influences all aspects of life in the North Central United States and a better understanding of climate and careful land management choices can help sustain both healthy ecosystems and prosperous livelihoods. However, future climate projections indicate that the climate of the past is not necessarily the climate of the future, and there are indications that . . .

Ecosystems will be challenged by future climate

The North Central U.S. is characterized by awe-inspiring natural landscapes; from the snow-capped Rockies in the West to the vast prairie grasslands in the East, and an immense network of streams, rivers, and wetlands running throughout. The amount of precipitation, magnitude of storms, duration of snow pack, timing of spring thaw, and changes in soil moisture during the growing season are all likely to change in the future. All have important effects on the frequency, size, and severity of forest disturbances like wildfires and insect outbreaks. Each of these changes have different implications for the diverse ecosystems in the region.

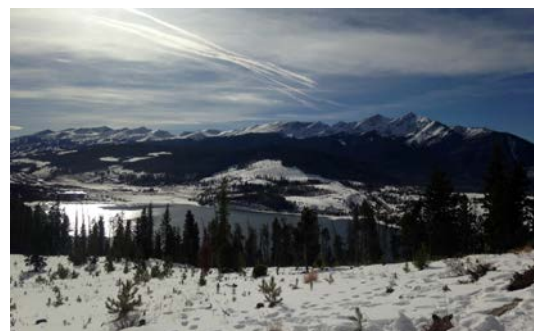
Landscapes and wildlife are at risk

The North Central U.S. is home to many iconic wildlife species, such as the grizzly bear, gray wolf, American bison, and cutthroat trout. Migratory birds travel the Central Flyway and utilize the Great Plains for habitat and as a stopover on their migration. All of these species are vulnerable to increasing temperatures, seasonal changes to the water cycle, and/or negative interactions with non-native species.

Strong connections to land and waters will be disrupted

The residents of the North Central U.S. have strong cultural connections to the land and water. Projected short- and long-term changes in climate will affect many aspects of the North Central U.S., with already threatened water resources, including essential agricultural and ranching activities, unique natural and protected areas, and the social and economic well-being of its citizens.

Therefore the North Central Climate Science Center is committed to building a better understanding of how changes in climate will impact ecosystems and wildlife in the coupled human-natural systems of the North Central U.S.



Brianne Walsh



USFWS



USDA

Rising temperatures and rising demands equal greater risk

Droughts are a natural process in the North Central United States

Drought is a naturally occurring feature of climate in the North Central U.S. and Great Plains Region, and historically, the region has experienced prolonged droughts. Forests in the North Central U.S. are disturbance adapted (e.g. fire, insect outbreaks). As such, natural functioning, habitat integrity, and ecological services provided by forests are a result of past disturbance regimes (e.g. frequency, size, and severity of disturbances). However, as the impacts of climate change become more widespread, forests will experience a departure from the historical disturbance regime, potentially exceeding the limits of resilience.

At what point do droughts become too large, and too prolonged, for the ecosystems of the North Central U.S. to maintain their normal state?

Higher temperatures exacerbate drought

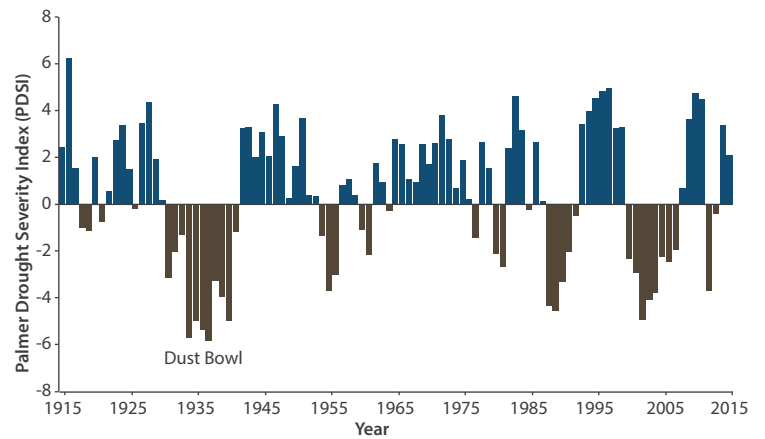
Average temperatures in the North Central U.S. have increased approximately 1.0°C (1.8°F) over the last five decades. Temperatures are projected to continue to increase, with larger changes in the summer months, leading to increases in evapotranspiration and changes in soil hydrology. Precipitation is projected to change, particularly in the winter and spring, with conditions becoming wetter in the north and drier in the south. Warming temperatures in the central United States have resulted in the shift from snow to rain, a decrease in snow cover extent, and earlier spring melt.

