# Understanding and Assessing Climate Change: Preparing for Nebraska's Future

## 2024 Climate Change Impact Assessment Report

## Chapter 7 - Ecosystems

Whooping and Sandhill Cranes. Photo courtesy: Mariah Lundgren, Platte Basin Timelapse.

# Chapter 7

# Ecosystems

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## Key messages

1. Change is driving rapid ecosystem transformations.
2. Species changes and biodiversity loss are accelerating.
3. Impacts on ecosystem services create risks and opportunities.

# Introduction

The Fifth National Climate Assessment updates the evidence regarding how climate change influences ecosystems, biological diversity, and the implications for changes to critical ecosystem services—as noted in the key messages above (McElwee et al., 2023). Large-scale transformational changes to ecosystems are occurring, including—but not limited to—land-use conversion, hydrological alteration, and fire regimes. Implications of such transformational change include ecosystem capacity to maintain biological diversity and ecosystem services, impacting recreational opportunities (e.g., hunting and fishing, birding, ecotourism) and agriculture production (McElwee et al., 2023). A central tenet of the Fifth National Climate Assessment regarding ecosystems was the shifts to alternative states and how the Resist-Accept-Direct (RAD) framework may guide the adaptive management of ecosystems moving forward (Lynch et al., 2022).

Nebraska is in the northern Great Plains, where extremes in climate and resulting ecosystem processes are experienced (Knapp et al., 2023). Pressures on ecosystems to provide essential services, including healthy soil and water to benefit humans and animals, will inevitably impact economic development, urban and rural communities, and fish and wildlife populations as climate change continues (Knapp et al., 2023). All ecosystems will be impacted in Nebraska, but aquatic systems—wetlands, aquifers, lakes, streams, and rivers—may be most impacted, given the scarcity of water as human demand (i.e., agriculture and a growing population) persists and increases (Bathke et al., 2014). Major knowledge gaps remain regarding how fish and wildlife populations will persist in changing environments. Past changes, including large-scale land conversion, water delivery systems, and water storage (construction of reservoirs), suggest that some species can adapt to novel environments and shift distributions. However, many more species may be maladapted to the expected changes in climate. Species may be unable to move to suitable habitats, and biological constraints under rapidly changing conditions may impede adaptation—resulting in extirpation and potential extinction. Further, changing conditions open multiple pathways for invasive species and novel diseases, impacting native fish populations, wildlife populations, and human health.

# Climate change challenges for fish and wildlife populations undergoing ecosystem change in Nebraska

Nebraska has distinct landscapes that host many aquatic and terrestrial species critical to healthy ecosystems and people (Schneider et al., 2011). Nebraska is broadly divided into ecoregions (Figure 7.1) that include (from west to east) the Shortgrass Prairie, Sandhills, Mixed-grass Prairie, and Tallgrass Prairie (Schneider et al., 2011). Iconic species, including swift fox, whitetail deer, channel catfish, and prairie grouse, reside in these landscapes.

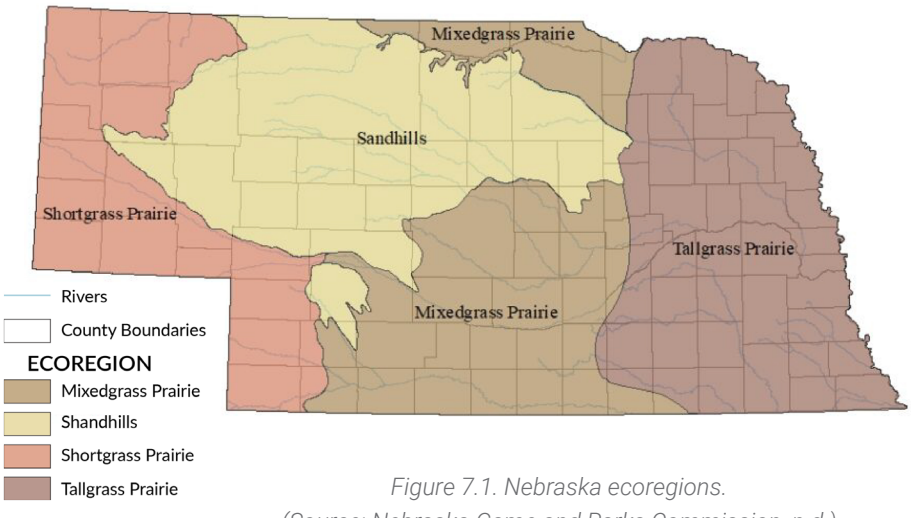


*Figure 7.1. Nebraska ecoregions.*
*(Source: Nebraska Game and Parks Commission, n.d.)*

Healthy ecosystems and the landscapes supported therein are critical to maintaining rich biodiversity within Nebraska. For instance, healthy

grassland systems void of woody plant encroachment support upland bird populations, including the greater prairie chicken (Roberts et al., 2022). Migratory species access Nebraska landscapes on their way to critical habitats used for reproduction and overwintering. Given the wetlands and grasslands within the Sandhills and Rainwater Basin, Nebraska has a major role in waterfowl production. The Platte River provides a habitat for migrating sandhill cranes and endangered pallid sturgeon. As climate change alters hydrologic cycles, these species will face an unknown distribution and quantity of water that may no longer meet their habitat needs.

Climate primarily influences the distribution and abundance of species across Nebraska landscapes. Species have evolved unique adaptations to their local climate, including when and how often they reproduce, stress tolerance to extreme heat and cold, and feeding habits. For instance, temperature is critical for many physiological processes in mammals, fishes, and invertebrates across Nebraska. Temperature and other environmental cues can induce movement across the landscape. Further, many species in Nebraska are ectotherms (e.g., fish, reptiles, and amphibians) and depend on a finite range of temperatures.