To what extent will the interactions between increasing temperatures and changes in hydrological cycle play out on the ecological processes in the region?

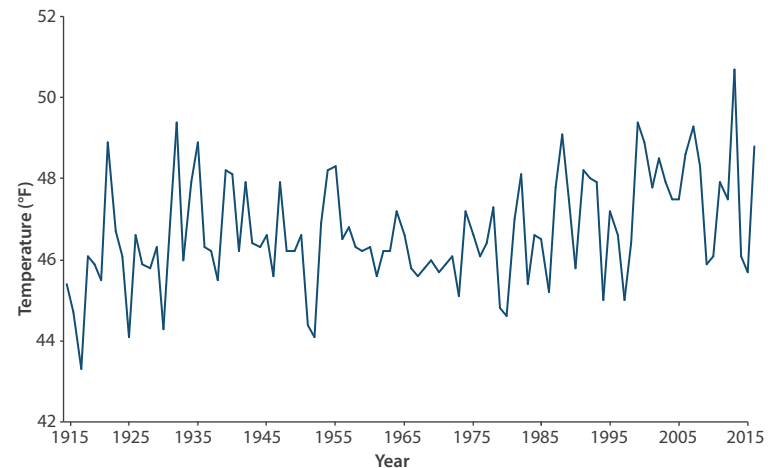
Greater demand for less water

Increased competition for limited water resources will significantly affect both human and ecological communities in the North Central U.S. Changes in the water balance and stream flow in this region will impact the fauna and flora of the region. However, the hydrological demands of a healthy ecosystem must be balanced against the demands of municipal water supply, agricultural irrigation, and navigation.

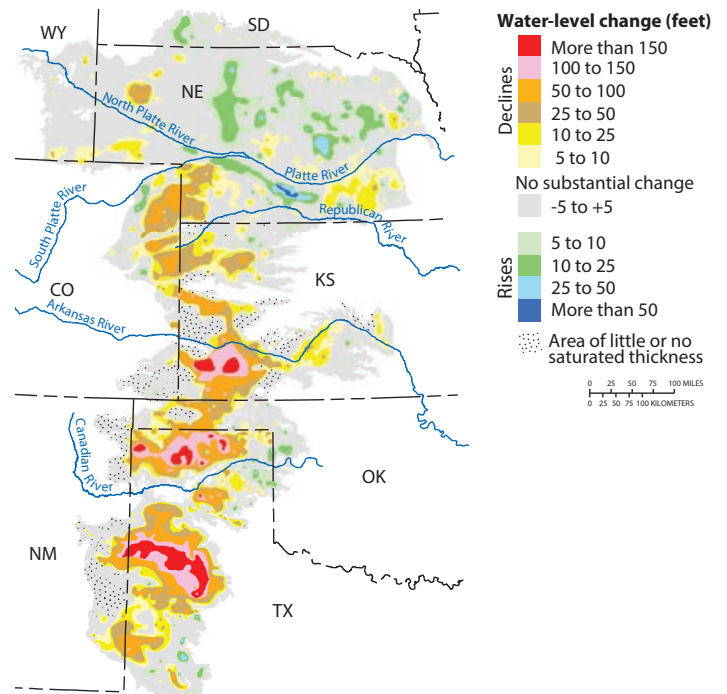
Do these somewhat competing demands run the risk of becoming more adversarial with changes in climate?