Changes in climate may result in environmental regimes that overshoot the physiological limits of and alter critical biological cues for many species, which will influence biodiversity patterns in Nebraska and the surrounding region. Climate change and human alteration to the landscape have already affected ecological processes such as fire and hydrologic regimes and nutrient cycling critical to ecosystem health, particularly in the northern Great Plains (Knapp et al., 2023). Such changes alter the distribution of critical habitats needed by species. Changing precipitation patterns and extreme events, including flooding and drought, will be particularly important. Flooding and drought are not new phenomena in Nebraska or the Great Plains, but rapid movement away from the historic patterns may limit the adaptive capacity of many species. For instance, stream fish can tolerate a range of water temperatures (often termed reaction norms or phenotypic plasticity). Prolonged periods of intense heat and elevated water temperatures during extreme low-flow periods may result in additional mass mortalities or the inability to carry out life stages, including reproduction. Species confronted with changes to climate may be forced to adapt to new conditions by altering the timing of movements and reproduction. The pace at which species adapt to changing conditions may outpace evolutionary timescales. Further, if conditions are not suitable and species cannot adapt to new environments, movement to suitable locations to complete their life cycles (i.e., growth and reproduction) is needed. However, many species cannot move great distances or are prevented from movement given human infrastructure (e.g., dams) and poor connectivity among habitat patches (e.g., disconnected wetland complexes too far apart for movement). As such, climate change may also exacerbate non-climate stressors, including habitat loss and fragmentation, pollution, and the spread of invasive species.

As with other northern Great Plains states, Nebraska is expected to experience an expansion of climate extremes, including variability in precipitation, severe droughts, floods, and increases in hail frequency. Such changes directly influence fish and wildlife populations by acting on key demographic parameters. Populations are regulated through births, deaths, immigration, and emigration. Climate change can influence all such regulating processes. For instance, climate variables have a major role in regulating bobwhite quail population dynamics (Edwards et al., 2024). Prolonged periods of drought can cause stream drying and constrict species into refuge habitats where multiple species are confined. Predation may increase and direct mortality from complete desiccation (Magoulick, 2000). Movement and emigration may be influenced as continued land conversion continues and stream fragmentation intensifies, given the need to increase agriculture production and infrastructure to combat changing water distribution and quantity. Mechanisms directly or indirectly influencing births, deaths, immigration, and emigration of fish and wildlife may manifest in unexpected ways within the context of changing climate and influence the continued presence and distribution of species across Nebraska.

# Conceptual frameworks for managing fish and wildlife populations under uncertain climate variability

Conceptual frameworks exist to aid managers in decision-making while facing uncertainty about how species will respond to changing climate. These frameworks are gaining traction and offer potential paths forward for informing management scenarios in the future. Two primary frameworks for viewing ecosystems under change and how to address those changes are Panarchy and The Resist-Accept-Direct (RAD) framework. Panarchy is a conceptual framework that depicts complex systems (e.g., Nebraska ecosystems such as Sandhills ecoregion) comprised of people and nature as dynamically organized across spatial and temporal scales (Allen et al., 2014). Panarchy is a way to conceptualize how ecosystems change through time and space in the context of human-mediated change and non-human processes. Depending on the ecological resilience of the system, changes may be very slow (eastern red cedar expansion) or fast (land conversion for agriculture production). Large-scale changes in climate variables may either act synergistically or antagonistically in many ecosystem processes across Nebraska. Panarchy emphasizes cycles and the periods in which an ecosystem is "stuck" in a particular part of a cycle. An example is the eastern red cedar expansion, which transformed grasslands into transitional woodlands, reducing grassland production. Another example includes the internal loading of nutrients in lakes and reservoirs, limiting the successful transformation of an aquatic system back to a less eutrophic state. Using the Panarchy framework to assess the state of an ecosystem can directly inform whether to resist change, accept change, or direct change on an alternative path.

The RAD framework, along with adaptive resource management, is suggested as a working guide for resource managers challenged with confronting changes to ecosystems under current and future changes in climate (Lynch et al., 2022). The Resist in RAD refers to efforts to maintain current ecosystem status and function, effectively resisting ecosystem changes. Resisting changes in ecosystems in Nebraska include the efforts to thwart invasive species introduction and spread (e.g., zebra mussels) and state transitions of ecosystems (e.g., removal of eastern red cedar to maintain intact grasslands). Examples of accepting ecosystem change include the large-scale conversion of grasslands for agricultural production, increased temperatures, and changes in precipitation patterns. Managers may be able to direct ecosystems to the desired state despite transformations from a previous state. For example, water infrastructure has played a pivotal role in Nebraska's agriculture production and recreation and may need to continue as prolonged periods of intense drought evolve in the future. Using a RAD framework in coordination with monitoring to reassess ecosystem conditions may benefit future management decisions as changes in climate occur and understanding of impacts to fish and wildlife and ecosystem services improves.

The future of Nebraska's rich biodiversity is uncertain, given the predicted constraints placed on species from changing ecosystems under a changing climate. Generalist species may have the adaptive capacity to shoulder future changes, as many have done under previous and current large-scale transformations. However, evidence suggests some species that were thought resistant to changes are experiencing declines (i.e., wild turkey). Specialist species dependent on the finite bounds of ecosystems may not be able to adapt and may further decline until extirpation from the state. This could include the greater prairie chicken, blacknose shiner, and many other species of conservation concern (Schneider et al., 2011). Climate change may alter many ecosystem properties, including reducing biodiversity, altering species distribution and life history strategies able to survive in historic regions, and increasing the prevalence of disease and invasive species. Such ecosystem changes in Nebraska will influence local and state economies and human health in multiple, often unexpected, ways.