Palmer Drought Severity Index (PDSI) for the Northern Rockies and Plains for years 1915 to 2015. Interspersed conditions of drought (negative values) and non-drought (positive values) conditions have occurred historically over the past 100 years. Data: NOAA Climatic Data Center/NESDIS.



Average January-December temperatures in the National Weather Service Central region. Following a period of relatively stable temperatures, average winter temperatures began to increase around the 1970s. Data from NOAA National Centers for Environmental Information.



Water-level changes in the High Plains aquifer, predevelopment (about 1950), to 2013. The aquifers of the great plains are rising in the North but declining in the South. Adapted from McGuire, V.L. 2014. USGS Scientific Investigations Report 2014-5218.

Ecological drought threatens the resilient landscapes of the North Central U.S.

Drought is a normal feature in the North Central U.S. climate. Yet, as the North Central U.S. continues to warm, and the impacts of climate change are more widespread, the threat of ecological drought has the potential to result in major social and ecological impacts. Historically, the region has been able to adapt and rebound from droughts, however; as humans have manipulated the landscapes, with the added impacts of climate change, the resilience of the North Central United States region may be reaching a tipping point in drought recovery. The ecosystems of the North Central United States are shaped by contrasts in climate and topography, and each ecoregion is threatened by ecological drought on a local and regional level.

Predevelopment (early 1900’): natural processes dominated the hydrologic cycle.






The present day (2016): water extraction for agricultural and urban use have changed groundwater flows, and climate change has impacted the hydrologic cycle.





Future trajectories of water use: highly modified water systems (dams and reservoirs) depleting the groundwater aquifer exacerbated by climate change, fires, and forest pests.




Climate impacts

-  Shift in precipitation from snow to rain.
-  Increase in cloud cover.
-  Reduction in snow pack reduces water available during spring freshet and downstream ecosystems, and reduces aquifer recharge capacity.




Hydrological impacts

-  Water extraction for agricultural and urban use have increased the depth of groundwater aquifers.
-  The construction of dams and reservoirs have modified stream flows and reduced ecologically available water downstream and for aquifer recharge.




Social impacts

-  Lack of snow can shorten ski season and reduce water availability for summer water-dependent recreation such as rafting.

Ecosystem impacts

-  The timing and length of snow season can have major impacts on the life histories of Great Plains flora and fauna.
-  Snow season length influences growing season length, which can lead to changes in plant species ranges, and changes in phenology.
-  Changes in timing of snowmelt and freeze-up can influence migratory bird species, and habitat availability.
-  Habitat fragmentation due to drought and success of invasive species will reduce grassland and migratory bird species, such as Sage grouse.
-  Wildfire frequency and size will increase as forests experience a departure from historic regimes.
-  Transition from forest to non-forest catalyzed by climate-driven increases in wildfires and insect outbreaks.

Agricultural impacts

-  Changes in temperature and precipitation will increase the need for irrigation water.
-  Agricultural practices will shift North due to precipitation projections declining in southern North Central U.S.
-  Shift from small-scale ranching to larger, industrial scale feed lots.

This three panel triptych illustrates historical, predevelopment conditions in the North Central United States, in comparison to the current state, and future trajectory of land and water use. Historically, the region adapted and rebounded from droughts, however, with human use and climate change, the resilience of the North Central United States against drought is reaching an unknown state.

The eco-drought theme in the North Central US region

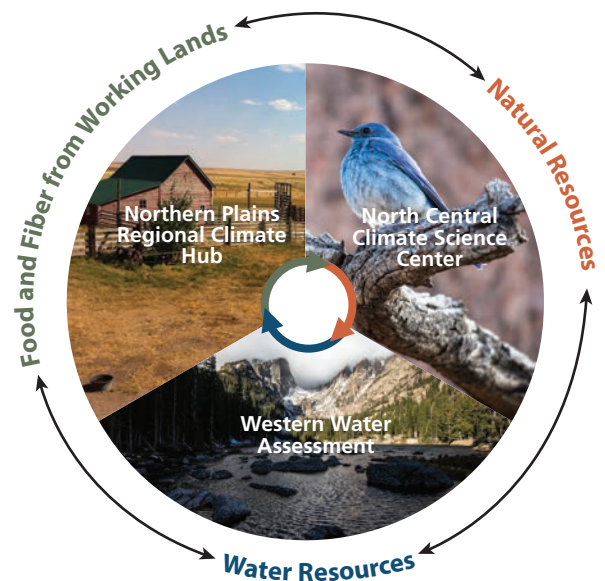
Given the importance of water limitations in our region, while not explicitly labeled 'eco-drought', much of the work of the North Central Climate Science Center focuses on drought impacts on ecosystem, species, habitat, and related livelihoods.

The eco-drought theme provides an organizing framework that can not only shed light on the importance of how drought impacts our ecosystems, but also promotes a common platform across the Climate Science Centers, and allows for coordination with other climate initiatives.

The North Central Climate Science Center is working closely with the Western Water Assessment, and the U.S. Department of Agriculture North Great Plains Regional Climate Hub to coordinate efforts on climate in general and drought resilience in particular. While each of the three entities have unique constituencies, the North Central Climate Science Center as a Department of Interior initiative, has a focus on fish and wildlife. The eco-drought theme described in this newsletter helps to broaden the discussion of drought beyond municipal water supplies, agriculture, and grazing to also consider implications for eco-tourism and recreation, fish and wildlife habitat, and critical ecosystems throughout the domain.

We consider this newsletter as a way to open the dialog with managers and a very general description on the state of knowledge on the topic. *The North Central Climate Science Center is focused on providing credible, salient, and legitimate information for stakeholders in the region.* This newsletter, we believe presents a credible summary of some key issues and questions. The legitimacy and salience of how we address eco-drought will rely on our continued interaction with stakeholders through management-driven projects of the North Central Climate Science Center, with a participatory approach that values the co-production of knowledge.

– Jeff Morisette, Director, North Central Climate Science Center



The North Central Climate Science Center works closely with the Western Water Assessment, and the USDA North Great Plains Regional Climate Hub to coordinate efforts on climate change and drought resilience.



Participants at the North Central Climate Science Center workshop held in Fort Collins, Colorado in December, 2015.

Workshop participants

Shannon McNeeley, Brian Miller, Dennis Ojima, Colorado State University.
Chad McNutt, National Oceanic and Atmospheric Administration.
Kim Hall, The Nature Conservancy.
Justin Derner, United States Department of Agriculture.
Shawn Carter, Amanda Cravens, Emily Fort, Mike Langston, Jeff Morisette, Parker Norton, Holly Padgett, Gabriel Senay, Susan Skagen, Kim Winton U.S. Geological Survey.
Candida Dewes, Brian Harvey, Bets McNie, Imtiaz Rangwala, Todd Sanford, University of Colorado, Boulder.
Simon Costanzo, William Dennison, Brianne Walsh, University of Maryland Center for Environmental Science.
Molly Cross, Erika Rowland, Wildlife Conservation Society.
Shelley Crausbay and Aaron Ramirez, National Center for Ecological Analysis and Synthesis.

Science communication, layout, and design:

Brianne Walsh, University of Maryland Center for Environmental Science Integration & Application Network

Photos:

Cover: Amber Childress, Colorado State University; Back page: Dream Lake Jacob Frank, NPS; Mountain Bluebird Jacob Frank, NPS; Montana Farm Daimon Eklund, Flickr.

For more information regarding ongoing research and activities at the North Central Climate Science Center, visit nccsc.colostate.edu

